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Effective International Technology Transfers

by

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Faculty Comments

This paper explores how "successful" international technology transfer can be achieved. Hypotheses are developed based on a review of the previous literature, and these are used to guide a detailed case analysis of the technology transfer practices of a Japanese automotive company operating in the US. The scope of the findings is limited by the single-firm focus and the lack of significant variation in the performance of individual technology transfer efforts within the firm. Nonetheless, Finbarr has done excellent and diligent work gaining access to participants in the international technology transfer process in different areas of the company, and as a result, the paper offers several useful insights into the knowledge management and conversion processes necessary for successful technology transfer.

Oxley

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Introduction

This study seeks to identify the key elements and processes for effective international technology transfers by using the case study method. The research builds upon extant literature pertinent to international technology transfer and uses this literature to design several hypotheses dealing with effective international technology transfers.

The hypotheses in this study form the basis for structured interviews (Appendix A) and were designed to gather information on international technology transfers from several key participants involved in the different areas of international technology transfers, including research and development, technology implementation, and technology management. Analysis of the data from the interviews seeks to provide the primary validation of these hypotheses.

The context chosen for this study was the international automotive industry, specifically the Japanese transplants in the United States. That is, those firms based in Japan with an overseas presence in the United States. This context was chosen for several reasons. First, the successful expansion of the Japanese automotive manufacturers in the United States and the transfer of technology from Japan to the United States during the 1980's and the 1990's provides a valuable pool of research candidates. Several of the automotive manufacturers' operations have evolved to include research and development facilities in the United States. Second, the emergence of the Japanese transplants as a major industry and technology force in the United States automotive industry makes them a very attractive group of research candidates. Third, the ongoing localization efforts of the Japanese automotive transplants in the United States allow us to

examine ongoing current international technology transfers. Fourth, by restricting our study to the Japanese transplants in the United States, we minimize the variations that might arise as a result of international and cultural differences.

Literature Review and Research Hypotheses

The following discussion serves two purposes. The first of these is the identification of the key elements of international technology transfers that are common to much of the current literature on technology transfers and international technology transfers. The second purpose is the introduction of the research hypotheses which form the basis of the questionnaire.

International Technology Transfers

Before proceeding onto the key elements of international technology transfers, it is necessary to identify a definition of international technology transfers as it applies in the context of this study.

International technology transfers have been studied by authors in many different ways, each depending on the individual perspective of the author. Despite these different perspectives, nearly all authors agree that what is meant by international technology transfers is difficult to define. Authors appear to unite in the belief that international technology transfers entail some form of knowledge flow (including product or process knowledge) across national boundaries. This knowledge flow occurs from the supply side, the transferor, who possesses advanced or proprietary technology to the demand side, the transferee, who desires the technology. Additionally, there must be a productive or economic catalyst for the transfer to occur.

By combining these areas of unity, we can offer a definition of international technology transfers that is appropriate for our study.

Definition An international technology transfer is a flow of information from the transferor in one country to the transferee in another country. (The transferor and the transferee may be entities of the same firm). The information can be used or implemented to improve the economic or productive position of the transferee.

Using current literature we can define the three key elements (fig 1) of international technology transfers:

1 Participants

2. Technology

3. Methods / modes of transfer

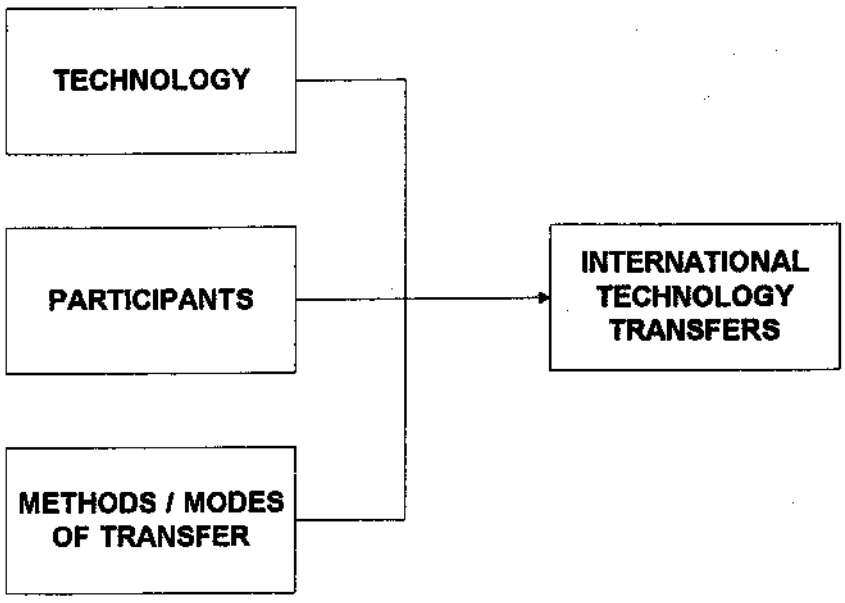

Figure 1: Key Elements of International Technology Transfers

1. **Participants**

The second key element that emerges from current literature (fig 1) is that which analyzes the participants in international technology transfers. In all international technology transfers, there are two central participants. The first of these is the supply side or the transferor which possesses the technology. The second is the demand side or the transferee which is interested in acquiring the technology. Regardless of the mode or context of the international technology transfer, these two participants play the central roles in, and are subsequently directly affected by, the international technology transfer.

As international technology transfers increase in complexity, other parties participate to play facilitating or supporting roles. A full analysis of all participants is beyond the scope of this study. Therefore we will concentrate only on the transferor and transferee in international technology transfers.

1.1 **Experiences and Expertise** of **the Participants**

In an international technology transfer, although both the transferor and transferee share the same goal, each can have, by virtue of their own individual expertise and experiences, a unique impact on the effectiveness of the international technology transfer.

1.1.1 The Transferor

In any technology transfer the transferor's goal is the effective introduction and transfer of technology to the transferee. The different factors which can have an influence on the outcome

of the international technology transfer have been documented on the side of the transferor (Robinson, 1988). Considering the focus of our study, two of these factors stand out as the most significant potential determinants of the effectiveness of an international technical transfer. These are, firstly, the transferor's expertise in the technology being transferred and, secondly, the transferor's prior experiences of international technology transfers.

Given that that the technology is in a transfer-ready state, we can assume that the transferor has already developed an expertise in the technology which is at least superior to the transferee's expertise. The remaining influencing factor yields:

Hypothesis 1: The effectiveness of the international technology transfer is dependent on the transferor's prior experience in conducting or participating in international technology transfers.

1.1.2 The Transferee

As a participant in an international technology transfer, the transferee's goal is the effective transfer and implementation of the new technology. Just as the factors on the side of the transferor have been documented, so too have those on the side of the transferee (Robinson, 1988). Considering the focus of our study and the goal of the transferee, the factor with the greatest potential to affect the success of the international technology transfer is the transferee's prior experience with technology, specifically technology which is similar or identical to that which will be transferred (Cusumano & Elenkov, 1993). Thus we have:

Hypothesis 2: The effectiveness of the international technology transfer is dependent on the transferee's prior experience with identical or similar technology.

