# Perspective Service Knowledge and Technology Transfer Model of Intra-Firm in IC industry

**James K. C. Chen, Assistant professor, Department of Business Administration, Asia University, Taiwan**

## ABSTRACT

*The paper presents a perspective on service knowledge and technology transfer model of intra-firm. This study is based on one Europe international firm for case study exploring how building up service knowledge and technology transfer model in the IC firm. The technology transfer methodology and the performance were investigated. Based on an in depth evaluation of the project setup and a lessons learned workshop after the project, improvements to the project setup are proposed. The IC firm extends semiconductor manufacturing sites (wafer fabs) for rapidly growing IC market. One multi national companies built new fabs and have to transfer the manufacturing knowledge and technology to new sub-fabs. This study purpose is to propose an efficient methodology for multinational intra-firm knowledge and technology transfer in the IC firms.*

***Keywords:*** *Multinational, Technology transfer, knowledge transfer, Intra-firm, IC-Industry*

## INTRODUCTION

The integrated circuit(IC) market keeps on growing in current, which in turn requires continues extension of semiconductor manufacturing sites (wafer fabs). International IC companies built new fabs and have to technology transfer to the new manufacture factory. This leads to the research problem: How building up an intra-firm technology transfer model across international borders. The purpose of this study is to propose an efficient technology transfer model for international company to do intra-firm production process and technology transfer in IC industries. This study conducts by performing a case study on a recent technology transfer. Figure 1 is showing current technology transfer flow chart of the case firm.

Exploring the different kinds of flow chart and technology transfer efficiency will be evaluated in this case study. We expect building up an efficiency technology transfer model for IC industries. This study will focus on the skill knowledge communication flow in particular. This study utilizes an intra-firm technology transfer for case study and is based on firm's technology transfer from an existing wafer-fab (***sending site***) to a newly constructed wafer-fab (***receiving site***). The new wafer-fab production technology is 100% come from the mother company. The majority of production technologies and skill knowledge has already been successfully transfer from sending site, but still find out some critical skills was lose in the new fab, and production performance should be improve it. This study will through project management methodology solve those problems of critical skills and low performance. The objective of this study is exploring the correct/excellent technology transfer flow chart build into new technology transfer model.

**Figure 1: Original technology transfer flow chart of IC case firm**

The excellent technology transfer model is considered that can reach a matured IC production technology level, what means the production technology and process should be transferred is already in mass production state at the sending site with high yields and no quality problems. This objective reduces the risk of production and process instability during transfer, which might occur for newly developed products and technologies.

## THEORETICAL BACKGROUND

The importance of knowledge as a strategic resource has recently recognized by several scholars who have proposed a knowledge-based view of the firm (Amit and Schoemaker, 1993; Grant, 1996; Kogut and Zander, 1992; Spender, 1996). This view supplies considerable theoretical support for the assertion that a firm's performance is directly linked to its efforts in competence building and renewal. A detailed review of the related literature was done.

### Knowledge transfer

Knowledge is a tangible or intangible element and how to do knowledge transfer are very critical issues. "The act of knowledge transfer from one individual to another by means of mentoring, training, documentation, and other collaboration" (CSU Monterey Bay, 2008). Grant (1996) asserts knowledge that the role of the firm and its source of unique advantage. Effective sharing of ideas, knowledge, or experience between units of a company or from a company to its customers

(a) Types of knowledge

There are four main types of knowledge defined: Embrained, encultured, embedded and encoded knowledge (Blackler, 1995). It should be mentioned, that these knowledge types can be applied to any organization, not just those that are knowledge-based heavy. All knowledge types which are mentioned are relevant to technology transfer.

(b) Definition of Knowledge Transfer

The act of transferring knowledge is from one individual to another by means of mentoring, training, documentation, and other collaboration. Firm can through knowledge transfer got effective sharing of ideas, knowledge, or experience between units of a firm. Also can from a firm transfer to its customers and strategic alliance firms. The knowledge can be either tangible or intangible event that not only technical knowledge.

