Management Review: An International Journal, 15(2), 1-153 (December 31, 2020).
ISSN: 1975-8480 eISSN: 2714-1047

# Factory Automation and Learning Capability in the Knowledge Transfer Process of Multi-National Corporations: A Case Study of Japanese Healthcare Company

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Received Oct. 18, 2020, Revised Nov. 29, 2020, Accepted Dec. 29, 2020

## ABSTRACT

*In a volatile global environment, it is critical to respond to unpredictable variables in the global market. Multi-national corporations (MNCs) operating across national boundaries face complex risks and a high level of uncertainties. Therefore, MNCs need to sense changing market dynamics and prepare diverse responsive options with future scenario planning. In terms of global management with subsidiaries, MNCs that target the global market need to implement a balance of global business integration and local adaptation. Recent new technologies are one critical factor that contributes to this balance. The introduction of new automation machines to the production line is also an external force of change, requiring line workers to acquire new knowledge as well. Understandably, many Japanese domestic firms have enthusiastically introduced machines and robots to automate their factories. In response to this automation fever, we investigate under what conditions automation might be a barrier to effective* *knowledge transfer. We explore this question using an in-depth qualitative case study of a Japanese manufacturing firm with subsidiaries in Vietnam and China. Through analyzing two aspects of vertical and horizontal knowledge transfer, we find the recipient's degree of prior knowledge affects knowledge transfer. Based on our findings, we provide propositions to explain two aspects of vertical and horizontal knowledge transfer.*

**Keywords**: Factory Automation, Learning Capability, Knowledge Transfer Process, Case study, Multi-national corporations, Japanese Healthcare Company

## INTRODUCTION

In the era of digital transformation (DX), machines and automotive robots have started replacing humans in various dimensions of our daily lives. The Internet of Things (IoT) refers to this wave of automation and the Industrial Internet of Things (IIoT) refers to the revolutionary change in manufacturing processes. For example, by 2023 the industrial robot market is expected to reach some 73.5 billion USD, up from around 42 billion USD in 2017 (Wagner, 2019). The most salient benefits of the IIoT in industrial automation are enhanced efficiency, accuracy, cost-effectiveness, faster process completion rates, lower power needs, decreased errors, and greater control. In particular, the IIoT's greatest benefit has been reducing costs to automate factories. Business areas that are expected to benefit the most from the IIoT are security, automation of processes, maintenance, smart logistics management, integration of smart tools, data analysis with custom software, advanced packaging, smart vehicles, and easy quality control (Neil, 2019).

In the past decade, Japanese manufacturing firms have attempted to ride on the currents of the IIoT. Most Japanese firms are suffering from a shortage of workers due to the rapidly aging society and low birth rate. Small and medium-sized enterprises (SMEs) have especially struggled to manage the labor shortage (Park and Fukuzawa, 2020). One response to this problem has been the introduction of many machines and automotive robots to automate their factories. An alternative option has been venturing into foreign countries that have lower labor costs.

In the face of these two strategies, Japanese SMEs have confronted the need to weigh the cost-efficiency of machines vis-à-vis humans. One criterion is the different learning curves between humans and machines. By repeating the same task over a series of trials, humans learn a body of knowledge over time and increase their proficiency level. Conventionally, Japanese firms have attempted to maximize the proficiency level through fostering multi-skilled workers. While new joiners do not have the skills to begin their task initially, as they learn, they become proficient in 2-3 types of tasks. As a result, an individual evolves from a single-skilled to a multi-skilled worker. While studies have investigated how environmental, cultural, and firm-level factors affect the learning curves, less work has examined the headquarter-subsidiary differences in employees' learning curve. Thus, we ask, what are the inter-subsidiary differences in the learning curve? This is an important gap to address because it will inform managers on when is the optimal time to switch from a human to machine-centered manufacturing line.

In particular, we focus on core human resources in (1) vertical knowledge transfer process between HQ and subsidiaries and (2) horizontal knowledge transfer process between subsidiaries in different countries. To address this question, we conducted an in-depth case study comparing two subsidiaries of Firm-OH, a

Japanese firm. Through conducting on-site visits and interviews with respective managers of the units in China and Vietnam, we suggest a framework that illuminates two aspects of knowledge transfer and provides propositions based on our findings.

## LITERATURE REVIEW

### Organizational routines and learning curve relating to automation

Focusing on the relationship between automation and learning capability in the knowledge transfer process, this paper addresses recent studies on organizational routines and learning. Generally, an organizational routine is a stimulus to response and can be said to be an activity programmed in the organization to make organizational activities more efficient. To increase the efficiency of organizational activities, firms attempt to reduce organizations' wasteful actions. As such, the organizational routines are naturally built-in through a variety of the organization's activities. In an early study, Stene (1940) defined organizational routines as interaction patterns that are pertinent to the coordination of organizational activities and differentiated them from actions that are preceded by decision making. Meanwhile, Nelson and Winter (1982) defined organizational routines as organizational capabilities needed to evaluate and select new solutions through exploration. Since the exploration of a new solution results in a new organizational routine emerging from an existing organizational routine, new solutions are continually being discussed within the organization (March, 1991). As individuals acquire new knowledge, organizational routines change (Huber, 1991).

Furthermore, in organizational theory, organizational routines can be described as repetitive, recognizable patterns of interdependent actions, carried out by multiple actors (Feldman and Pentland, 2003). Such organizational routines include forms, rules, procedures, practices, strategies, and descriptions (Levitt and March, 1988). As organizations are formed and enacted through routines they have implemented, organizational routines accumulate (Sugie, 2018). With regards to routines in the production system, Katz (1974) shows that effective administration depends on three basic personal skills: technical, human, and conceptual skills. First, sufficient technical skill is necessary to accomplish the mechanics of the particular job for which he is responsible. Second, he claims that human skill, the ability to work with others, allows one to be an effective group member and build cooperative effort within the team he leads. Third, conceptual skill allows one to recognize the interrelationships of the various factors involved in his situation, which will lead the individual to make decisions to achieve the maximum good for the total organization. Furthermore, the relative importance of these three skills varies with the level of administrative responsibility. For instance, at lower levels, technical and human skills take precedence. However, for middle managers, the administrator's effectiveness depends largely on human and conceptual skills. For top managers, the conceptual skill becomes the most incumbent for a successful administration.

