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## Tacit Knowledge Transfer through Co-activation: A Case Study of Design and Support by an Electronics Manufacturing Service Firm

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**Abstract**--This paper examines tacit knowledge transfer for competitive advantage. In a usual outsourcing business from Customer to EMS firm, only explicit knowledge is exchanged and know-how is transferred from Customer to EMS firm. However, in the case of the successful EMS firm, there was a case that the tacit knowledge including know-how was reversely transferred from the firm to the customer. Requirements of the customer stimulate inactive tacit knowledge of the firm from the production engineering (PE) points of view, which leads to the suggestion to be made to the customer. This activates the related tacit knowledge on the customer side and yields improved design by the customer to match the PE to maximize quality and productivity in volume production in the EMS firm. In this case, two kinds of tacit knowledge existed in both parties are activated separately by exchange of explicit knowledge. This co-activation process practically achieves tacit knowledge transfer. Tacit knowledge activated and transferred through this co-activation mechanism complements the gap of knowledge existed between the design of new products on the customer side and PE on the firm side, and can be a source of competitive advantage for the both parties.

### I. INTRODUCTION

US & Canada based Electronics Manufacturing Service (EMS) firms have executed the outsourcing activities in Japan since year 2000 and most of the firms acquired plants of Japanese electronics manufacturing firms as the base of outsourcing activities in Japan [1]. However, the EMS firm (hereafter called firm "A") acquired the development & engineering center of the US-based IT firm (hereafter called firm "B") in Japan, together with twenty five engineers who have design capability of Printed Circuit Board Assembly (PCBA). The firm "A" established a unique support system for the design of new products under collaboration with its customers with the transfer of technologies to its overseas subsidiary manufacturing plants for volume productions. Recently, Taiwanese Original Design Manufacturer (ODM) firms are expanding the outsourcing business in the product segments of not only personal computers but also digital consumer products such as LCD TVs and digital cameras, and pricing competitions are getting tougher [9][10][11]. However, under such situation, the firm "A" is expanding the business by using the unique system even with less competitiveness in the overall cost including overhead compared with Taiwanese ODM firms.

The purpose of this paper is to examine tacit knowledge transfer for competitive advantage as knowledge based innovation management through a case study of the EMS firm "A". In order to achieve the aim, we set up the major research question: How does the US-based EMS firm "A"

establish competitive advantage in the deals with customers in Japan?, with the subsidiary questions of : (1) What are differences between successful and unsuccessful deals in the firm "A"?, (2) What type of competitive advantage does the firm "A" generate in the successful business?, and (3) What characters do the engineers of the firm "A" have?

### II. THEORETICAL BACKGROUND AND A HYPOTHESIS

Reference [7] indicates that tacit knowledge is able to be transferred from a firm to the other party by mutual understanding and trust through experience sharing. The knowledge creation is made by the process of conversion of tacit to explicit knowledge and successive explicit to tacit knowledge circle across organizational boundaries Fig. 1.

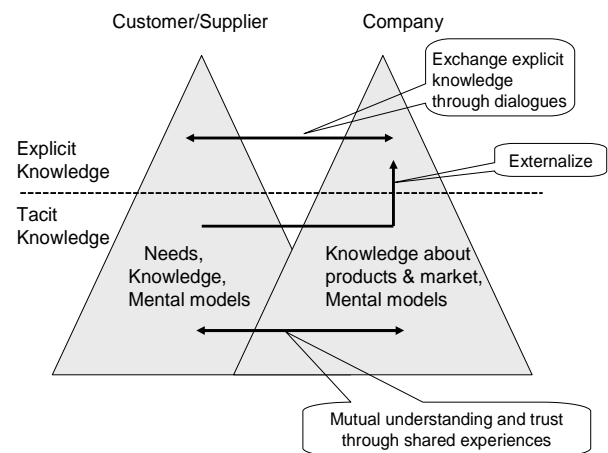


Fig.1. Creating knowledge with outside constituents  
Source: Nonaka, Toyama & Konno [7]

The basic reliance of a firm is an important condition and a source of complementary knowledge in external knowledge acquisition of R&D activities [2]. Strong unity, trust, and value sharing are important for tacit knowledge transfer in the international joint venture [3]. Reference [5] indicates the similar conclusion through a case study of multinational corporations. The equity joint ventures are able to transfer more complex capabilities than contract-based alliances and unilateral contract-based alliances are only available for the transfer of lower level of capabilities [6]. The intrinsic motivation is an important source to generate tacit knowledge transfer for competitive advantage of the firm [8].