**The influence factors of knowledge technology**

Knowledge transfer is considered to be more than just a communication problem. If it were merely that, then a memorandum, an e-mail or a meeting would accomplish the knowledge transfer. It is more complex because knowledge resides in organizational members, equipments, tasks, and their sub-networks. Therefore how to enhance knowledge transfer performance for moving technology or equipment from one factory to another: (1) adopting one more effective transfer approach; (2) accompany by moving the related experts to new factory. People play the most critical role in the success of technology transfer (Argote and Ingram, 2000). Seek out the right transfer approach and people are become a very important factors on transfer process.

Reed and DeFillippi (1990) at the study "Causal Ambiguity, Barriers to Imitation, and Sustainable Competitive Advantage" point out when in the knowledge transfer processing exist a less causal ambiguity concerning of the process that became barriers factors with connections between actions and results. The scholar express the success factor of the knowledge diffusion that knowledge can be codified, it is possible to exploit some of the non-standard commodity features of information including the possibility of non-rivalry in use and the low marginal cost of reproduction (Cohendet and Steinmueller, 2000). These features in principle may reduce the cost of technology transfer. The influence factors of knowledge transfer include intrinsic motivation enables the transfer of tacit knowledge under conditions in which extrinsic motivation (i.e. monetary benefits) fails (Osterloh and Frey, 2000).

**Perspectives on semiconductor firm technology transfer**

The objective of study is focus on semiconductor technology transfer of multinational firm. The following will show related technology transfer information of semiconductor firm. Renwick (1983) on "perspectives on the success/failure experience and the cost of semiconductor technology transfer" point out technology can be classified in 3 categories: (1) Product-embodied technology; (2) Process technology; (3) Management techniques and skills. Possible measure for success of a transfer trend for semiconductor technology is a minimum yield incentive provides a valuable benchmark in completeness of the technology transfer (Barton, 2007).

**Intra-firm technology transfer model**

The Intra-firm technology transfer model considers the case, that a company acquires a factory having the desired technology which should be transferred to the headquarters. The model proposes that for a successful technology transfer to ***receiving site*** (Beruvides and Khalil, 1990). Beruvides and Khalil (1990) propose the following guidelines for setting up a transfer team: (1) the smaller the team, the better; (2) People work best in trust and healthy competition; (3) Building teamwork and motivation are critical; (4) The chain of command and communication channel should be well understood; (5) Success depends on the quality of people performing the task.

## RESEARCH METHODOLOGY

This study utilizes case study method to do research. The case study is diversified consider methodology of doing social science research (Yin, 1994). It is involve an in-depth, longitudinal examination of a single instance or event for a case study. They provide a systematic way of looking at events, collecting data, analyzing information, and reporting the results. As a result the researcher may gain a sharpened understanding of why the instance happened as it did, and what might become important

to look at more extensively in future research (Flyvbjerg, 2006).

This study uses six primary sources of evidence for case study research. The six sources identified are: (1) documentation; (2) archival records; (3) interviews; (4) direct observation; (5) participant observation; (6) physical artifacts (Yin, 1994). The "documentation," "interviews" and "participant observation" by the author will be applied. The interview could take one of several forms: *open-ended*, *focused*, or *structured*. In an open-ended interview, the researcher could ask for the informant's opinion on events or facts. This could serve to corroborate previously gathered data. In a focused interview, the respondent is interviewed for only a short time, and the questions asked could have come from the case study protocol. The structured interview is particularly useful in studies of neighborhoods where a formal survey is required. The use of tape recorders during the interviews is left to the discretion of the parties involved. Participant observation is a unique mode of observation in which the researcher may actually participate in the events being studied. This technique could be used in studies of neighborhoods or organizations, and frequently in anthropological studies. The main concern is the potential bias of the researcher as an active participant. While the information may not be available in any other way, the drawbacks should be carefully considered by the researcher.

To practically perform a case study, the literature suggests following six steps follow as: (1) Determine and define the research questions; (2) Select the cases and determine data gathering and analysis techniques; (3) Prepare to collect the data; (4) Collect data in the field; (5) Evaluate and analyze the data; (6) Prepare the report (Stake, 1995). This study utilizes case study and project management to accomplish this research.