More recent studies assert that organizational routines are more dynamic and variable (Feldman, 2000; Feldman and Rafaeli, 2002; Feldman and Pentland, 2003; Pentland and Feldman, 2008). Two cycles of dynamic routines are known as the ostensive and performative aspects of organizational routines. The ostensive is the normative aspect of an organizational routine and is the basic form of an organizational routine. Performative routine refers to the actual action. Further, Feldman (2016) claims that the two cycles can be converted into patterning and performing. Patterning can be thought of as ostensive and performing corresponds to performative. Ostensive and performative routines have bidirectional influences, and as organizational patterns are repeated, these routines are increasingly embedded.

As discussed before, to manage the labor shortage, current Japanese firms, especially SMEs have decided to introduce many automotive robots to automate their factories or moved their production facilities into foreign countries that have lower labor costs. Besides, Japanese firms have tried to improve their productivity to win over productivity competition against low labor cost countries. Comparing the cost-efficiency of machines vis-à-vis humans, we should recognize there are different learning curves between humans and machines. Historically as Japanese firms have done, humans learn a body of knowledge over time and increase in their proficiency level by repeating the same task over a series of trials, ending up fostering multi-skilled workers. At the production level, previous routines become patterned as a practice is repeated. As Feldman (2016) asserted, Japanese multi-skilled workers evolved previous routines and expanded their routines according to education and continuous learning.

Historically, organizational routines have been formulated to achieve stable and relatively high organizational performance against rivals over the long run (Nelson & Winter, 1982; Schonberger, 1982; Feldman & Pentland, 2003; Feldman & Pentland, 2008; Schonberger and Brown, 2017). However, if an existing organizational routine is perceived to be fool-proof, or is recognized as routine grounded in experiential knowledge or know-how, people rely too much on such organizational routines (e.g., process, experience knowledge, know-how, etc.) and neglect search for a new solution (Park, 2014). Overreliance on such excellent organizational routines is known as the “competency trap” (Park and Hong, 2012; Denrell and Mens, 2020). To avoid the competency trap due to organizational fossilization, firms need to embrace evolution.

To overcome organizational rigidity, dynamic organizational learning is needed in a volatile environment to change previous routines and explore new routines. Knowledge sharing of new routines acquired by exploration eventually promotes innovation in organizations (Alam et al., 2020). Thus, it is crucial to acquire resources, learn through the exploration activities and internalize those into key corporate capabilities (Kim et al., 2018). New technology introduction such as automation robots utilizing IIOT technologies or transferring previous routines to different organizational contexts can stimulate dynamic organizational learning.

In this paper, we consider the routine transfer and learning curve from an organizational learning vantage. While studies have investigated how environmental, cultural, and firm-level factors affect the learning curves, less work has looked at the headquarter-subsidiary differences in employees' learning curve in the routine transfer process. Thus, this paper asks: what are the inter-subsidiary differences in the learning curve? This is an important gap to address because it will inform managers of the optimal time to switch from a human to a machine-centered manufacturing line. New technologies such as IIOT technologies and artificial intelligence (AI) allow organizations to automate an increasing number of routine tasks in the changing world of work. For instance, assembling complicated components is a task requiring technical skills which nonetheless can be automated if it is routine, whereas improving works whilst being unskilled are non-routine and therefore harder to automate. In particular, as Katz (1974) asserts, conceptual and human skills are harder to automate than technical skills at the shop level.

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ISSN: 1975-8480 eISSN: 2714-1047

## Vertical and horizontal knowledge transfer of MNCs and barriers to learning

In a volatile global environment, it is critical to respond to unpredictable variables in the global market. Multi-national corporations (MNCs) operating across national boundaries face complex risks and a high level of uncertainties. Therefore, MNCs need to respond to changing market dynamics and prepare diverse responsive options with future scenario planning (Wilkinson and Kupers, 2013; Hong and Park, 2020). In particular, in terms of global management with subsidiaries, MNCs that target the global market need to implement global business integration and local adaptation (Duncan, 1976; Tushman and O Reilly, 1996; Park and Shintaku, 2016). Duality/ hybrid model or network capabilities serve as a paradigm to investigate the double-edged nature of global management (Kogut, 1985; Bartlett and Ghoshal, 1989; Evans, 1999 ; Hillman and Wan, 2005; Graetz and Smith, 2008; Park and Hong, 2012; Hong and Park, 2014; Park and Shintaku, 2016).

In other words, MNCs not only need to achieve organizational integration for the strategic focus in global operation but also respond with flexibility to deal with local needs. Balancing the conflicting demands between the needs of integration and local adaptation is an enormous challenge (Prahalad and Doz, 1987). New technology is an external force that affects this balance. For instance, the introduction of a new automation machine to the production line requires line workers to acquire new knowledge as well. In that regard, it is necessary to have an absorption capability to acquire new technology-related knowledge. Cohen and Levinthal (1990) defined absorption capability as the ability to recognize the value of new, external information, assimilate it, and apply it to commercial ends. Kogut and Zander (1992) also argued that combining an organization's existing knowledge and externally acquired knowledge allows the firm to exploit knowledge for the firm's innovation. Much of the prior research on inter-organizational learning has focused on the role of absorptive capacity, a firm's ability to value, assimilate, and utilize new external knowledge (Zander and Kogut, 1995). However, Lane and Lubatkin (1998) reconceptualized the firm-level construct absorptive capacity to relative absorptive capacity, a dyadic construct. A firm's ability to learn from another firm depends on the similarity of both firms' knowledge bases, organizational structures, and compensation policies, and dominant logic. By analyzing pharmaceutical-biotechnology R&D alliances, they find the similarity of the partners' basic knowledge, lower management formalization, research centralization, compensation practices, and research communities were positively related to inter-organizational learning.

Building upon the dynamic capabilities view of the firm, Zahra and George (2002) distinguish between a firm's potential and realized capacity and show a model outlining the conditions when the firm's potential and realized capacities can differentially influence the creation and sustenance of its competitive advantage. On the other hand, Minbaeva et al. (2003) analyze the relationship between MNC subsidiary human resource management (HRM) practices, absorptive capacity, and knowledge transfer. Through examining the relationship between the application of specific HRM practices and the level of the absorptive capacity, they suggest that absorptive capacity should be conceptualized as being comprised of both employees' ability and motivation and indicate that both ability and motivation for absorptive capacity are needed to facilitate the transfer of knowledge from other parts of the MNC. Recently, Sugie (2018) states that in addition to knowledge absorption capacity, it is important to note that knowledge binding capacity is also a neglected skill for innovation and organization learning, and especially critical when the technology information is complex.