In summary of the literature review, the condition for knowledge creation with the involvement of tacit knowledge transfer can be described as in Fig.2. Namely, reliance (trust), equal partnership & value sharing are the key to complement the gap of the knowledge and recognition of values in each firm, and the knowledge creation is achieved through mutual understanding and experience sharing.

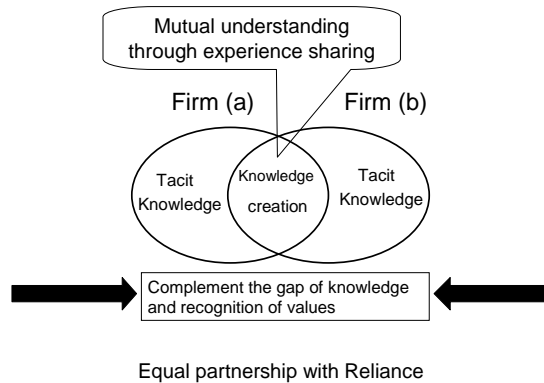


Fig. 2. Condition for Knowledge Creation with Tacit Knowledge Transfer

From the viewpoints of the models of Fig. 1 & 2, successful and unsuccessful deals of two cases each were investigated for business activities of the US-based EMS firm “A” for the last ten years in Japan. From the initial review, we found that the successful deals have the knowledge transfer from the EMS firm to the Customer under equal partnership, but unsuccessful ones have one-way transfer from the Customer to the EMS firm under hierarchical relationship. Namely, a hypothesis was generated that the knowledge transfer from EMS firm to Customer under equal partnership creates competitive advantage. We verified it based on the interviews, e-mail communication data, and minutes made by the meetings conducted by the firm “A” and the customers.

### III. METHODS AND FINDINGS

The process to find the answers of the research questions for the conclusion is summarized as in Table 2.

TABLE 2 PROCESS OF BUILDING THEORY FROM CASE STUDY RESEARCH [4]

Step	Activity	Output
Selecting each two cases of successful and unsuccessful deals of the firm “A”	Specified hypothesis	The knowledge transfer from EMS firm to Customer under equal partnership creates competitive advantage
Investigation of each two cases	Analyzed from the view point of knowledge transfer	The unsuccessful deals have one-way transfer from the Customer to the firm “A”, but successful ones have transfer from the firm “A” to the Customer
Entering the Filed	Interviews with both the firm “A” and the Customer of successful deals were conducted	According to the suggestion given by the firm “A” after review of the design data through proto-building activities, the Customer modified the original design to match the production engineering to maximize quality and productivity in volume production in the subsidiary plant of the firm “A” in China
Analyzing Data	Verification of the interviews and e-mail communication data	Without group work in the same place, the Customer received the suggestion from the firm “A” with recognition as a really new technology and modified the original design with appreciation, but the firm “A” considered that it’s just an applied technology in the past for the solution of the Customer’s needs. The interviews indicate that the different activation of tacit knowledge is generated in each party through exchange of explicit knowledge
Shaping Hypothesis	Verification of tacit knowledge of five senior engineers in the firm “A” through frequent interviews	The tacit knowledge of each engineer of the firm “A” was unable to describe clearly, but the knowledge of the firm “A” to convert from the design of new products to suit production engineering is the source of competitive advantage for the successful deals
Enfolding Literature	Comparison with similar and conflicting literatures	The literatures indicate that mutual understanding and trust are important for tacit knowledge transfer from a firm to the other party and <u>face to face meetings or “Ba” for knowledge sharing is the key</u> . However, in the case both companies are in workable relation of co-activation mechanism, the tacit knowledge transfer is available <u>without experience of the knowledge-sharing</u>

IV. ANALYSIS

A. Difference between the successful and unsuccessful deals

The unsuccessful deals have one-way transfer of the knowledge from the Customer to the firm “A” & its China plant under hierarchical relationship Fig3(a).

In contrast, the successful ones have the knowledge transfer from the firm “A” to the Customer for the support of design activities Fig. 3(b). In this case, according to the Customer’s needs and design data, the firm “A” executes proto-building and provides the Customer with the solution. After the completion of the re-design by the Customer, the technology relating production engineering (PE) together with the re-design by the Customer is transferred from the firm “A” in Japan and then to its China plant. The knowledge transfer from the EMS firm to the Customer under the equal partnership is the key for success in this process.