1.2 Organizational and Operational Similarities Of Participants

In an international technology transfer, the participants share the common goal of a successful transfer of technology from transferor to transferee. Technology transfer literature points out that this common goal cannot be realized unless there is a concerted and collaborative effort between the transferor and the transferee (Seurat, 1979). From our own experiences and from current literature we can deduce that such a collaborative effort tends to be more effective if the collaborating parties share not only the same goals but also the same operating philosophies and styles (Cusumano & Elenkov, 1993; Robinson 1988, Zander in Cusumano & Elenkov, 1993).

Similarities between organizations may have a significant influence in partner selection for international technology transfers (Robinson, 1988). For the participants in an international technology transfer, this yields:

Hypothesis 3: The effectiveness of the international technology transfer is dependent on the similarity of the transferor's and the transferee's organizational and operational styles.

2. Technology

Derived from the Greek word "techne" which means an art or skill, the term "technology" has

been given a wide variety of meanings, many of which have been fashioned by authors to be analysis- specific. Many authors describe it according to a sets of characteristics, or dimensions of technology. One such example is Robinson's thirteen dimensions of technology: maturity, dynamism, relative importance, environmental specificity, factor substitutability, scale specificity, availability, complexity, centrality, production continuity, susceptibility to reverse engineering, process/product, and firm specificity (Robinson, 1988). Another example is the use of the different classifications of technology including "core" and "peripheral", "bundled" and "unbundled", "embodied" and "unembodied" technologies (Robinson, 1988).

2.1 Technology as Knowledge

For the purpose of this study we need to consider technology as comprising two different types of know-how or knowledge. The first of these is explicit or codified knowledge which can be articulated in formal language and impersonal media and includes specifications, manuals, and blueprints (Nonaka and Takeuchi, 1995). The second is tacit knowledge which, because of its ambiguities, is difficult to articulate with formal language and may be difficult to transfer. Tacit knowledge includes personal knowledge embedded in individual experience or "know-how" and involves intangible factors including involvement, demonstration, and personal interaction (Nonaka and Takeuchi, 1995). We can visualize these two types of knowledge by adapting an existing technology package model (fig 2 - Brooke in Robinson, 1988) to include explicit and tacit technology (fig 2).

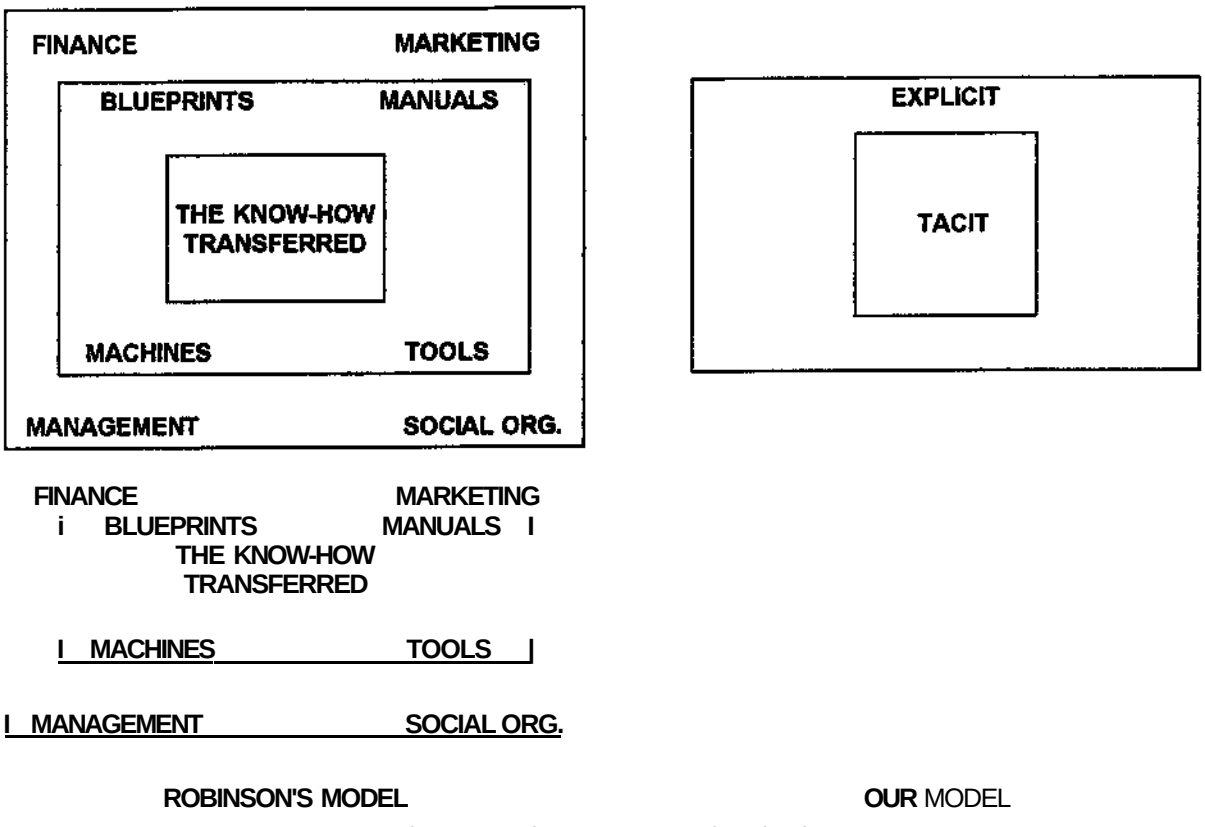

Figure 2: The Two Forms of Technology

Many researchers have viewed tacit and codified technology as a dichotomy - for example in Robinson's identification of "hard", or "embodied", technology and "soft", or "disembodied" technology as two separate elements of the technology package. In more recent literature there appears to be a departure from this belief in the exclusivity of explicit and tacit technology. For example, Nonaka and Takeuchi recognize and study the continuous overlap and interaction between the explicit and tacit technology and conclude that independence of the two is difficult if not impossible.

There is significant previous evidence that the more codified the technology or the knowledge is, the more easily or more economically it can be transferred (Teece, 1979). Thus we have:

Hypothesis 4: The effectiveness of the technology transfer is dependent on the conversion of tacit knowledge to explicit knowledge prior to the transfer.

2.2 Maturity of Technology

Current literature makes reference to another area of international technology transfers which can have significant influence on the effectiveness of international technology transfers, technology maturity.

Technology maturity refers to how long the technology has been in existence. As the maturity of the technology increases, the learning associated with it becomes more accessible and more widely available as, for example, when labor skills associated with the technology become more widely known (Robinson, 1988).

Thus, technology maturity increases the probability that the transferee has previously established and developed the necessary capabilities for the international technology transfer. For the transferor, it can mean greater ease in sharing existing technological capabilities with the transferee.

In conclusion, we can extract the following hypothesis:

Hypothesis 5: The effectiveness of the technology transfer is directly proportional to the maturity of the technology being transferred, ceteris paribus.

3. Methods / Modes of Transfer

The third element of international technology transfers is the method or mode used to transfer the

technology from the transferor to the transferee. Much of current literature is devoted to the study of the different methods and modes of technology transfers. This study will not explore the different methods and modes of international technology transfers.

4. Effectiveness of International Technology Transfers

As mentioned earlier, this study seeks to identify the key elements and processes for effective international technology transfers. In order to do so, a measure of effectiveness must be selected.