Moreover, knowledge transfer issues relating to balancing the conflicting demands between headquarters (HQ) integration and local adaptation are so critical for the successful global business of MNCs. Even though many theoretical and empirical studies in the field of organizational knowledge management have been published in recent years, little attention has been paid to the specific aspects of horizontal knowledge transfer within subsidiaries of MNCs (Park and Shintaku, 2016; Faems et al., 2020). Furthermore, most of these studies focus on HQ's control of subsidiaries and R&D and innovation activities in terms of vertical knowledge transfer (Hollingshead, 2001; Almeida and Phene, 2004; Björkman and Barner-Rasmussen, 2004; Brandon and Hollingshead, 2004; Mudambi and Navarra, 2004; Andersson et al., 2007; Minbaeva, 2007; Bouquet and Birkinshaw, 2008; Monteiro et al., 2008; Phene and Almeida, 2008; Ambos and Ambos, 2009; Ciabuschi et al., 2010; Alnuaimi et al., 2012; Dellestrand and Kappen, 2012; Baaij and Slangen, 2013; Belderbos et al., 2013; Achcaoucaou et al., 2014; Ciabuschi et al., 2014; Najafi-Tavani et al., 2014; Argote and Fahrenkopf, 2016; Grigoriou and Rothaermel, 2017).

As a representative study focusing on the specific aspects of vertical knowledge transfer, Minbaeva (2007) analyzes the joint effect of four determinants of knowledge transfer between HQ and subsidiaries, which are characteristics of knowledge, characteristics of both knowledge senders and receivers, and the relationships between them. He also finds that the success of knowledge transfer is exclusively a function of the characteristics of that knowledge and asserts that it is important to include characteristics of the individuals involved in the transfer process as well as characteristics of the context in which knowledge transfer takes place to fully understand the process of knowledge transfer.

On the other hand, as a representative study focusing on horizontal knowledge transfer, Park and Shintaku (2016) present a research framework that describes the nature of localization strategies and their replication processes among HQ and two subsidiaries and conduct case studies on two LG Electronics divisions, LG India and LG Poland, describing the story of LG executives who implemented the empowerment management style and effective knowledge transfer in India and Poland. They also show that the lessons of the localization successes in these two countries provided an excellent learning effect in Korea and that the middle manager who learned the principles of localization from a senior executive in India moved to Poland, where he successfully applied the same principles of localization. Faems et al. (2020) also explore conditions under which subsidiaries of MNCs can benefit from the external networks of sister subsidiaries in terms of new knowledge generation and focus on the phenomenon of unconnected sister alliances—that is, alliances of sister subsidiaries with whom the focal subsidiary lacks a recent history of internal R&D collaboration. Effective MNCs need to carefully consider the delicate balance among the seemingly contradictory natures of organizational dynamics to manage both vertical and horizontal knowledge transfer effectively (Evans and Doz, 1992; Shiraki, 2002; Park and Shintaku, 2016). In that regard, it is necessary to pay attention to core human resources in (1) vertical knowledge transfer process between HQ and subsidiaries and (2) horizontal knowledge transfer process between subsidiaries in different countries. Figure 1 shows our research framework to analyze two aspects of knowledge transfer.

ISSN: 1975-8480 eISSN: 2714-1047

For the analysis of two aspects of vertical and horizontal knowledge transfer, we select a suitable case to be able to see both aspects, especially focusing on an administrator transferring production routine and knowledge, using the human and conceptual skills of Katz (1974).

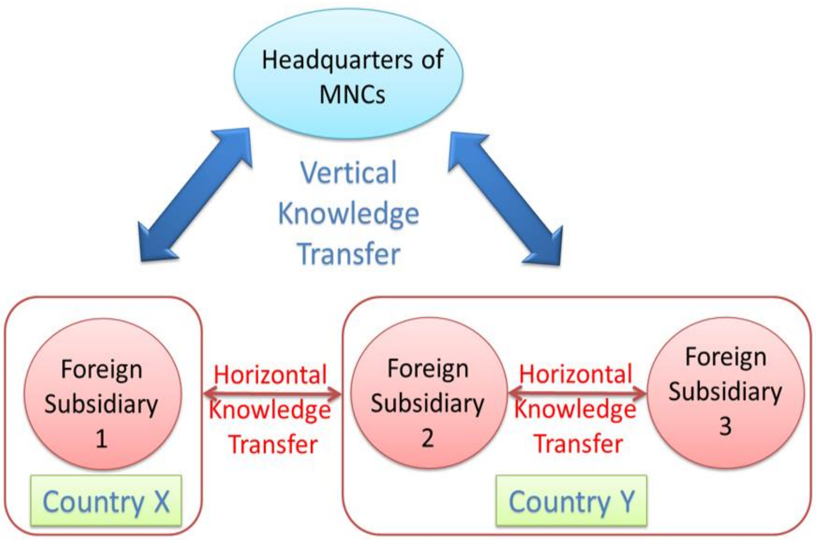

Figure 1. Research framework

## METHODOLOGY

In the paper, based on the theoretical framework of vertical and horizontal knowledge transfer, we suggest a solution to answer how to respond to recent factory automation issues. We chose to conduct an in-depth case study of two Japanese subsidiaries of Firm OH, a Japanese Healthcare Company. We chose a qualitative approach because it allows us to trace the mechanisms and chronological evolution of the subsidiary manufacturing patterns.

We conducted site visits to the firm's HQ in Japan and subsidiaries in Vietnam and Dalian and interviewed the CEOs and senior managers.

### Case selection

To address the gap mentioned in the literature review, we investigate inter-subsidiary differences in the knowledge transfer process and learning capability in terms of automation and job proficiency level. This setting will allow us to control firm-level effects such as top management leadership, organizational structure, and corporate culture.