B. Customer’s needs in successful deals

As an example, this process is described by the successful deal case of PCBAs for digital cameras as follows. Customer’s needs for the design of new products are the integration of more functions in the compact size body when the periodical model changes are required by the customers in every six months. For the solution, as many electronic components as possible are needed to be mount on smaller size PCBs. However, the ratio of solder defects increases due to the narrow space of each electric component as side effects of higher density Fig.4. For instance, using the conventional production engineering, the performances of quality and productivity in the volume production line decreases from “x” to “y” when the density increases from “a” to “b” in order to meet Customer’s needs. Namely, the optimum design means to minimize the side effects for efficiency in the production line in higher density of SMT (Surface Mount Technology). In terms of the design rules of the firm “A”, thirty items of specifications in the high density of SMT were improved for the last ten years. Therefore, it is confirmed that the capability of SMT in the firm “A” was enhanced as the result of continuous challenges to satisfy Customer’s needs. We will discuss hereafter how these challenges have lead to the increase of the SMT performance of the firm “A”.

C. Character of engineers of the firm “A”

Tacit knowledge of five senior engineers of the firm A is the key for creating the solution for the customer’s needs. They have gained and accumulated great experiences during their work in the firm “B” for more than thirty years, and they each have their own unique character & style, which are different from each other Table 2.

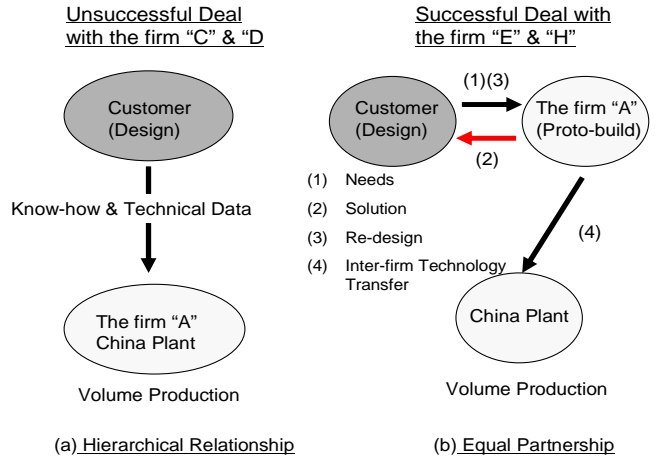


Fig.3. Comparison of successful & unsuccessful deals

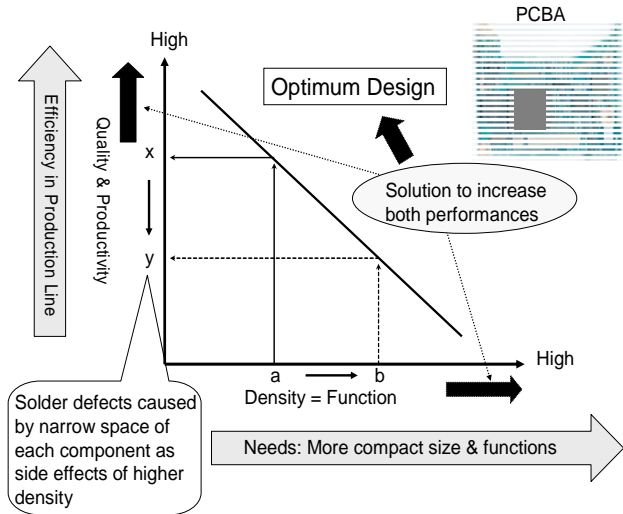


Fig.4. Customer’s needs for Optimum Design

TABLE 2. CHARACTER AND STYLE OF THE FIVE SENIOR ENGINEERS OF THE FIRM “A”

Character	Style
Big-boss-type	To put emphasis on meeting Customer’s requirements
T-shaped experience-type	To put emphases on consistency with precedents and experiences
Craftsman-type	To believe own intuition
Scholar-type	To put emphasis on theory
Coordinator-type	To mediate the friction among four engineers

*D. Activation of Tacit Knowledge in the firm "A"*

During the interviews with the five senior engineers, they explained as follows:

- Interviewee-1<sup>1</sup>: We have done nothing new, but just responded to the customer's needs based on experiences in the past.
- Interviewee-2<sup>2</sup>: We proposed the solutions per existing technologies in order to resolve Customer's problems and they are not new but just empirical ones. It is up to customers how to take the technologies as new ones or not.

