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THE FOUR RATIONALES OF TECHNOLOGY TRANSFER ~IDENTIFYING TECHNOLOGY TRANSFER RISKS~

Up until now, most technology transfer activities have been carried out on trial-and-error basis. However, recent studies have emerged to provide scientifically-based guides for technology transfer in recognition of the fact that technology transfer is important for global advancement. Along with these studies, this research aims to present a systematic methodology, called the Four Rationales of Technology Transfer, for identifying the risks of technology transfer. This methodology is derived from an empirical study conducted on 50 recently-implemented technology transfer projects. With the proposal of the methodology of Four Rationales of Technology Transfer and the presentation of the results of the empirical study, it is the hope of this research that future activities of technology transfer will become more successful.

1. INTRODUCTION

In a previous paper by the author, the Two-Factor Continuum Model for Risk Identification [1] was proposed. The objective of the previous paper was to suggest a methodology by which technology transfer projects may be conducted such that project delays are prevented or reduced and project risks are minimized. Fig. 1 shows the Two-Factor Continuum Model for Risk Identification. The approach of the aforementioned model can be summarized as follows:

"Problems or risks of Technology Transfer Projects (TTP) can be predicted by mapping two basic factors, namely, (1) Resource Basis of the Technology and (2) Scope/Level of Integration of the Technology with TTPs conducted previously."

The previous paper aimed at systematically presenting the risks of technology transfer as correlated with the characteristics of the technology transfer project. As mentioned in the previous paper, although incremental, the modelling of the risks of TTP based on some characteristics of the TTP is expected to provide improvement over the trial-and-error method of conducting technology transfer that has been the common practice.

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2. OBJECTIVE OF THIS STUDY

The objective of this paper is to present the refinement that has been done on the previously proposed Two-Factor Continuum Model for Risk Identification. Specifically, this paper aims to present a methodology for identifying the potential risks of a TTP that:

1. Considers other factors aside from the two factors of resource basis and scope of integration which were established by the Two-Factor Continuum Model for Risk Identification.
2. Is derived from the experiences of a considerably large sample, i.e., greater than 30, of previously and recently conducted TTPs all over the world. (Note: The previously proposed Two-Factor Continuum Model was derived from the experiences of 10 sample TTPs.)

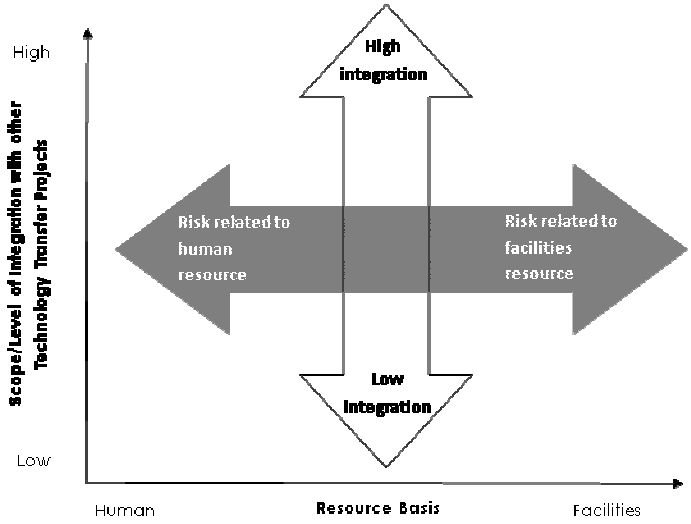

Fig. 1. The two-factor continuum model for risk identification proposed in the previous research

3. THE PROPOSED FOUR RATIONALES METHODOLOGY FOR IDENTIFYING THE RISKS OF TECHNOLOGY TRANSFER

To identify the kind of risks that will most likely be encountered by a TTP within the first five years of implementation, this study proposes the Four Rationales Methodology for Identifying the Risks of Technology Transfer. The following describes the proposed methodology in more detail:

1. Break down the TTP into its different components of People, Product, Parts, Procedures and Plant. Collectively, these components are referred to in this research as the 5Ps.
2. Identify the rationale of the technology transfer that most likely describes the objective of the TTP. For this step, it is the proposal to use the Four Rationales Table that is recommended within the Four Rationales Methodology.