For this purpose, we conducted a field study. For the case study processes, we first defined selection criteria in terms of actual knowledge transfer in Japanese firms. Among the potential candidates of the initial selection, a Japanese global firm (Firm-OH) and its two subsidiaries (Firm-OHV and Firm-OHC) were chosen. Although multiple cases are desirable, only these organizations met all the selection criteria such as the inter-subsidiary relations of an MNC to analyze two aspects of vertical and horizontal knowledge transfer (Eisenhardt, 1989; Choi et al., 2010; Jensen, 2012; Ketokivi and Choi, 2014). After confirming their willingness to participate in this research, we made appointments with senior managers in these organizations for extensive interviews. Besides, we also visited the firm sites in Japan and other countries (i.e., Vietnam and China), where their two subsidiaries are located. We also distributed the sample interview questions in advance for their review. In our interviews, we inquired about the knowledge transfer process between HQ and its subsidiaries. Figure 2 shows the coverage of our case analysis including (b) Vertical Knowledge transfer, (c) Inverted Vertical Knowledge transfer, and (d) Horizontal Knowledge transfer except (a) Inside HQ Knowledge transfer.

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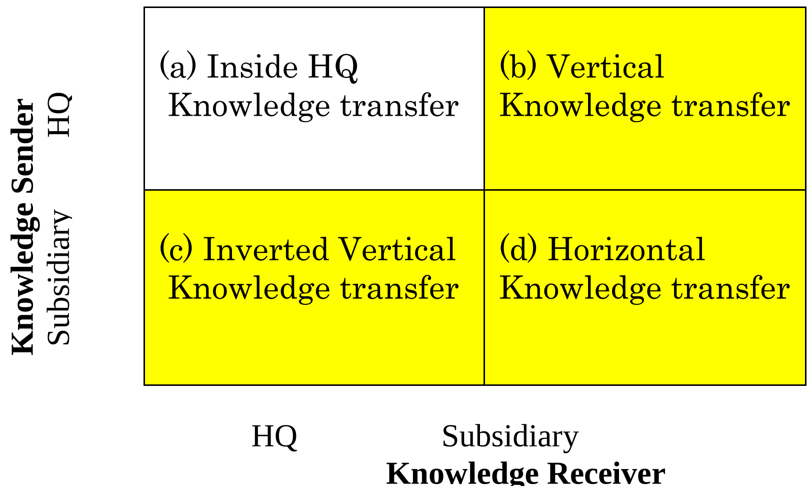
ISSN: 1975-8480 eISSN: 2714-1047




*Yellow color refers to the coverage of our case analysis

Figure 2. The coverage of Case analysis

**Firm-OH and two subsidiaries (OHV and OHC)**

Firm-OH is a large Japanese manufacturing firm with five primary business segments: industrial automation (46%), automotive electronic component (15%), electronic component (12%), healthcare equipment (13%), and social system (7%) as of 2019.

While the firm is currently a large conglomerate, it started as a humble venture spurred by an engineer who wanted to exploit his knowledge. In 1932, the founder's friend remarked, "If there were a high-precision timer for X-ray photography capable of operating accurately at a speed of 1/20 of a second, it would be a bestseller." Spurred by this comment, the founder invented an induction-type protective relay, building upon the technical skills he had gained in his previous position at Inoue Electric Manufacturing. After spending a month to complete a sketch of the timer, he delivered a handmade prototype to Nissei Hospital in Osaka. Impressed by the timer, the hospital managers recommended the timer and the founder soon began to receive large orders from the company. The firm has also been highly influenced by the prosocial leanings of the founder, heralded in its corporate philosophy: "Let us improve our lives and create a better society".

Our case revolves around the healthcare equipment segment (OH) with a significant market presence as one of the leading global manufacturers of blood pressure monitors (BPMs). The healthcare business has eight domestic offices, twelve overseas offices, one R&D center in the headquarters, and three production sites in Matsuzaka of Japan (OH HQ), Dalian of China (OHC), and Binh Duong of Vietnam (OHV) as of 2019. The healthcare business is largely stable, so when the world economy improves, the factory automation business will grow while the healthcare business will look relatively stagnant. Conversely, when the economy gets worse, the healthcare business looks comparatively strong given the sudden fall in the other business segments that are sensitive to the global economic trends. OH's highest sales destination is Japan, accounting for 38% of OH's global sales. This is followed by America, Europe, China, and Asia. It is expected that the Southeast Asian market will grow in the future and overtake the American and European markets. In terms of employee size, there are many factories in China and the current employee size is roughly equivalent between China and Japan. Furthermore, Japan's domestic hires have steadily been decreasing. In China alone, they had 13 to 14 factories but after the firm sold the automotive business, there are currently only three factories in Asia (Vietnam, Indonesia, and Malaysia).

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Firm-OHV, the Vietnam subsidiary of Firm-OH, manufactures two products: blood pressure monitors and nebulizers. Looking at the sales ratio, blood pressure monitors are 57% and nebulizers are 12%. The Matsuzaka factory, the past mother factory in Japan also manufactures blood pressure monitors, producing about 3 million units/ year. Vietnam produces 9 million units, so the Japanese factory is about 1/3 in scale. Dalian factory in China also manufactures about 9 million units. Brazil also has a factory, which produces a few hundreds of thousand units.

Since 1991, the firm has begun investing in China to avoid Japan's high manufacturing costs. Seeing China open up its borders, OH established a base in Dalian, China in 1992. The parent company in Japan designed and developed all products, and sent parts for final assembly in China. Then, to continue the downward pressure on costs, the company began outsourcing to local Chinese suppliers. A Japanese expatriate executive recognized the cost and other advantages of locally sourcing parts. Prohibitive import taxes were a deciding factor. Although the subsidiary had to respond to rising wages in China, the localization of production was essential to any plans for a greater share of a rapidly growing but price-sensitive domestic market. As Japan's labor costs continued to rise, the management continued to replace products that were made in Japan with those of the Chinese factory. By 2002, the Japanese factories' production volume fell close to 0%, and the Dalian plant was responsible for the production of most of the healthcare products.