Current literature identifies three different types of measures:

1. **Financial Measures.** These quantitative measures focus on the financial aspects of the international technology transfer. One such example is Transfer Cost (Robinson, 1988) which considers both the cost of the technology and the price paid by the transferee for the technology. Quantitative measures are universal in application and relatively easy to establish. However, for international comparisons they are flawed in that they are closely linked to exchange rates which may distort comparisons. Also, financial measures require information which is typically sensitive and confidential.
2. Operational Measures. Typically quantitative, these measures focus on the areas directly related to the implementation and application of the technology. Examples include production efficiencies (Robinson, 1988) and productivity resulting from improvements to technology (Cusumano & Elenkov, 1993). Operations measures are easy to establish and are

particularly appropriate for comparison of manufacturing firms. The use of operations measures requires access to confidential data and information.

3. **Organizational Measures.** Typically qualitative, these measures focus on organizational issues related to international technology transfers. Typical measures include the development of indigenous capabilities to support international technology transfers (Cusumano & Elenkov, 1993), ability to manage technology, organizational learning required for and resulting from international technology transfers (Robinson, 1988), and the impact of international technology transfers on organizational cultures (Robinson, 1988). These measures can show the overall effect of international technology transfers on firms but, as a result of their qualitative nature can be difficult to establish. Also, it can be difficult to isolate those effects that can be solely attributed to international technology transfers.

Of the different specific measures of effectiveness available, the one selected for this study was the "SOP Measure" which is defined as:

Definition The completion date of the international technology transfer and the Start of Production (SOP) relative to the planned SOP date.

Data Collection

A comprehensive analysis of all Japanese automotive transplant firms is beyond the scope of this study. Therefore, the most suitable research subject was chosen from the different candidate firms. Of the different Japanese automotive transplant firms, several, especially those with

extensive production and research operations in the United States, were attractive research subjects. However, only one of these offered a combination of previous and ongoing experience in international technology transfers and, more importantly, a willingness to discuss these experiences. In exchange for data collection opportunities, the research subject was assured of anonymity and confidentiality.

Research data for this study was collected from different areas and levels throughout the transferor and transferee firms. These included executive and project levels in the different functional areas of both firms, both in the United States and in Japan. In addition to offering multiple perspectives of international technology transfers, the multiple data collection points facilitated data validation.

The SOP Measure

The SOP measure was used for several reasons. The most significant of these was the issue of confidentiality. As previously mentioned, the research subject requested that all proprietary information and data be treated as confidential. This request excluded the use of use of much of the data typically used in measuring effectiveness, such as financial and production results.

The SOP measure allows us to maintain the confidentiality requested by the research subject. Additionally, given the context of our study, it as an appropriate and easy-to-establish measure of effectiveness.

By being limited to the SOP measure our analysis does have certain limitations. We are prevented from using standard financial measures which are used to objectively measure and compare effectiveness. Also, the SOP measure focuses only on the initial stages of the international technology transfer (defined by Robinson as the "acquisition and assimilation" stages and by Cusumano and Elenkov as the "acquisition and adaptation" stages of international technology transfer). By omitting the later stages we exclude such valuable measures as improvement to the technology (Cusumano & Elenkov, 1993) .

Recognizing the limitations of the SOP measure, the analysis is supplemented with qualitative assessments of effectiveness by the transferor and the transferee. These assessments are based on the interviews held with both of the participants.

Technology Transfer History Between Transferor and Transferee

The history of international technology transfers between the transferor and transferee extends back to the early 1980's when a manufacturing plant was established in North America (fig 3). Since that time, a series of international technology transfers has taken place between the two organizations. All of these have involved the transfer of technology from Japan to the United States. All were planned for specific Start of Production (SOP) dates.

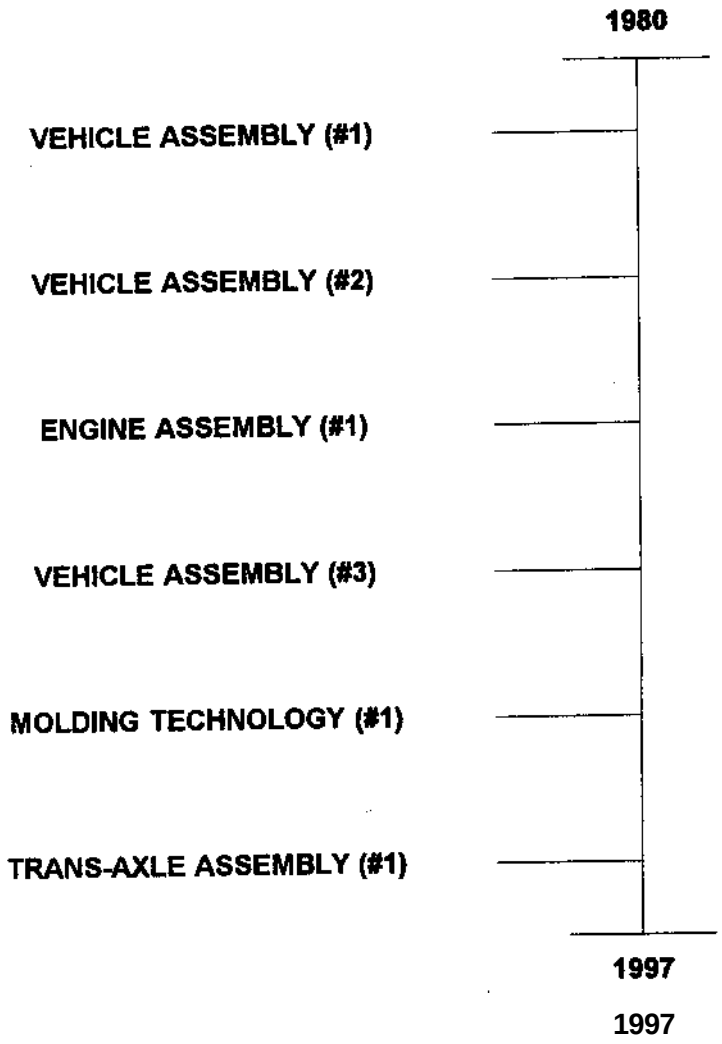

Figure 3: History of International Technology Transfers

The first international technology transfer between the transferor and the transferee was an assembly line for a passenger vehicle. The technology had been in use in Japan for several years. The finished vehicle included limited finished product variations and a relatively small number of components. Considering the transfer options available to the transferor at this time, the technology transferred was considered relatively simple. Production commenced two weeks in advance of the target date. (Information regarding the total time allowed for production preparation was not available.)

Two years later, another vehicle assembly technology transfer took place between the two parties.

This time the vehicle represented a less modular assembly, more finished product variations, more assembly components, and, overall, a more complex assembly process. The technology used in the assembly process was newer and more advanced than that in the previous technology transfer. Start of production was achieved on schedule.

The next international technology transfer, one year later, represented a departure from vehicle to engine assembly. The assembled engine would be used by both the transferee and a domestic (United States based) vehicle manufacturer. As a result, the transferor had to consider the specifications of both internal and external customers. The engine launch was successfully completed on schedule.

Following the engine technology transfer, the transferor and transferee once again participated in the transfer of another vehicle assembly line from Japan to the United States. This transfer included more finished product variations, more assembly components, and a more complex assembly process which used more advanced technology than previously transferred. The vehicle launch was completed on schedule.