3. Identify the component of the technology, i.e., People, Product, Parts, Procedures or Plant or the P, that is expected to encounter challenges during the TTP. For this step, it is the proposal to use the Table of 5Ps mapped according to the four rationales. This table is also being recommended within the Four Rationales Methodology that is proposed in this research.

3.1. THE DIFFERENT COMPONENTS OF THE TTP: THE 5P'S

This research defines the different components of any TTP as follows:

1. People
2. Product
3. Parts
4. Procedures
5. Plant

The aforementioned components are based on the 5Ps of Operations Management [2]. Each P is described as follows:

1. *People.* The human resources in the TTP. This component of the TTP includes all issues concerned with the knowledge, mindset, culture and other thought-process-based elements that are possessed by the participants of the TTP.
2. *Product.* The technology to be shared or transferred between the participants of the TTP. Specifically, this component of the technology transfer is concerned with the definition of the technology, particularly the definition of the boundaries or scope and limitations of the technology to be transferred.
3. *Parts.* The hardware and the codified software that are part of the technology which are transferred during the implementation of the TTP.
4. *Procedures.* The procedures external to the TTP which are essential to the TTP. These include customs procedures that are related to inbound shipment which usually causes delays in the TTP.
5. *Plant.* The physical infrastructure of the office, factory or teaching/learning venue that is used for the TTP.

3.2. THE FOUR RATIONALES OF TECHNOLOGY TRANSFER

This research defines four rationales or reasons behind the conduct of any TTP. Each rationale is described as follows:

1. *Developing*
   TTP participants, who are of equal technological knowledge capability, develop a new technology to tap an opportunity to serve a need that is yet unrealized globally.
2. *Sharing*
   TTP participants, who are of equal or slightly different knowledge capability, share knowledge about an existing technology with the aim of "globalizing" or extending

the application or use of the technology to other countries. Furthermore, the objective of the TTP can also be specifically to "localize" or customize the technology to the needs of other countries.

3. *Teaching*
   TTP participants, who are of different knowledge capabilities, assume the role of "technology transferor" and "technology transferee or recipient." The technology involved in the TTP is an existing and mature technology. The objective of the TTP is for the technology transferor to mentor the technology recipient about the technology intended to be transferred by the TTP.
4. *Sustaining*
   TTP participants, who are of much different knowledge capabilities, assume the role of "technology transferor" and "technology transferee or recipient." The technology involved is very mature and may be at risk of decline.

To aid the reader in identifying the rationale of the TTP, Table 1 shows a quick guide.

To use Table 1, for example, a TTP involves participants who are identified to have a very significant gap (note: please refer to the last row). Furthermore, the participants are engaged in the technology transfer project in order to transfer an existing technology. Most likely, the rationale is to "sustain" the technology.

Table 1. The four rationales table

Gap Between the Knowledge of the TTP Participants About the Technology	*Technology Existing or Not Existing*	*Identified Rationale of the TTP (As Proposed by This Research)*
None or Narrow	Not Existing	Developing
None or Narrow	Existing	Sharing
Significant	Existing	Teaching
Very Significant	Existing	Sustaining

3.3. THE CRITICAL P'S FOR THE TTP RATIONALE

This research proposes the following matching of Critical Ps for the proposed TTP Rationales:

Table 2. Critical Ps for the TTP rationales

P	*TTP Rationale*			
	Developing	*Sharing*	*Teaching*	*Sustaining*
Plant	LOW	LOW	MEDIUM	LOW
Procedures	LOW	MEDIUM	MEDIUM	HIGH
Parts	LOW	MEDIUM	MEDIUM	LOW
Product	MEDIUM	HIGH	HIGH	LOW
People	HIGH	HIGH	HIGH	LOW

Table 2 shows the mapping of the 5Ps against the Four Rationales of TTP. To interpret Table 2, for example, if the identified rationale of the TTP is “Sustaining”, the most critical resource would be “Procedures” or the external procedures that are needed to facilitate the TTP. As mentioned earlier, procedures include customs procedures related to the inbound shipment of parts that are needed for the conduct of the TTP. In general, it includes all government regulations of participants as regards the TTP. As another example, if the rationale of the TTP has been identified using Table 1 to be “Sharing”, the critical resources that should be focused on are the “Product” and the “People.” This means that the technology itself and the human resources are expected to present the most challenges. Thus, clear definition of the scope of the TTP is required and caution must be exercised in dealing with the knowledge, culture and mindset of the TTP participants.