The interviews indicate that tacit knowledge of each senior engineer is inactive state when there is no specific task. Once tasks are given by Customer, the empirical knowledge of each engineer is activated and responds. Then, the problem and suitable solution are specified through proto-building activities.

*E. Activation of Tacit Knowledge in the customer*

The interviews with the customers were also conducted, which included the following interviewee explanations:

- Interviewee-3<sup>3</sup>: We appreciate technical support of the firm "A". Especially, the factor of productivity in the volume production (of the firm "A") is able to be taken into consideration for the re-design by the suggestion of the firm "A".
- Interviewee-4<sup>4</sup>: We realize the value of the solution only when pointed out by the firm "A" (without the suggestion, the firm "H" is unable to find out the problem & solution).

The interviews indicate that the explicit knowledge with background tacit knowledge of the firm "A" stimulates Customer's own related tacit knowledge to be activated for a change of the design.

*F. Different activation between the firm "A" and Customer*

Interviewees of the firm "A" and the customer have different views on the same technology, which was revealed by the following interviewee explanations:

- Interviewee-3<sup>5</sup>: XXX technology is a really new and useful solution for us.
- Interviewee-2<sup>6</sup>: XXX is an existing technology for us in the past.

- Interviewee-1<sup>7</sup>: XXX is only an applied technology in the past.

The interviews indicate that both engineers of the firm "A" & "H" have the different recognition to the same technology, which means the different activation is generated in each party.

V. DISCUSSIONS

*A. Tacit Knowledge Transfer through Co-activation*

Inactive tacit knowledge of the firm "A" is activated and responds to Customer's needs to deliver the solution, where knowledge conversion is made for the design of a new product on the customer side to match the production engineering (PE) in the firm "A" considering quality and productivity in volume production. To achieve this tacit knowledge transfer, as a first stage the explicit knowledge with background tacit knowledge of the firm "A" is transferred to the customer as the suggestion of optimum design. This explicit knowledge transfer stimulates Customer's own related tacit knowledge to be activated for a change of the design to be in line with PE in the volume production of the subsidiary plant in China of the firm "A" for the new product manufacturing as in Fig. 5.

*B. Knowledge Conversion & Roles of Senior Engineers in the firm "A"*

For the analysis of tacit knowledge activation in the firm "A", the knowledge conversion & the role of each senior engineer in the firm "A" are described as in Fig. 6. The knowledge conversion from a product design made by the customer to the production engineering and the knowledge creation for the solution to achieve more compact size & functions with better productivity & quality in the volume production is a source of competitive advantage both for the customer and the firm "A". For the knowledge creation, each senior engineer has the different role on the proto-building activities in the firm "A". "Coordinator-type" controls the schedule & progress of overall activities from receipt of a design data to submission of the proposal for design changes as interface of the customer. "T-shaped experience-type" verifies the design data technically. "Scholar-type" selects suitable materials such as solder paste considering surface mount technologies per the design data and prepares proto-building. "Craftsman-type" executes proto-building & test and summarizes the results and problems. Depending on the problem, "T-shaped experience-type" and "Scholar-type" join the test. "T-shaped experience-type" set-up the hypothesis for the solution of problems and the verification is made by "Craftsman-type". After completion of the test, five senior engineers have the meeting for the discussion of the problem and solution per the results of proto-building & test.

<sup>1</sup> Senior engineer (T-shaped experience-type), the firm "A", interviewed by author, the place of dinner, Nov. 26, 2009

<sup>2</sup> Senior engineer (Craftsman-type), the firm "A", interviewed by author, the place of dinner, Apr. 12, 2010

<sup>3</sup> Team Leader, Design Sect., the firm "H", interviewed by author, the meeting room of the firm "H", Dec. 4, 2009

<sup>4</sup> Manager, Engineering Sect., the firm "H", interviewed by author, the place of dinner, Nov. 20, 2009

<sup>5</sup> Team Leader, Design Sect., the firm "H", interviewed by author, the meeting room of the firm "H", Dec. 4, 2009

<sup>6</sup> Senior engineer (Craftsman-type), the firm "A", interviewed by author, the place of dinner, Apr. 12, 2010

<sup>7</sup> Senior engineer (T-shaped experience-type), the firm "A", interviewed by author, the place of dinner, Nov. 26, 2009