## AN EMPIRICAL CASE STUDY

### Introduction of the case

This study describes a Europe international company internal technology transfer from an existing wafer-fab (***sending site***) to a newly built wafer-fab (***receiving site***). The multi-national company has several manufacturing sites in different countries. The new wafer-fab is 100% owned by the mother company. At the point of time when this technology transfer project was started, several other technologies have already been successfully transferred and are running in mass production mode in the new fab. However, there is continuous demand for transferring more technologies in order to fill up the new fab and to achieve second sourcing for customers. The technology to be transferred is considered as a matured IC-production technology, what means the technology (and product) to be transferred is already in mass production state at the sending site with high yields and no quality problems. This reduces the risk of product and technology instability during the transfer, which might occur for newly developed products and technologies.

### Project organization

*Core Team and Support Team*

The project is led by the project leader, located at the business. The transfer project is organized in three sub-projects:

- Receiving Fab: Team has to pull the technology out of the sending fab and pull the product know-how out of the business unit.
- Sending Fab: Have to actively support the transfer by pushing the technology towards the receiving fab.
- Business unit: Have to actively support by pushing the product know how towards the receiving fab.

Each sub-project has dedicated project leaders. There are monetary incentives related to the project targets defined and agreed with the human resource departments in order to increase the motivation of the project members. The focus is in completing the project as fast as possible.

The business unit is the product owner and has the best competency in product functionality, design, analysis and test. The fab owns the manufacturing process and has the best knowledge about the numerous single processes, manufacturing tools and how to achieve high production yields. Figure 2 shows the schematic of the project organization. Furthermore the project setup distinguishes between "Core Team" and "Support Team". Core Team members directly report to their respective project leader and the transfer project is their daily work. Support Team members remain in their different line organizations. The support team functions are more central functions, like infrastructure, maintenance, failure analysis laboratory, quality and reliability, etc.