The next group of technology transfers concentrated on the transfer of molding technology. As a result of different transfers of molding technology, the transferee now manufactures critical injection-molded components in-house. Each of these projects achieved SOP in advance of the targets set by the participants.

The current international technology transfer deals with the technology for trans-axle manufacturing and assembly. In Japan, the transferor attributes its product's global success and appeal to many factors, of which superior trans-axle is amongst the most important. The transferee is cognizant of the importance of the current transfer and the role it will play in the development of the transferee as an independent entity. Internally, it is recognized as the "final frontier". At the time of interview, the transfer was on schedule for completion by the planned SOP date.

Upon review of the results of the international technology transfers, we can see that only two results were discussed by the representatives - "early **SOP"** and **"SOP** on schedule". Due to the lack of variation in these results, we cannot consider different degrees of achieving the Start of Production on target. Therefore, we must conclude that achieving an early SOP is significantly better than reaching SOP.

Technical Centers

For each of these transfers most of the activity has been between the transferor's and the transferee's manufacturing locations with some support from each participant's technical center.

The primary goal of each of the technical centers is to conduct product research and development. The technical center in Japan also researches new production technologies and evaluates these technologies for future use. Although the technical center in the United States does not perform this function, some transfer of production-related technology takes place. This

information is usually relayed back to Japan in an informal manner by visiting engineers from the Japanese technical center.

As previously mentioned, both technical centers support technology transfers from Japan to the United States. In the case of the Japanese technical center, this support covers all aspects of the transfer including the codification of information, training, and transfer planning. Its United States counterpart has in recent years adopted a more active role in the technology transfers but its participation remains at best minimal.

Japan Launch Assistance Team (JLAT)

For all international technology transfers the transferor assembles a "Japan Launch Assistance Team (JLAT)" (fig 4). This team has two main responsibilities. The first of these is to plan the technology transfer. The team interacts with various contact points throughout the transferee firm to determine the needs of the transferee and to communicate the plan for the technology transfer. The second responsibility of the JLAT is to ensure that the technology transfer is adequately supported by the transferor firm. To do this, the JLAT draws its members from all of the relevant functional areas of its own organization. These members coordinate and monitor activities in each of their areas to ensure a smooth international technology transfer.

On the transferee side, the JLAT interacts with several technology transfer teams. Each of these teams represents a functional area within the transferee organization which is involved in or will be affected by the international technology transfer. All of these teams report to a central cross-

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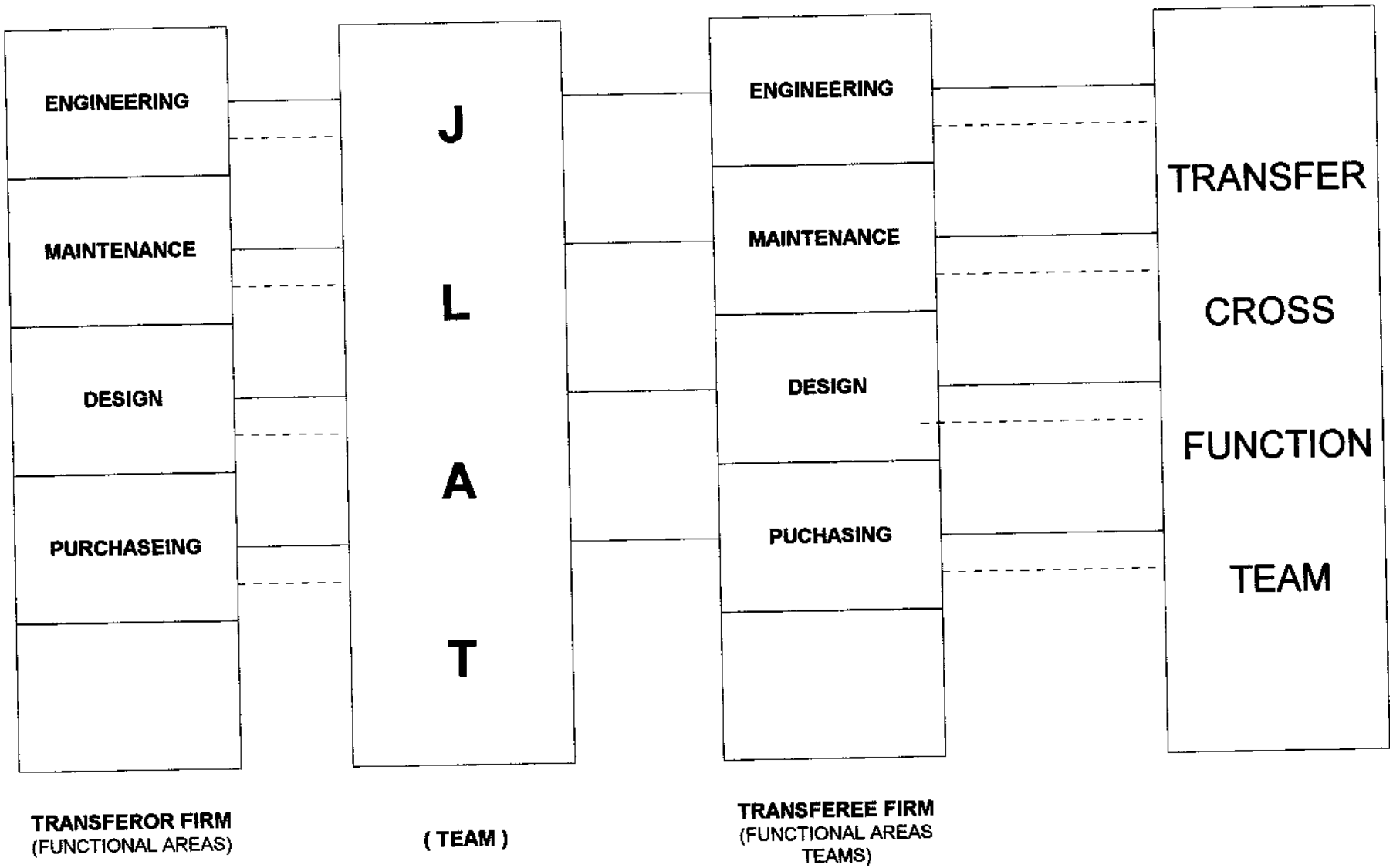

INTERACTION
MEMBERSHIP

Figure 4: Japan Launch Assistance Team (JLAT)

functional team. This team directs and monitors the progress of the international technology transfer on the transferee side of the transfer.

For the initial technology transfers the relevant areas for inter-firm training were selected by the JLAT members. The training programs were conducted at the transferee's location and lasted for three to six months. Additional training and support was provided by the JLAT members who were frequently assigned to the transferee firm for periods up to one year.

For the more recent international technology transfers, the transferee has participated more actively in the selection of the areas for training. The training programs now take place at both participants' locations and are noticeably shorter in duration. JLAT members travel less frequently to the United States and stay for shorter durations.

Transferor and the transferee representatives interviewed acknowledged that JLAT activities, especially the joint JLAT activities in more recent years, have contributed greatly to each organization being able to overcome the fears associated with international technology transfers. On the transferee side, the JLAT has helped the transferee organization to study Japanese technology and to overcome their fear of unknown technology and the NIH (Not-Invented-Here) syndrome. On the transferor side, the JLAT has involved the different departments of the Japanese organization in international technology transfer activities and has fostered a cooperative spirit throughout the transferor organization, This has become increasingly important in recent years as localization activities have increased between the United States and

Japan.