However, the top management slowly began to realize that concentrating all the healthcare production at one geographic location would be too risky. The current Vietnam subsidiary OHV's general director (GD) said, "Retrospectively, the executives in the headquarters realized that they were blinded by the cost-efficiency of the Chinese subsidiary that they didn't think strategically about the importance of maintaining the Japan headquarters." Thus the management decided to diversify the production sites and established the Vietnam subsidiary in 2008. Right at that time, the yen suddenly depreciated. Previously the yen-USD rate was in the 80 yen range, but it suddenly depreciated to 100 - 120 yen level, and the management began seriously considering manufacturing in Japan. Therefore, since 2013, the firm has restarted manufacturing in the Japanese factory. Not only did the restart of domestic manufacturing disperse the geopolitical risk, but it also created opportunities for the firm to leverage the 'Made in Japan' label for the marketing and sales department. For instance, in Vietnam, they found that they could sell the products made in Japan and Vietnam side by side in drug stores at different prices because consumers were willing to pay the premium price for high-quality products made in Japan.

## CASE FINDINGS

### Cost and lead time competitiveness of mother factory (OH) and subsidiaries (OHV and OHC)

The current Vietnam subsidiary OHV's GD believes the mother factory (OH HQ) can continue to run the factory as long as the conversion rate is in the range of 100 yen to USD. The costs of production in Vietnam have fallen since 2015. In 2015, it fell by 3%, then the following year by 5%, in 2017 by 3.7%, and in 2018, by 2.3%. Thus, in total, the cost fell by 14% over the 4 years. On the other hand, the cost of production at the Dalian factory (OHC) has hardly changed. Therefore, it can be said that there is a 14% difference in the cost of production when compared with China. Comparing China and Japan, Japan is slightly costlier than China, while there is a difference of about 20% in cost between Japan and Vietnam.

The main focus of the Vietnam subsidiary is to reduce the lead time. Throughout the GD's stay in the OHV, the production cost has dropped by 14% and the wages have risen by 10%. In this regard, as fixed costs have fallen by 4% due to the reduction in the number of employees and sales have grown by 16%. In other words, despite the rising costs, the business model is structured so that the firm can continue to be profitable.

The reason why OHV concentrated on lead time reduction is so that it can deliver to customers as soon as possible. As a result, the number of units sold increases and there is no shortage in stock. Profits naturally rise when sales increase. If the lead time is shortened, the fluctuation range becomes smaller. It is common for sales and distributors to prepare extra stock for Christmas sales. Because they don't want to be short of stock, they always overstock. However, when the holiday season is over, the product demand suddenly falls. This cycle of sudden rise and fall in demand will continue whenever the next event occurs. It can decrease the fluctuations when it just replenishes the number of units that were sold last week. When the fluctuations decrease, there is less waste and cost.

The Dalian office of OHC first worked on shortening the lead time, reducing the amplitude, and improving efficiency. After improving on these aspects for 5 years in Dalian, the lead time reached almost satisfactory levels. The GD then came to Vietnam and tried to improve operational efficiency in 5 years. He focused on copy-pasting the entire model by translating the workbooks and procedures that were originally created at the Matsuzaka Plant. When the Dalian plant was first built, the Japanese instruction manuals were translated into Chinese. After the Vietnam plant was built, the Chinese manuals were translated into English, and then into Vietnamese for their workers.

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However, he realized that transferring instructions verbatim would not transfer the routines correctly, given that the local employees held a completely different worldview from those in Japan. In Japan, the factory preferred to receive the production forecast and prepare the number of parts based on the forecast. Once the parts are ready, they will be produced and supplied. Using this flow, it took about a month to prepare the parts. Therefore, the manufacturers told the sales department to ask customers for the number of orders one month in advance. The GD emphasized the limitations of this inefficient model as the fact that "there are many salespeople who are ready to sell what was sold yesterday."

## Knowledge transfer and psychological barriers

There are approximately 50 mechanical parts and 50 electronic parts in one blood pressure monitor (BPM). The Dalian subsidiary has seen reasonable levels of turnover, especially amongst the younger employees. Those with relatively high levels of experience often remain in the firm and therefore senior staff members in Dalian are on average about 45 years old. On the other hand, even the oldest employees in Vietnam are a decade younger, at about 35 years old.

One neglected barrier was the psychological barriers that hindered the smooth operations amongst the factory line workers. Using Eliyahu M. Goldratt's Theory of Constraints (TOC), the GD of OHV brainstormed with the employees, where they reached a consensus that the fundamental bottleneck preventing an optimal production cycle was the lack of commitment to shorten the lead time. Gradually, he gave the line workers the authority to decide how to organize the production line, including when to take breaks and how to adapt to changes in the line structure. For instance, whenever an employee resigned, instead of filling the position with a new hire, the line workers adapted to cover the gap.

Another change has been an increase in individual employee's motivation. The factory workers have witnessed that when they work hard on leveling the production system, their manufacturing performance will improve drastically, having direct effects on their salary. Consequently, in regular staff meetings when GD reports to them all the areas that have improved, the workers are further encouraged to find better suggestions to level production. One salient example was the growth in motivation when they heard that they overtook Dalian's track record in terms of productivity.

Through addressing these psychological barriers, the GD of OHV trained its production system to adapt to the high turnover, resulting in decreasing labor costs, which in turn translated into reducing fixed costs by 4%. Figure 3 illustrates the total number of employees decreasing across the four years the GD was in the Vietnam subsidiary.


Figure 3. The number of employees in OHV

**The job proficiency level of skilled workers and cognitive schema**

Since labor costs are the largest fixed costs in the firm, managing the individual's job proficiency level, or the degree of learned skills is crucial. In general, the function of proficiency level is based on fostering multi-skilled workers and highly efficient workers. While they don't have the skills to begin their task in the initial stage, as they learn, one worker can do 2-3 types of tasks. Accordingly, from the perspective of individual proficiency, an individual evolves from a single-skilled to multi-skilled worker. Vietnam (OHV) has the highest level in terms of skilled workers. It surpassed Dalian (OHC) and Japan (OH HQ) within 10 years. In 2018, the production manager from Dalian visited the Firm-OHV factory and looked at the line. He was surprised to see how fast each person's fingers were moving.

In Firm-OHV, 92% of the factory's line workers are women. The GD stated that women, in general, are better at the assembly work because the products are not heavy, and thus not requiring heavy lifting, a skill more suitable for men. Furthermore, in terms of productivity, women are more competent in the long-term. At the time of joining the company, men on average assemble machines faster and have a faster learning rate. However, after men reach a certain level of proficiency, they tend to get bored with repetitive tasks and lose productivity. Therefore, the firm prioritizes hiring women who have a higher job proficiency level in the long run.