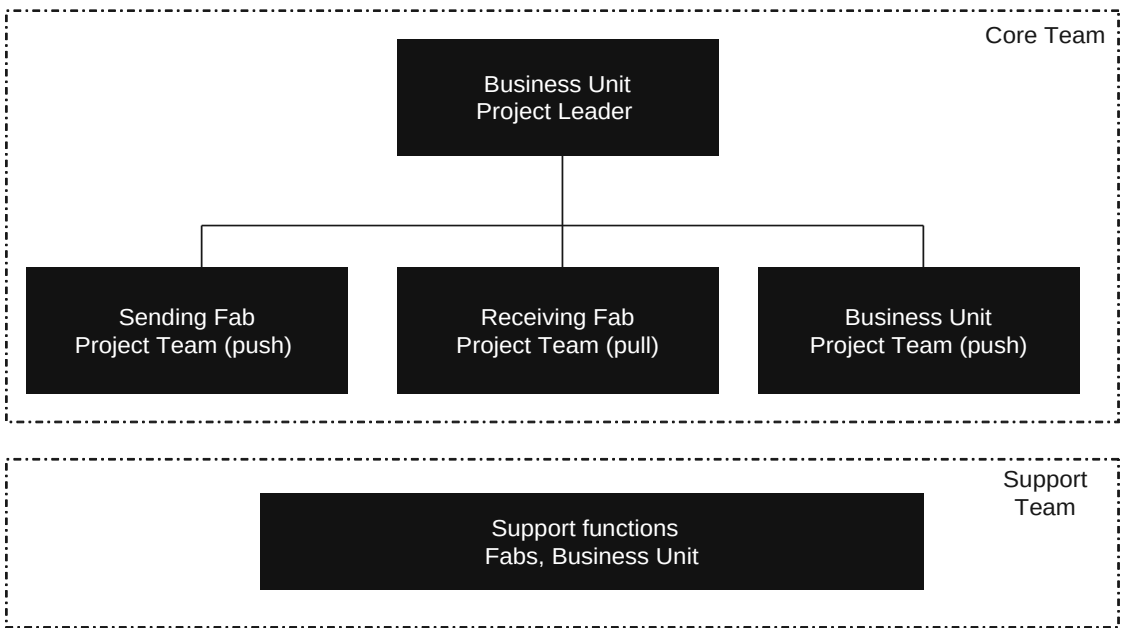


**Figure 2: Project organization**

*Project in respect of the company organization*

The project is embedded in an organization of the multinational company which has many subsidiaries and plants worldwide. Support team functions are more widely spread throughout several parts of the whole company. The transfer project is organized in a matrix organization, which means that different departments and resources throughout the company are assigned to the project. It is necessary to highlight, that the common official boss of the three sub-projects is only at top level in the company organization. The business unit and the sending fab have their common boss at the '*E-division*', whereas the receiving fab belongs to the '*A-division*' of the company. The consequence of this is that escalation in case of e.g. resource conflicts is difficult and takes a long time.

**Communication flow**

Communication flow means the information exchange between all related parties among the project. This paragraph is focusing on the communication in regard of management and administrative

instructions (command and control), not about knowledge exchange which is explained later in this chapter. Figure 3 below describes the following types of information:

- "*Project Management*" (doted lines): Instructions and requests regarding time schedule, targets, and priorities and funding.
- "*Technical*" (solid lines): Instructions and requests regarding how to technically implement the technology in regard of product and process.
- "*Level of control*" (line thickness): The strength of the relation or bond between the related communication partners.

Besides direct and immediate information exchange (phone calls, emails) between the involved parties, several meetings are setup for a structured way of communication:

- Receiving Fab, daily: Internal morning meeting. Discussion of technical achievements and problems of the last day. Early feedback to the local project leader in case of problems which might affect the project targets. Escalation in case of resource conflicts.
- Receiving Fab, weekly. Wrap up of the achievements of the past week. Verification of 'actual' vs. 'plan'. Summary for reporting to the local management of the receiving fab and to the project leader.
- Weekly phone conference with the product experts of business unit: In depth discussion of problems related to product and process. Definition of improvement actions .Update on project progress.
- Workshops and business trips, irregular: Update to top-management. Know how exchange.

The communication of the project leader to the three sub-project leaders is mostly related to project management. Naturally the strongest control of the project leader is regarding to the project team in the business unit (the team directly reports to him). The level of control over the sending fab and receiving Fab is only medium. Technical information (product, process) exchange takes mostly part only between the receiving fab and the sending fab and between the receiving fab and the project team at the business unit. Due to the weekly phone conference, the bond between the receiving fab and the project team at the business unit is medium strong. The weakest bond or level of control is between the two fabs. There is no regular meeting between them.

Regarding this project, there is nearly no communication between the product experts in the business unit and the process experts in the sending fab, which is also not necessary. Therefore there is no connection drawn in the diagram.