The Transferee's Experience with Similar or Identical Technology

For the purpose of evaluating the hypothesis which addresses the transferee's prior experience with similar or identical technology, we focused our attention on the technology transferred to the transferee's manufacturing plant. These technologies can be divided into two different categories (fig 5). The first of these is "groundbreaking" or new technology. Examples of this type include the initial transfer of vehicle assembly technology and the more recent transfer of engine technology. The second type is "development" technology. Development technology is more advanced than, but uses technology similar to, existing technology. Examples include the second transfer of vehicle assembly technology.

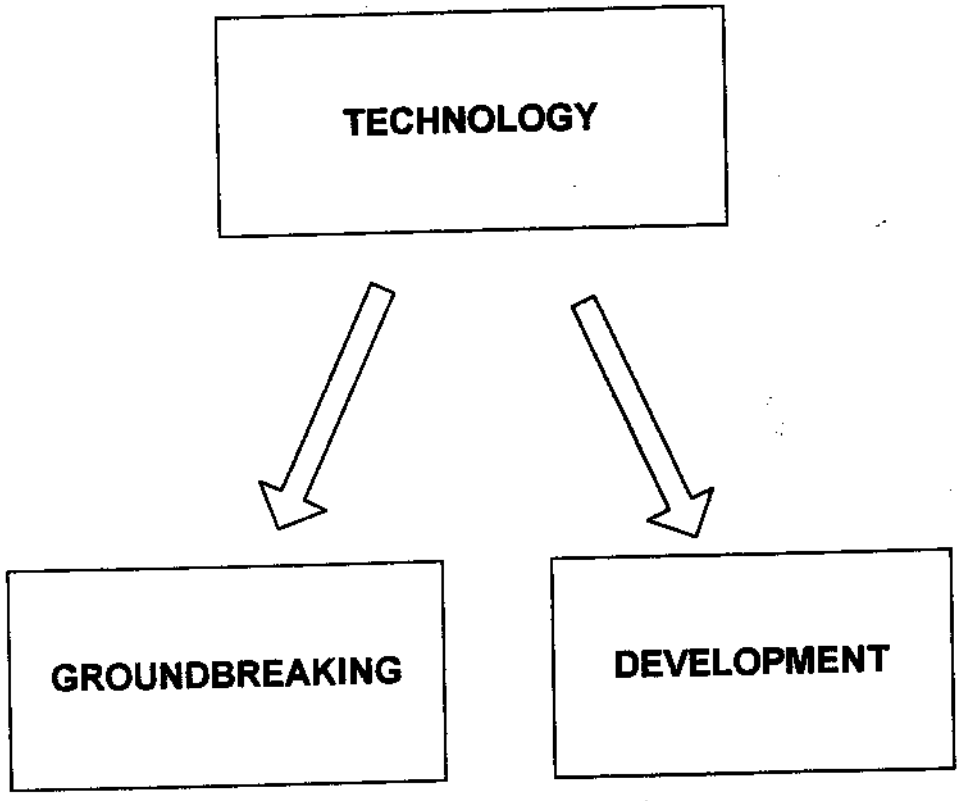

Figure 5: Technology Categories

In order to evaluate the dependence of the effectiveness of the international technology transfer on the transferee's prior experience with similar or identical technology, we should examine the category that each transfer falls into and the outcome of the transfer relative to the SOP measure of effectiveness (fig 6).

Of the results, the most surprising is that, although the initial or groundbreaking vehicle assembly launch (vehicle assembly (#1)) was completed in advance of the SOP target, all subsequent development vehicle assembly launches (vehicle assembly (#2) and (#3)) failed to follow its example. All other groundbreaking technology transfers were completed in advance of the designated SOP target.

Over the past fifteen years, as the transferee has progressed from the international transfer of groundbreaking technology to that of development technology (for example, vehicle assembly), there has been a decline in transferor participation. As a result, the transferee assumes more responsibilities and progresses up a steeper learning curve than would normally be experienced if the transferor maintained the same level of participation in development technology transfers as in groundbreaking technology transfers. One of the most frequently cited effects of this phenomenon of transferee development was that, in some cases, the transferee learns by making mistakes. Subsequently, interim dates are sometimes missed and eventually, SOP targets are not met.

Further data collection yielded speculative information from both the transferor and transferee

TRANSFER	CATEGORY	SUCCESS MEASURE	RESULT
VEHICLE ASSEMBLY (#1)	GROUND BREAKUP	SOP TARGET	EARLY SOP
VEHICLE ASSEMBLY (#2)	DEVELOPMENT	SOP TARGET	SOP ON SCHEDULE
ENGINE ASSEMBLY (#1)	GROUND BREAKUP	SOP TARGET	SOP ON SCHEDULE
VEHICLE ASSEMBLY (#3)	DEVELOPMENT	SOP TARGET	SOP ON SCHEDULE
MOLDING TECHNOLOGY (#1)	GROUND BREAKUP	SOP TARGET	EARLY SOP
TRANS-AXLE ASSEMBLY (#1)	GROUND BREAKUP	SOP TARGET	IN PROGRESS

Figure 6: International Trechnology Transfer Evaluations

regarding a "steady" rate of transferor participation in international technology transfers. Both parties felt that if the transferor had maintained the same level of participation in the transfer of development technology as had been established during the groundbreaking technology transfers, the SOP dates would have been in advance of the SOP targets. However, this accomplishment would have cost both parties the opportunity to develop the transferee's international technology transfer capabilities. Both parties felt that the independence and improved capabilities of the transferee warranted the price of not surpassing SOP records.

We conclude therefore that the effectiveness of the technology transfer is dependent both on the transferee's prior experience with identical or similar technology and the transferor's support to the transferee during the international technology transfer.

The Transferor's Experience in Technology Transfers

All centers and levels of data collection concurred that, without the transferor's prior experiences in technology transfers, each of the international technology transfers would not have been completed either on schedule, or ahead of schedule. This experience has affected the transferor and how it conducts international technology transfers in many ways.

One of these affects is the use of JLAT's (fig 4) in international technology transfers. Members of JLAT's are frequently used in future JLAT's either as core-team members or as resource members. This involvement ensures that previous experiences and expertise are made available to new JLAT's,

Of the different effects and manifestations of the transferor's prior experience in technology transfers, the most dominant and most frequently noted was the planning activities conducted by the transferor prior to the technology transfer.

During data collection, the transferor explained that it advocates planning for all international technology transfers that it participates in, including those between Japan and the Unites States. The transferor attributes this strong belief in planning to its previous experiences both as a transferor and a transferee of technology. In these previous experiences, the transferor felt that the successes resulted from detailed planning while the failures resulted from lack of, or poor, planning.

Participants in the planning process include both JLAT members and all levels of management from a variety of functional areas including finance, purchasing, engineering, maintenance, manufacturing and quality control. The planning activities typically address all subject and functional areas which contribute to, and are affected by, the international technology transfer. During planning all potential risks and outcomes are considered and evaluated so that by the time the transfer is ready to proceed, risks to the project have been addressed and minimized.

Originally, the planning activities were conducted in Japan by the transferor with little or no input from the United States based transferee. As the number and frequency of technical transfers between the transferor and transferee increased, the transferee was invited to participate

in the planning activities.