When they established the Vietnam plant, it took about 10 people on average in Dalian to produce one unit while it took about 13 to 14 Vietnamese workers. In other words, the production in Vietnam took 1.3 to 1.4 times longer than in that of Dalian. Both the Dalian and Vietnam subsidiaries have been manufacturing the same blood pressure monitor. Yet since 2017, the Vietnam subsidiary's performance trumped that of the Dalian's. It takes about 8 Vietnamese workers as of 2019 and requires around 30 seconds to assemble one component unit. This is an unusual achievement because it normally takes 10 years to inculcate the TOC philosophy within the employees.

Furthermore, the TOC was first applied in the Japanese HQ, followed by the Chinese subsidiary and finally to the Vietnamese subsidiary. Though the Vietnam subsidiary was the latest to learn philosophy, it quickly caught up and surpassed both firms' performance. How did the Vietnam subsidiary change so quickly?

One reason for the OHV's success lies in the differences in cognitive schema across the labor supply in the firms (Schallert, 1982). When the Vietnam subsidiary was first established, employees who assembled the blood pressure monitors had only about 8 years of experience on average, indicating the limited knowledge repository on the subject. Thus, whenever the GD introduced a new way of thinking, they were able to come with little preconceptions that often hinder the full acceptance of a way to do things. On the other hand, employees in the Japan HQ have a lot of preexisting knowledge so they tend to be more proud and rebellious. The contrast shows a unique case where existing knowledge can serve as a burden rather than an asset to facilitate employee productivity.

**Comparison of humans and the automated machines**

There is a positive relationship between the labor costs in the region and the firm's degree of automation. Japan (OH HQ) has the most sophisticated automation machine, while Dalian (OHC) has a smaller automation machine and Vietnam (OHV) scarcely adopts those machines. While automation has been lauded for its efficiency, the inter-subsidiary comparison highlighted the drawbacks of machines. One of the main demerits is that machines decrease flexibility. Automation machines that are deemed usable have an operating rate of about 85%. When they are used well, the operating rate can reach 90-95%. However, in the case of a production line that tries to mix machines and people, it might decrease the efficiency. For instance, if one person is replaced with a machine in a five-person line, and the machine is only 95% operational, this will increase the four workers' waiting time. As a result, partial adoption of machines might have calculated higher efficiency on paper, but the actual efficiency level may have fallen. Below we note how the GD identified various local contexts that hindered the knowledge transfer and his role in adapting the manufacturing process to transfer the essence of the manufacturing process.

Compared to machines, humans' operating rate is only at about 85%. While this seems lower compared to that of the machines, humans' operating rate increases as the number of devices they experience increases as well. Furthermore, humans can control when they rest, often finding slack time in their routines to take a break. On the other hand, the machine stops without considering the other workers in the line. Toyota's system is based on the assumption that the machine will not stop in the first place. But modern machines that are supposedly more "advanced" come with various sensors that inadvertently result in the machine stopping more frequently. Furthermore, as the machines stop due to built-in sensors, users of the automated machines don't need to think anymore and let the machine "think". As a result, the operating rate of machines is lower than when using humans, and also impairing man's critical thinking capacity.

Due to these reasons, the GD of Firm-OHV thinks mechanization can be dangerous. Since there is no one in Vietnam developing automation technology, if they ever decide to automate some of the processes, they will need to purchase the machines from Dalian. At this point, he says he will only decide to purchase automation machines if there are machines that have a 99% operating ratio.

Despite these drawbacks of automation, as the labor costs in Vietnam increase by 10% annually, the GD is aware that they will need to incorporate automatic machines in the long run. Over the past 10 years, Dalian chose the automation route while Vietnam caught up relying only on manpower, modeling after the processes previously used in Dalian (OHC). While the OHV received basic task-related knowledge from Dalian, the fact that it surpassed Dalian and Japan is due to the tacit knowledge such as the TOC philosophy, which was transferred directly from the GD. Thus, through the leadership of the GD with the human and conceptual skills, the Vietnam subsidiary learned tacit knowledge and received explicit knowledge from Dalian. Since Vietnam is not automated, the next knowledge that Vietnam will need to absorb is how to adapt to automated technology. One key aspect is knowledge on how to speed up and shorten lead time.

### Role of leadership: the key components in the knowledge transfer process

The inter-subsidiary relations in Firm-OH have been vital, and the employees from both the Vietnam and Dalian subsidiaries have interacted with each other many times. Dalian and Vietnamese workers have also gone to Japan, and employees from the Japan HQ have come to the subsidiaries to learn from the subsidiaries' successes. But when they go back to Japan, they end up following the preexisting routines in the mother factory. Many employees have studied and practiced Toyota's production system. Yet they fail to take the abstract knowledge they learn and apply it to the contexts that they reside in.

Many Japanese firms tried to copy Toyota's Kanban method, but in reality, they haven't reached the true meaning of leveled production. These firms still follow the traditional way of receiving forecasts and preparing production plans based on those forecasts.

But if the components are produced and supplied beforehand, this isn't following the Toyota production system because production cannot be leveled. Creating forecasts destroy the whole purpose because the Kanban method was initially developed to prevent the accumulation of stock. As a result, these firms just increase the number of Kanbans and inventory. Furthermore, the warehouse gets confused and begins to incorrectly say that there are no parts when in fact there are.

The Vietnam factory hasn't been able to produce all types of models (A, B, C, D) of blood pressure monitors each day. More than a year has passed since the GD of Firm-OHV began talking about implementing the Kanban system in Vietnam, but they haven't achieved it yet. Many factory workers in Vietnam are reluctant as the lead time has been shortened. Some people complain that they don't want to change the system because the setup change is cumbersome and fear that productivity will fall. In Vietnam, they have about 80 models in total with 20 lines. This means if they run 4 models in one line every day, they can produce all models in a day. Currently, the process goes like this: the A model is put on the line on Monday, the B model on Tuesday, the C model on Wednesday, the D model on Thurs/Friday, then they will return to the A model again on Monday. However, the GD wants to switch to production of all models within a day so that A, B, C, D models are built on Monday. There are opinions on the pros and cons of this process. A demerit is that it will be more troublesome as the number of setup changes per day increases. However, a positive aspect is that creating all the same model every day will result in better quality, improved proficiency, and lower rates of failure because it means that the workers' routine will be the same daily. Furthermore, since OHV can produce changes of the models according to the market, they can flexibly respond to the fluctuation in quantity which requires only the adjustment of the timing when they change the setup between models. As a result, level production is possible. In this way, they can't fully follow the Kanban method without following the level production at this level. If the Kanban system is operated correctly, small adjustments by the staff will decrease as well. Then the workload of the staff will be more manageable and the workers can become more independent. The workers and suppliers will know how many models the firm is selling because it is directly correlated with the switching time. The operation linked to sales will increase the motivation of everyone. The line workers will see that the products they are producing now are not ending up in stock but will be sold next week. As of 2019, the GD is reducing the cognitive barriers by showing why this change in routine will be beneficial.