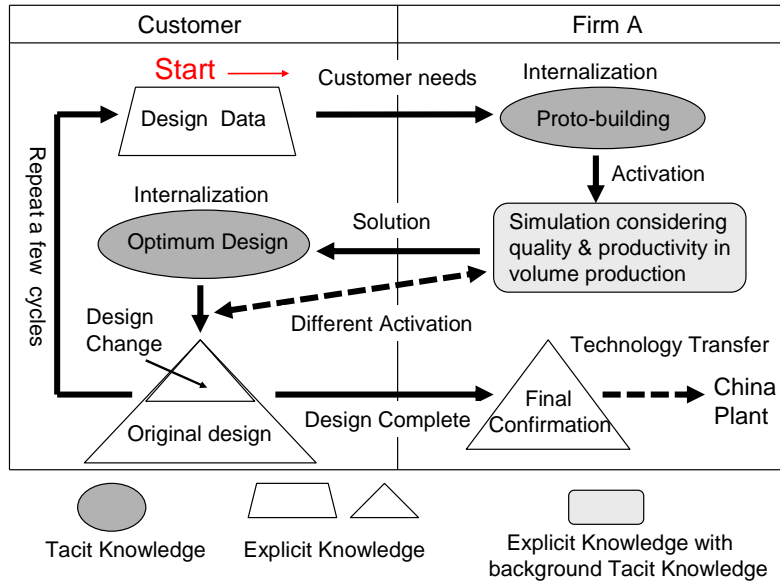


Fig.5. Flow of Knowledge in Design Support of the firm “A”

It is most important for the knowledge creation to exchange opinions based on tacit knowledge of each senior engineer in the firm “A”. “T-shaped experience-type” makes a report based on the result of proto-building & test including the proposal of re-design. “Big-boss-type” makes a final judgment & approval and “Coordinator-type” submits a

report to the customer. “T-shaped experience-type” explains the reason of design changes to the customer if necessary.

For all successful deal cases studied, each of the five characters described above contributed to the activities of the firm “A” and were necessary for the firm “A” to be able to suggest improvements to the Customer; no exclusion of every character was possible for the success.

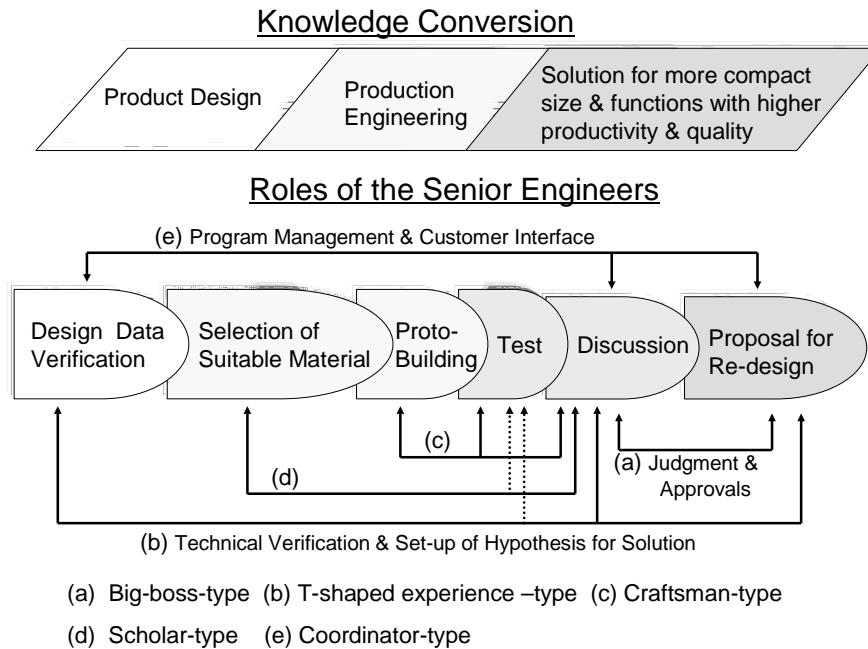


Fig.6. Knowledge Conversion & Roles of the Senior Engineers in the firm “A”

VI. CONCLUSION

A. The answers to the research questions

Considering the case analysis as discussed above, the answers to the research questions can be described as follows:

- Subsidiary research question-(3) What characters do the engineers of the firm “A” have?  
Five senior engineers who have the different characters and styles of Big-boss-, T-shaped experience-, Craftsman-, Scholar and Coordinator-types, are the key for successful support system of the design activities in Customer. These five characters functions very well for their varieties of tacit knowledge to constitute competence to convert design of new products in the Customer to suit production engineering in the volume production line of the firm “A”.
- Subsidiary research question-(2) What type of competitive advantage does the firm “A” generate in the successful business?  
The capability of SMT for higher density in the firm “A” is enhanced as the result of continuous challenges to meet Customer’s needs which gradually increase difficulties in the periodical model changes for new products. The competitors are unable to catch up with the technical level of the firm “A” because it is successively upgraded through the response to Customer’s needs, where tacit knowledge transfer from the firm “A” to the Customer happens.
- Subsidiary research question-(1) What are differences between successful and unsuccessful deals in the firm “A”?