Planning for the current trans-axle technology transfer was conducted by a joint planning team with 60% of the membership drawn from the transferor's organization and the remaining 40% drawn from the transferee's organization. Both the transferor and transferee believe that increased participation by the transferee in the planning of international technology transfers will prove invaluable in the development of the transferee's capabilities to participate in international technology transfers. It is hoped that eventually the transferee can conduct its own international technology transfers to pass its technology on to other organizations.

In conclusion, the effectiveness of an international technology transfer is dependent on the transferor's previous experience in conducting or participating in international technology transfers. As the transferee gains more and more experience with international technology transfers, the transferee's experience can also contribute to the effectiveness of the international technology transfer.

Organizational and Operational Similarities Of Participants

Like most of the Japanese automotive manufacturers, organizational and operational similarities exist between the Japanese parent organization (the transferor) and the United States based manufacturer (the transferee). These similarities were established when the Japanese parent established the United States operation in the early 1980's and at the same time transplanted much of their organizational and operational styles and practices including the use of cross-

functional teams, cross-functional training of employees, and project planning, review, and approval processes. From an external perspective much of these similarities still exist today. However, during data collection, it became apparent that as the transferee organization became more autonomous, the operational and organizational styles which were transplanted to the United States also evolved. What remains today in the United States organization is a stripped-down version of the transferor's operational and organizational philosophies which has been transformed to accommodate the transferee's national and organizational culture.

A good example of this evolution is the use of cross-functional teams. For the initial international technology transfers during the early 1980's the transferee adopted verbatim the transferor's teaming philosophies. Each technology transfer team was made up of members from the different functional areas who supplied information and data to the central team. The leader of the central team was typically a member of management who had been sent to the transferee organization to manage the technology transfer. This leader also depended also on the input of the transferor organization and was responsible for all decision making related to the technology transfer. This central decision-making which was heavily influenced by the transferor ensured that the result of the technology transfer was similar if not identical to that which existed in the transferor's organization.

For the more recent technology transfers, this Japanese team leader has been replaced by an American team leader and central decision making has been replaced with decision making at the functional level. The team leader still interacts with the transferor organization, often via the

JLAT, but his function has become less of a leading function and more of one of empowerment. As a result, decision making for the more recent technology transfers has become more autonomous and tends to recognize the unique national and organizational cultures of the transferee.

Over the years, the transferor organization has not sought to preserve the similarities between its own organization and that of the transferee. Instead it has facilitated the evolution of the transferee as an independent organization. Since the late 1980's the transferor has reduced its influence by encouraging the paiticipation of the transferee organization in JLAT's and at the same time reducing the number of Japanese staff members sent on overseas assignment to the transferee organization and the duration of their stays in the United States.

Although the results of the international technology transfer differ only slightly from the technology which existed prior to the transfer, the different approach adopted by the transferee assures the continuing evolution of the transferee as an independent, unique organization.

Therefore, we can conclude that similarities between the transferor's and the transferee's organizational and operational styles can impact the effectiveness of international technology transfers. Over time these similarities may diverge but as long as the basic principles remain the same or both firms are aware of or participate in the changes, the effectiveness of future international technology transfers will not be jeopardized.

(..

(Note: Although representatives from the transferor organization felt that the transferor organization could learn by studying the evolution of the transferee's organizational and operational styles, they also admitted that there are no plans to do so.)

Knowledge Conversion Prior To The Transfer

Understanding of the critical role of effective information and knowledge transfer was apparent at all levels of the transferee and the transferor firms. This understanding was strengthened by the relationship between the technology transfer parties and the mutual understanding that the knowledge being transferred had been developed in-house by the transferor and as such, was proprietary and central to the future successes of the transferor and the transferee.

In the early stages of the international technology transfer, both the transferor and transferee participate in a knowledge conversion and transfer process. This process addresses the geographical separation and the differences in languages, time zones, and ways of thinking of the transferor and transferee and seeks to establish a foundation for effective international technology transfer. The process (fig 7) follows certain well established and proven steps which mirror those steps (fig 8) identified by Nonaka and Takeuchi in their 'knowledge spiral' (Nonaka and Takeuchi, 1995).

This process has been used by the transferor for all international technology transfers. In some cases it has been used by the transferee when it transfers technology to its suppliers in the United States. This process is recognized as one of the key contributing factors to the efficiency and