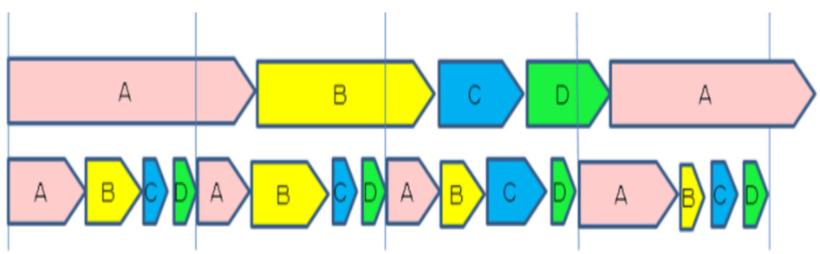


Figure 4. New Kanban method of OHV as a flexible production system

Through the process-tracing, we identified that one of the key components in the knowledge transfer process is a leader who has expertise in the source of knowledge as well as multinational experience to serve as the boundary-spanner between the source and receiving end. The GD's leadership skill of OHV in knowledge transfer is similar to the human and conceptual skill of Katz (1974). He did not try to teach technical skills. In transferring specific knowledge into factory workers with different languages and cultures, these two skills are critical. As Katz (1974) explained, human skills contribute to transferring knowledge factory workers in working with others to be an effective group member and to be able to build cooperative effort within the team he leads. Furthermore, sufficient conceptual skill is necessary to recognize the interrelationships of the various factors involved in his situation, which will lead him to take that action which is likely to achieve the maximum good for the total organization, which is close to TOC philosophy.

The GD of the Vietnam subsidiary (OHV) began his career in the Japanese headquarters and was dispatched to Dalian, China in 2003-2008, and 2010-2015 to reform the inventory management system. Armed with experience in those two offices, he was called to go to Vietnam in 2015 to plant the know-how that he learned and cultivated as well. Effectively, throughout his career, he traced the three-generation headquarters-subsidiary relationship and observed how all three factories followed the same task, work procedure, and used the same tools; yet there was a clear difference in the levels of efficiency. He deduced that the factory's local conditions could play a significant role in influencing their efficiency. Specifically, two factors explain these differences.

First, human capital is crucial. The Japanese factory discontinued its operations by 2002, and only restarted the Japanese factory in 2013. During those years, much of the know-how on how to build a BPM was lost. Therefore, when the management decided to establish the Vietnam subsidiary, they had to get workers from the Chinese subsidiary (OHC) to transfer their skillsets to the new office in Vietnam. This move signified that the "child" in China knew more than its "mother" in Japan. Supplementing this explicit knowledge was the difference in softer aspects of skill, or "tacit knowledge". The GD claimed that the employees in Vietnam were very hardworking, and especially the female employees took longer to learn a skill, but their performance was an upward trajectory whereas the male workers quickly got bored and their proficiency level fell over time. The fact that more than 90% of the current line workers in Vietnam are females meant that the labor supply met the OHV's employee demand.

Second, each factory has automated its manufacturing process to varying degrees. When the labor costs rose in China, the Dalian factory began to automate some of the processes using a small automation machine (price around 5,000,000 JPY). Furthermore, when the Japanese factory resumed operation, due to the high labor cost in Japan, they adopted 10 -20 of more sophisticated Firm-O's Factory Automation division's machines (price range from 5,000,000 - 10,000,000 JPY) and rebuilt a line that minimized human involvement. On the other hand, the Vietnam subsidiary (OHV) still hasn't relied on any machines. While automation has many benefits such as accuracy and decreasing manpower, the GD noted a disadvantage (i.e. decreasing flexibility).

## Propositions of knowledge transfer of MNCs

In the case of analysis of two aspects of vertical and horizontal knowledge transfer, we find the degree of previous knowledge of receiver (=recipient) can impact on knowledge transfer. As we addressed, the TOC was first applied in the Japanese HQ, followed by the Chinese subsidiary and finally to the Vietnamese subsidiary. Though the Vietnam subsidiary was the last to learn philosophy, it quickly caught up and surpassed both firms' performance. One secret for the OHV's fast catch-up lies in the differences in amounts of previous knowledge. When the Vietnam subsidiary was first established, employees who assembled the blood pressure monitors had only about 8 years of experience on average, indicating the limited knowledge repository on the subject. However, employees in the Japan HQ have a lot of preexisting knowledge so they tend to be more proud and rebellious. The contrast shows a unique case where existing knowledge can serve as a burden rather than an asset to facilitate employee productivity.

Table 1 is a summary of four types of absorptive capability with two axes of vertical and horizontal knowledge transfer. The factory workers of OHV with scarce production knowledge show high absorptive capability. Ironically, the factory workers of OH HQ with ample production knowledge show low absorptive capability.

Table 1. Types of absorptive capability with two axes of vertical and horizontal knowledge transfer

| | Vertical High Absorption | Vertical Low Absorption | Horizontal High Absorption | Horizontal Low Absorption |
|---|---|---|---|---|
| Knowledge Transfer | Vertical (HQ⇔ Subsidiary) | Vertical (HQ⇔ Subsidiary) | Horizontal (Subsidiary ⇔ Subsidiary) | Horizontal (Subsidiary ⇔ Subsidiary) |
| Degree of Previous Knowledge of Receiver | Scarce | Ample | Scarce | Ample |
| Primary Example | OHV/ Previous OHC | OHC | OHC | - |
| Absorptive Capability | High | Low | High | Low |

Figure 5 presents the different types in response to knowledge absorption by knowledge transfer and degree of previous knowledge of receiver as the two axes. Based on our findings, we suggest propositions with two axes.