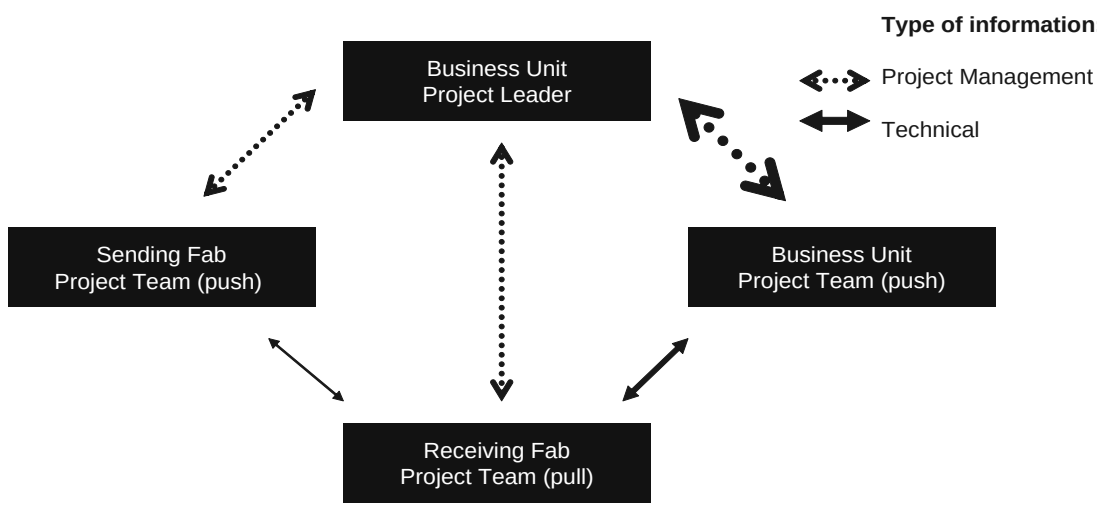


**Figure 3: Communication flow**

**Analysis of the project setup in respect of the communication flow**

As seen in the case study before the following elements are from importance in order to understand the results. Case study framework follows as: (1) Project organization; (2) Communication flow; (3) Flow of people; (4) Flow of technology; (5) Flow of material; (6) Flow of funds.

*Communication flow*

According to the project preparation workshop, the communication flow between the project leader and receiving site has several problems. Several specific problems are highlighting due to bad communication. The project setup goes above continents: This brings several difficulties along. Because of the long distance, the control of the project leader is limited. The progress of the project can not be monitored so closely and the local project manager at the receiving fab is sometimes bypassing the project leader and communicating directly with the project manager at the sending fab. This would be correct in case of purely technical discussion, but not for steering the project.

The ability of the project leader to control the different subprojects is dependent on several factors. The only factor which can be changed by the project leader immediately is "Place", meaning the location of his own office. Other factors like the corporate organization are given and can not be changed easily. Table 1 (at *sending site*) and Table 2 (at *receiving site*) below are summarizing the level of control of the project leader dependent on his location.

**Table 1: Level of control of project leader located at the business unit and sending fab**

| Current | Business Unit | Sending Site | Receiving Site |
|---|---|---|---|
| Place difference | Same | Close | Very far |
| Time difference | Same | Same | 6h shift |
| Organizational relation | Line | Assigned to project | Assigned to project |
| Culture and Language | Same | Same | Different |
| Level of control | Very Strong | Strong | Weak |

This means, that the most important and crucial relationship between project leader and the subproject leader in the receiving fab is weak. In order to increase the level of control of the project leader about the local project leader at the receiving fab, it is proposed to relocate the over all project leader to receiving fab as shown in Figure 4 below. This will somehow change the whole configuration of communication flow. The project leader and the receiving fab are now located together in the center with virtually no boundaries.

Table 2 is showing the resulting levels of control due to the relocation of the project leader. It is assumed, that he agrees on the relocation and that is personally able do deal and accept the local living and working conditions.

By that move it is assumed, that the project leader will not loose control of the Business Unit, because they are still in the same line organization. Besides that the same culture and language will also strengthen their ties. The control over the sending fab might be a bit weakened, but is still considered as strong, because of the same culture and language background and the fact that the local project leader at the business unit could act "on behalf of" the project leader to control the sending fab.

Despite the different culture, language and line organization, the project leader could have strong control over the local project manager at the receiving fab. Just due to the fact to be on-site and "visible", the level of control will be increased strongly.

**Figure 4: Improved communication flow**

**Table 2: Level of control of project leader located at receiving fab**

| Proposed | Business Unit | Sending Site | Receiving Site |
|---|---|---|---|
| Place difference | Very far | Very far | Same |
| Time difference | 6h shift | 6h shift | Same |
| Organizational relation | Line | Assigned to project | Assigned to project |
| Culture and Language | Same | Same | Different |
| Level of control | Very Strong | Strong | Strong |

## CONCLUSIONS AND SUGGESTIONS

In current, due to the technological progress in IC-manufacturing, the market continues to increase in demand of about 8-10% per year. Technology transfer of the highly sophisticated manufacturing process comes into play, if for example like in this case the established technology should be used in another manufacturing site.