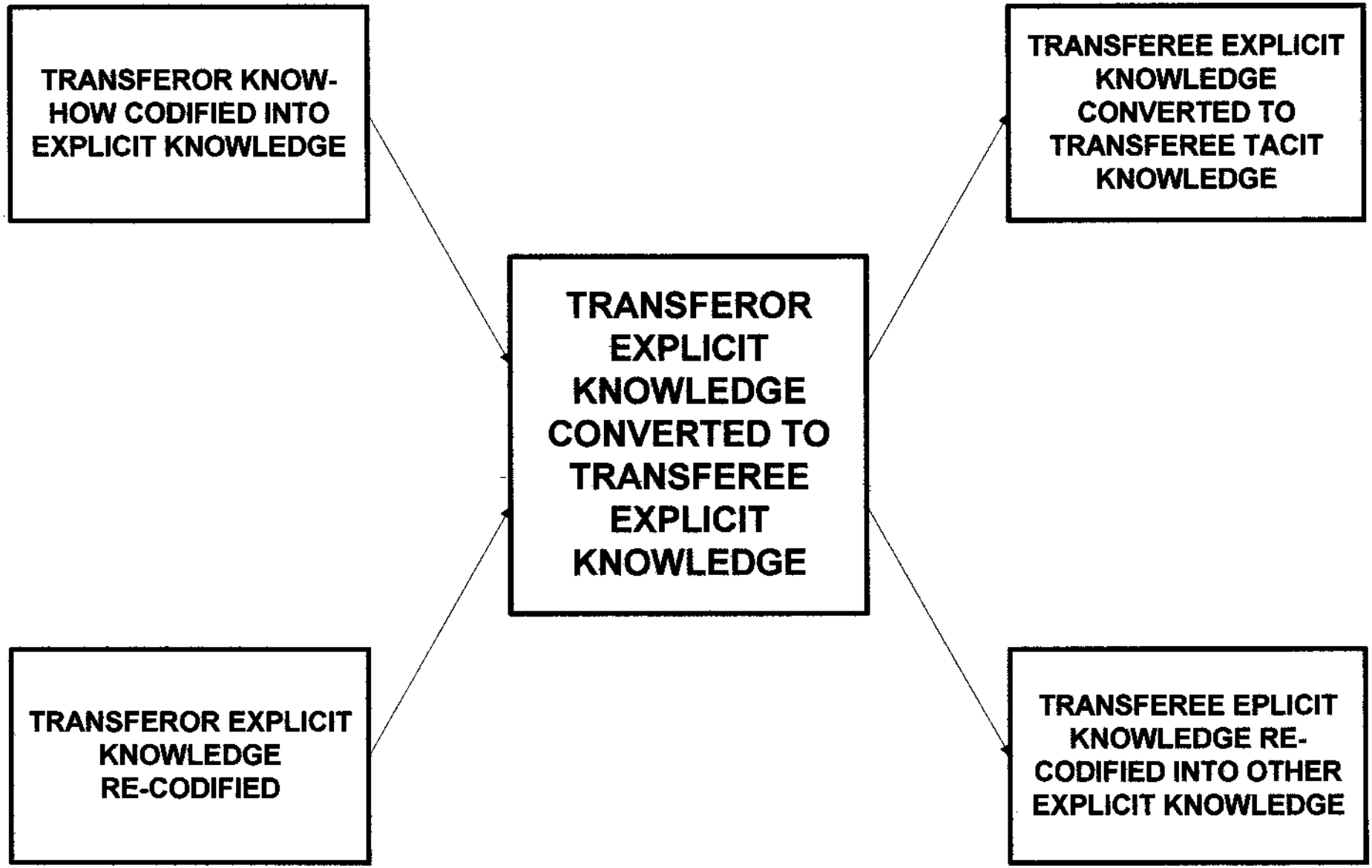

Figure 7: Knowledge Conversion and Transfer Process

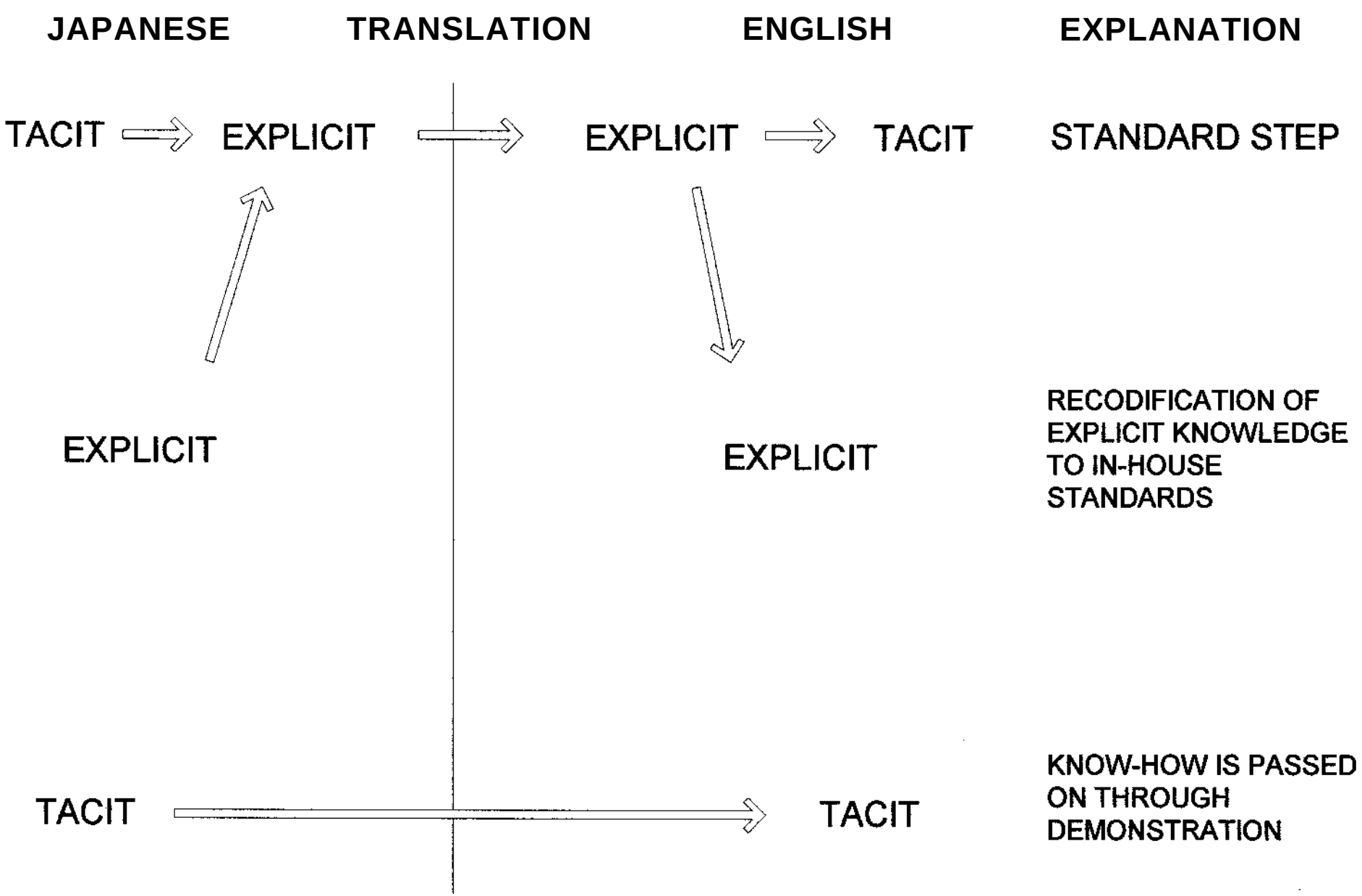

Figure 8: Knowledge Conversion Steps

success of previous international technology transfers. Support for the process is evident at all executive and project levels in the transferor and transferee firms

During the data collection, the steps governing knowledge codification from tacit knowledge to explicit knowledge and the conversion (translation) of (Japanese) explicit knowledge to (English) explicit knowledge were identified as the most critical in international technology transfers between the United States and Japan. Successful execution of these steps is necessary to overcome the many barriers between the participants, including language, culture, and standards. Additionally, both the transferor and transferee strongly believed that successful completion of these steps enhances the success of later training sessions. This appears to support our hypothesis that the effectiveness of the international technology transfer is dependent on the conversion of tacit knowledge to explicit knowledge prior to the transfer and expands it to include the conversion or translation of explicit knowledge to explicit knowledge.

It appears that over time, as the number of international technology transfers between the same transferor and transferee increases, this hypothesis becomes less and less important. As the transferor participates in, and in some instances leads, the development of the transferee's technological capabilities, the transferor develops what was described as a "sense of trust" in the transferee who now operates in a more independent manner. As a result, the level and amount of knowledge codification by transferor decreases and the knowledge transfer process evolves into more of a "pull" system, as the transferee becomes more active in specifying and requesting information from the transferor. Data collection supported this phenomenon. Regardless of the

types of technology being transferred, the initial technology transfers were marked by the transfer of extensive amounts of explicit or codified knowledge which in turn were supported by lengthy training. More recent transfers have been executed by using adequate, but noticeably less codified knowledge. Training periods have also been reduced in frequency and duration.

As a result, we can conclude that the effectiveness of the international technology transfer is dependent on the conversion of tacit knowledge to explicit knowledge prior to the transfer. In cases where the number of international technology transfers between the same transferor and transferee increases, the level and amount of knowledge conversion prior to the transfer may decrease over time without affecting the effectiveness of the technology transfer.

The Maturity of the Technology

For the purpose of evaluating the effect of technology maturity on the effectiveness of international technology transfers, our focus was limited (for confidentiality reasons) to manufacturing and assembly equipment transferred from Japan to the transferee's facility in the United States.

This equipment comes from two different sources

(i) The transferor. These transfers involve the export of the transferor's equipment directly to the transferee.

(ii) Equipment Suppliers. These suppliers are chosen by the transferor and are charged with the task of duplicating he transferor's existing processes. The equipment suppliers chosen are often those suppliers involved in the design and introduction of the current Japan process. Many of the equipment suppliers are based in Japan with operations in the United States.