Vertical High Absorption (P1A) and Vertical Low Absorption (P1B) represent knowledge absorption patterns when vertical knowledge transfer from HQ to subsidiaries occurs. As shown in Vertical High Absorption (P1A), it seems to be so high for receivers to absorb knowledge.

The second pattern could be Vertical Low Absorption (P1B). For our case of vertical and horizontal knowledge transfer, employees in the Japan HQ have a lot of preexisting knowledge and tend to be reluctant to absorb knowledge from subsidiaries (OHV and OHC), ending up inferior to subsidiaries in productivity. This finding shows existing knowledge can serve as a burden rather than an asset to facilitate employee productivity.

The third and fourth patterns are Horizontal High Absorption (P2A) and Horizontal Low Absorption (P2B), which show types of knowledge absorption in terms of horizontal knowledge transfer. When the GD of OHV, who experienced HQ and OHC, began to teach the TOC, the factory workers of OHV easily absorbed new production methods and improved their job proficiency, finally caught up with the productivity of OHC. However, it is difficult for the factory workers of OHC with ample knowledge more than those of OHV to absorb knowledge from OHV. Therefore, giving up maximizing proficiency level, they try to develop production robots like HQ in Japan. This proposition can apply to knowledge transfer in the same factory. As addressed before, the female employees of OHV took longer to learn a skill in the beginning, but their performance was on an upward trajectory whereas the male workers quickly got bored and their proficiency level fell over time. In the long run, more than 90% of the current line workers of OHV are females.

Management Review: An International Journal, 15(2), 1-153 (December 31, 2020).
ISSN: 1975-8480 eISSN: 2714-1047

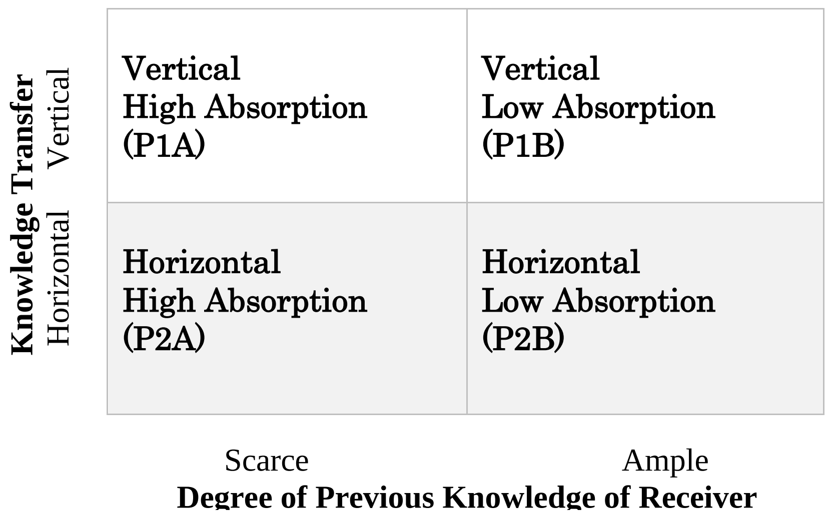


Figure 5. Propositions with types of knowledge transfer

## CONCLUSION AND IMPLICATIONS

In this paper, we conducted a case study of the inter-subsidiary relationship of a Japanese Firm-OH. We visited the Japanese HQ (OH HQ) and subsidiaries in Vietnam (OHV) and Dalian (OHC). We identified significant differences amongst the subsidiaries in terms of employee efficiency level. This is a striking finding because, across the subsidiaries, the task (assembling blood pressure monitors) is uniform; yet workers in Vietnam surpassed those in Dalian and Japan within 10 years. While we noted other alternative region-specific factors such as labor cost, we nevertheless believe labor costs do not sufficiently explain the regional competitive advantage. Our case elucidates that an individual's prior knowledge can hinder the absorption of knowledge. For highly sticky knowledge, we identified the important role of a leader who serves as the expert and international boundary-spanner to contextualize the knowledge to fit the mental models of the Vietnamese employees.

Besides, we found that in the case of Firm-OHV, the Japanese HQ develops the blueprints, supported by a development team in Dalian and a few individuals in Vietnam. The drawings are managed in a cloud system, and anyone can see the same drawing. Unfortunately, because employees in the HQ are mostly proficient in Japanese, all the documents are also written in Japanese. From the standpoint of knowledge transfer, such language barriers undermine the effectiveness of the system. Based on the author's recommendation, the GD at Firm-OHV is preparing to ask the Japanese HQ to switch the language to English.

Another theoretical contribution is that we integrated two disparate pieces of literature: the transactive memory systems and learning curve literature. While social psychologists have established the importance of transactive memory for teamwork and collaboration (Wegner, 1986; Wegner et al., 1991; Hollingshead, 2001; Lewis et al., 2005), to the best of our knowledge, this is the first paper that applied this concept in the context of an MNC in the manufacturing industry. As the work task mainly consists of simple assembly processes, we view this case as a conservative test of the importance of transactive memory to transfer knowledge from one geographic location to another and to integrate the knowledge into group-level routines where line workers need to know the skills of their colleagues in the same line. We also show how this picture is complicated by automation, which trades an individual with a machine that revolves around a completely different operating system.

Finally, we highlight the need to pursue further studies in the area of knowledge transfer strategies. This study has shown that a blueprint and an inspection procedure manual will not sufficiently guide workers to assemble the products because tacit knowledge of how to make the things in Japan was not reflected in the procedure manual. We advise managers that are attempting to standardize the practices across the subsidiaries to devise ways to input tacit know-how into the formal procedure manuals and drawings through digital knowledge-sharing tools (Claggett and Karahanna, 2018). However, we have yet to know how to best convey tacit knowledge. Would videos or pictures be sufficient mediums? Or would AI systems transfer the knowledge that words or pictures cannot convey? We are optimistic that digital technologies can cross the cultural chasms that conventional platforms had struggled to overcome.

## ACKNOWLEDGEMENTS

This article was supported by the Japan Society for the Promotion of Science (JSPS) KAKENHI (Grant-in-Aid for Scientific Research). Grant Numbers JP19K01856 and The Research Center for Sustainable Development in East Asian (SU-RCSDEA).

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