Tacit knowledge transfer from the firm “A” to the Customer through co-activation has been generated in the successful deals under equal partnership, but it has not been generated in the unsuccessful ones under hierarchical relationship.

The above answers to the subsidiary research questions lead to answering the major research question in the following way:

- Major research question: How does the US-based EMS firm “A” create competitive advantage in the deals with customers in Japan?  
The varieties of tacit knowledge of the firm “A” are activated and respond to the Customer’s needs to deliver the solution which is provided to the Customer with the documents as the suggestion of optimum design. This explicit knowledge transfer with background tacit knowledge stimulates Customer’s own related tacit knowledge to be activated for a change of the designs to match the production engineering (PE) in the firm “A”. The competence of the firm “A” to convert design of new products on the Customer side to suit PE in the volume production on the firm “A” side is a source of competitive advantage. This tacit knowledge transfer through co-activation achieves not only customer satisfaction but also enhancement of capability of the firm “A” for production of higher-density SMT through the periodical development of new products.

B. A model of Tacit Knowledge Co-activation

Based on the findings of this study, a model of tacit knowledge transfer through co-activation is proposed as in Fig. 7.

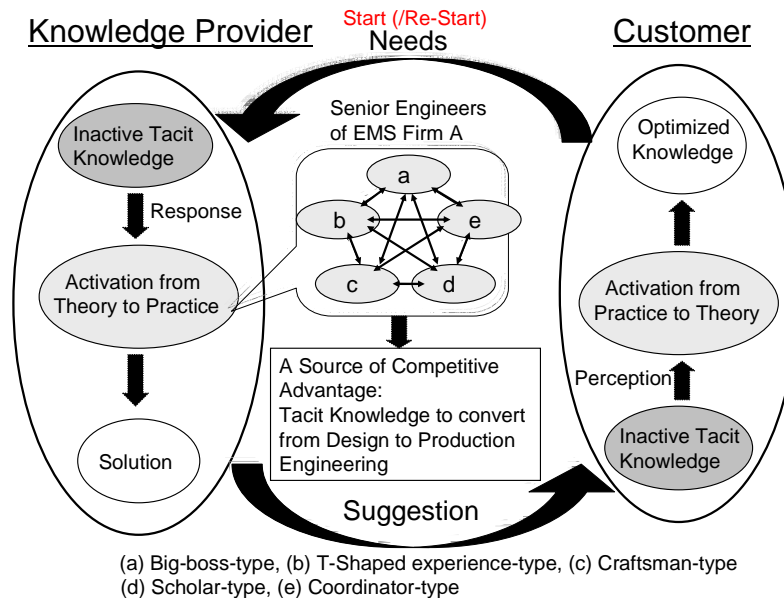


Fig. 7. A Model of Tacit Knowledge Co-activation

*C. Theoretical Implication*

Mutual understanding and trust are important for tacit knowledge transfer from a firm to the other party, and it is able to be generated through co-activation even without arranging face to face meetings or “Ba” for knowledge sharing, provided that the other party has also the same kind of, but different, tacit knowledge in the same domain to be stimulated by the transfer of the associated explicit knowledge of the firm. This co-activation process occurring in the both parties can make tacit knowledge transfer practically possible.

*D. Practical Implication*

For a nation with an aging society to establish competitive advantage, it is important to find an opportunity to call up superior tacit knowledge of seniors who have gained and accumulated great experiences in their past career. Tacit knowledge is one of the key aspects to keep competitive advantage, and tacit knowledge transfer with co-activation process can be beneficial for tacit-knowledge providing companies which wish to achieve successful outsourcing business deals.

In the case both companies are in workable relation of co-activation mechanism, the competent tacit knowledge of the company can be transferred to the other company without experience of knowledge-sharing, and both companies can enjoy the competitive advantage generated by knowledge creation led by tacit knowledge transfer through co-activation process.

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