In each case, the transferor will not permit the transfer (export or duplication) of technology unless it has been utilized and proven in-house at the transferor's facility for at least three years. During that period the transferor concentrates on mastering the technology, after which period the transferor believes the technology can be successfully introduced to and transferred to the transferee. As a result, all technology transferred to the transferee is proven, mature technology. Given that there is no basis of comparison in our study, we cannot conclude what effect the maturity of the transferred technology can have on the effectiveness of the international technology transfer.

(Note: During data collection, the transferor noted that recent political and economic pressures, along with requests from the transferee, are prompting a re-evaluation of the "three year rule". No indication was made regarding the possible outcomes of this re-evaluation.)

Conclusion

This study has identified and examined the key elements and processes for effective international technology transfers. Four distinct themes regarding effective international technology transfers emerge from the study.

1. The effectiveness of international technology transfers is dependent both on the transferee's prior experience with identical or similar technology. At the same time, the effectiveness is also dependent on the transferor's support to the transferee during the international technology transfer.
2. The effectiveness of international technology transfers is dependent on the transferor's previous experience in conducting or participating in international technology transfers. As the transferee gains more experience with international technology transfers, the transferee's experience can also contribute to the effectiveness of the international technology transfer.
3. The similarities between the transferor's and the transferee's organizational and operational styles can impact the effectiveness of international technology transfers. As the similarities change over time, the effectiveness of future international technology transfers will be assured if both of the participants are aware of the changes or the basic shared principles remain the same.
4. The effectiveness of international technology transfers is dependent on the conversion of tacit to explicit knowledge prior to the transfer. In cases where the number of international technology transfers between the same transferor and transferee increases, the level and amount of knowledge conversion prior to the transfer may decrease over time without affecting the effectiveness of the technology transfer

Each of these themes are based on the hypotheses put forth early in the study. The four themes also show how the evolution of one Japanese automotive manufacturing transplant has impacted the effectiveness of the international technology transfers in that compromises have been made

between the achievement of transfer targets, and the transformation of the transplant into an independent entity. These compromises appear to have been informed decisions and show another facet of the interplay between international technology transfers and international strategies,

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Appendix A

Questionnaire

Hypothesis 1: The effectiveness of the technology transfer is dependent on the transferor's previous experience in conducting or participating in technology transfers.

Q: Has the transferor previously conducted technology transfers ?

Q: Number, dates, extent, and details of transfers ?

Q: Importance / significance of this technology transfer ?

Q: Importance / significance of previous technology transfers ?

Q: Similarity to current transfer ? Aspects of similarity ?

Q: Efficiency of previous transfers ? (Start of production / scrap rates / down-time etc.)

Q: Does the transferor conduct support after transfers ?

Q: Is post-transfer support planned for this technology transfer ? For example, long term supervision ?

Q: Will transferor monitor effectiveness of technology after the transfer is completed ?

Q: Has transferor played a role in identifying external support for transferee ?

Q: Does the transferor's supply group have experience in technology transfers ?

Q: Do the transferor's suppliers have affiliates / operations close to the transferee ? Do they have relationships with the transferee ?

Q: Was supplier support selected and mandated by transferor and included as part of the technology transfer agreement ?

Hypothesis 2: The effectiveness of the technology transfer is dependent on the transferee's experience with identical or similar technology.

Q: Does the transferee currently produce or use products similar to those that will be produced by the new technology ?

Q: Technologically, how do the current and the new products compare ?

Q: Does the transferee have R&D resources ?

Q: What is the extent of the transferee's R & D investments ?

Q: Does the transferee have existing technology that is similar to that of the technology transfer ?

Q: Technologically, how does it compare to the level of the technology being transferred ?

Q: Prior to the technology transfer, did the transferee consider or investigate similar technology ?

Q: Was the current technology transferred, purchased, or developed by the transferee ?

Q: What is the extent of the transferee's support for existing technology and for the technology being transferred ?

Q: What were the transferee's main challenges / aids in the introduction of the technology ? Were these anticipated ?

Q: Ability of transferee to design / develop technology for same results (leading to NIH syndrome) ?

Q: Would it have been cheaper for the transferee to develop technology by itself than acquire from transferor ?

Q: Has the transferee identified internal / external support for existing technology and future technology ?

Q: What is the extent of the support ?

Q: Are these new / existing resources ?

Q: What training has been conducted related to the technology transfer ?

Q: Was training at request of transferor or at request of transferee ?

Q: Was the training conducted by the transferor ?

Q: Will there be post-transfer training ? (Technology development training with transferor ? Internal training ? Training with third parties ?)

Q: How does transferee evaluate the value of the training ?

Hypothesis 3: The effectiveness of the technology transfer is dependent on the similarity of the transferor's and the transferee's organizational and operational styles.

Q: Describe the organizational structure of the transferor and the transferee prior to the transfer ?

Q: Describe the organizational structure of the transferor and the transferee after the transfer ?

Q: What changes were made in each organization to accommodate / facilitate the transfer of the technology ?

Q: Were these changes anticipated or mandated by either party ?

Q: How were they received / perceived by the transferee's and the transferor's organizations ?

Q: Will these changes be continued / left in place after the technology transfer ?

Q: What impact did these changes have on the effectiveness of the technology transfer ?

Q: How did they impact the effectiveness of the transfer ?

Q: In the event of another technology transfer what changes would be recommended / introduced ?

Hypothesis 4: The effectiveness of the technology transfer is dependent on the conversion of tacit knowledge to explicit knowledge prior to the transfer.

Q: Was all necessary information specified prior to transfer ?

Q: What was the role of the transferor and the transferee in the specification of this information ?

Q: Was all necessary information available in explicit or documented form prior to transfer (drawings, handbooks, manuals, etc.) ? Approximately, what percentage ?

Q: After completion of the technology transfer agreement, approximately what percentage was in explicit / documented form ?

Q: After the completion of the actual transfer, approximately what percentage of the knowledge was in explicit form ?

Q: Currently, what percentage of knowledge was in explicit form ?

Q: Was knowledge conversion a condition of the technology transfer ?

Q: What were the knowledge conversion roles of the transferor and transferee in the technology transfer agreement ?

Q: Was conversion cooperation specified in the technology transfer agreement ?

Q: At each stage of the technology transfer, which party undertook the responsibility for the knowledge conversion ?

Q: Was information conversion capabilities / resources a decision factor in the choice of transferee ?

Q: What methods of information conversion were used ? (tacit to tacit, etc.)

Q: How compatible are the transferor's and the transferee's knowledge conversion and information storage systems / devices ?

Q: Any opportunity / evidence in increase in collective know-how as a result of the technology transfer ?

Hypothesis 5: The effectiveness of the technology transfer is directly proportional to the maturity of the technology being transferred, ceteris paribus.

Q: When was the technology developed ?

Q: For what purpose was the technology developed ?

Q: Is the technology currently in use ?

Q: For how long has it been in use ?

Q: Operational characteristics ? (Down time, start-up time to mass production, efficiency, how long did it take to reach current efficiency, labor intensity of technology etc.)

Q: How do these characteristics compare with transferee's own / current technology ?

Q: What is the current application ?

Q: What modifications have been made to the technology ?

Q: Are modifications planned to increase efficiency ?

Q: Anticipated life of technology ?

Q: Are there plans for the incorporation / transfer of next generation of technology ?

Q: Is the technology available on the open market ?

Q; Has the technology been transferred previously ?