*Technology transfer needs to be done.*

Technology transfer is closely related to knowledge transfer. It's a time limited transaction and treated as a project. A structured and organized procedure with dedicated teams at the sending and receiving site is necessary. Technical execution wise the "copy smart" methodology is applied in this study. The case study methodology is a widely accepted research method and the data were gathered by participant observation by the author. The technology transfer in this case was organized in a project with 3 sub-projects: *Business Unit*, *sending fab* and *receiving fab*. The project leader is located in the business unit at the sending fab. The flow of communication, people, technology, material and funds was analyzed in detail.

For future transfers to come, the proposal is to relocate the project leader from the business unit (BU) at the sending fab to the receiving fab. This could help to get better control of the project and therefore be more focused in achieving all targets. Figure 5 is showing a comparison of the original (current) and the proposed communication flow.

**Figure 5: Communication flow compare "current" vs. "proposed"**

The simplification is resulting in basically only three communication parties where originally four parties were separated. To get a clear answer whether or not the proposed flow is resulting in a better communication, further case studies on an intra-firm technology transfer project with there party communication should be performed. In addition to the project setup, which was analyzed in the case study, another point which needs more research is the cultural difference between sending and receiving sites.

## REFERENCES


Amit, R. and Schoemaker, P.J.H. (1993). Strategic assets and organizational rent, *Strategic Management Journal* 14(1): 33-46.

Argote, L. and Ingram, P. (2000).'Knowledge transfer A Basis for Competitive Advantage in Firms.' Organizational Behavior and Human Decision Processes 82(1): 150-169.

Barton, J.H., (2007). 'New Trends in Technology Transfer. Implications for National and International Policy,' Stanford Law School Press.

Beruvides, M.G. and Khalil, T. M. (1990). 'Intra-Firm Technology Transfer: A Model and Case Study', Management of Technology II: 195-204.

Blackler, F. (1995) 'Knowledge, Knowledge Work and Organizations: An Overview and Interpretation,' Organization Studies 4(6): 1021-1046.

Cohendet, P. and Steinmueller, W. E. (2000). 'The Codification of Knowledge: A Conceptual and Empirical Exploration', *Industrial and Corporate Change* 9(2): 195-209.

Flyvbjerg, B.(2006). 'Five misunderstandings about case study research,' Qualitative Inquiry 12(2): 219-245.

Grant, R.M. (1996). Towards a knowledge-based theory of the firm, *Strategic Management Journal* 17: 109-122.

Kogut, B. and Zander, U. (1992). Knowledge of the firm, combinative capabilities and the replication of technology, Organization Science 3(3): 383-397.

Malik, K. (2003). 'Distributed capabilities: intra-firm technology transfer inside BICC cables', Int. J. Manufacturing Technology and Management 5(4): 311-323.

Osterloh, M. and Frey, B. S. (2000). Motivation, Knowledge Transfer, and Organizational Forms', *Organization Science* 11(5): 538-550.

Reed, R. and DeFillippi, R. (1990). 'Causal Ambiguity, Barriers to Imitation, and Sustainable Competitive Advantage', *The Academy of Management Review* 15(1): 88-102.

Renwick, D.K. (1983). 'Perspectives on the success/failure experience and the cost of semiconductor technology transfer', International Journal of Technology Transfer 8(1): 35-46.

Stake, R.E. (1995). The art of case study research, Thousand Oaks, CA: Sage.

Spender J. C. (1996). Making knowledge the basis of a dynamic theory of the firm, *Strategic Management Journal* 17 special winter issue: 45-62.

Urata, S. (2006). 'International Intra-firm Transfer of Management Technology by Japanese Multinational Corporations', RIETI Discussion Paper Series 06-E-006.

Yin, R. (1994). Case study research: design and methods (2nd ed.), Thousand Oaks, CA: Sage Publishing.

CSU Monterey Bay, Data Warehouse Glossary. 'Knowledge Transfer', 2008. http://it.csumb.edu/site/x7101.xml

Deardorff's Glossary of International Economics. 'Technology transfer', 2001. http://www-personal.umich.edu/~alandear/glossary/t.html