4. DATA AND ANALYSIS: DERIVATION OF THE CRITICAL P’S VERSUS TTP RATIONALE MAPPING

Table 2 is being proposed given that the mapping has been empirically derived by this research from 50 recently conducted, i.e., from years 2003 to 2010, TTPs. The 50 TTPs that were considered in the empirical study were engaged in by participants coming from various countries worldwide. Furthermore, the 50 TTPs involve a large variety of technologies.

Table 3. Industries or business sectors of the 50 TTPs selected

Sector or Industry	*Example*	*Number of TTPs Included in This Research*
Health and Medicine	Medical Diagnosis Technology	5
Agriculture	Technology for the Propagation of Fruits	5
Telecommunications	Technology of the Digital Business Ecosystem Satellite for Aerospace Industries	7
Manufacturing Process	Mass Production Technology for Auto Parts X-Ray Technology to Detect Air Bubbles in Lollipops	5
Manufacturing Product Design	RSX Reality Synthesizer Technology for the PlayStation	8
Education	Photogrammetry Technology	7
Energy	Technology for the Highly Efficient Use of Natural Gas	6
Environment and Natural Resources	Carbon Dioxide Sequestration Technology	7

Table 3 shows the distribution of the 50 TTPs in terms of their kind of technology based on their industries or business sectors. It was the aim of this study that technologies of different industries be represented equally.

5. CASE STUDIES

There are two case studies that are briefly discussed in this section. Both case studies are about TTPs where the participants are Japan and the Philippines. However, one case study is about a TTP that aims to transfer software development technology while the other case study is about a TTP that aims to transfer manufacturing technology for injection-molded products.

The discussions below will show that although these two TTPs involve similar participants, they differ in the challenges that they face. Furthermore, as hypothesized by this research, the challenges differ because the TTPs have different rationales. This section shows how the proposal of this research can be used for identifying the resource, i.e., within the 5Ps, that can be expected to present challenges.

5.1. JAPAN-PHILIPPINE SOFTWARE DEVELOPMENT TECHNOLOGY TRANSFER

This TTP aims to transfer software development technologies needed for the operations of consumer electronic products such as cameras and printers. Japan has set up a research and development office in the Philippines. The outputs of the office in the Philippines are blueprints of software design which are sent back to Japan to be integrated with the software blueprints of the other parts of the products that are to be manufactured either in Japan or elsewhere in the world. All of the consumer products for which software design is produced by this TTP are yet to be manufactured 3 to 5 years from the time of design.

The management of this TTP was interviewed for this research study. Specifically, the question was “what was the biggest challenge that was encountered during the first five years by the TTP? Furthermore, now that the TTP is continuing for 20 years since it started, what is the biggest challenge that is being faced?”

According to the management of the TTP, the biggest challenge that was encountered by the TTP within the first five years is finding a methodology by which the software development technology can be taught to Philippine engineers in the most effective, i.e., high knowledge absorption and retention, and most efficient, i.e., fastest, way. Even at present when the TTP is continuing and is on its 20^{th} year that is still the biggest challenge. Since the start of the TTP, the management has been seeking ways of how to present the Japanese technology to Filipino engineers such that the technology is easy to understand and easy to retain. The challenge of teaching and retaining the technology in Philippine engineers is made more pressing by the fact that the recent employee turnover rate in the Philippines has soared very high to 11% [3], making the Philippines have the second highest

employee turnover rate in the Asia-Pacific region.

Aside from the challenge of finding the methodology to teach the technology effectively and efficiently, another big challenge is determining the scope of the technology to be transferred such that the TTP results in technology exchange that will be mutually beneficial for both participants. Most of the technology transferred from Japan to the Philippines are not yet mature and are within the "growth" stage of the technology life cycle [4]. Because of this, the practice in this TTP is that Japan initially defines the "growing" technology and discusses it with the Philippines. Refinements to the definition of the technology are introduced as a result of the discussions. Iterations of discussion - definition occur until Japan decides on the final form of the technology, as well as, the breakdown of the technology in terms of the components to be assigned to Japan and to the Philippines.

The preceding discussions present the actual experience of the TTP. To compare the actual experience with the results of a "walkthrough" of the proposed methodology, the first step is to identify the rationale of the TTP. For this TTP, the knowledge gap between Japan and Philippines is identified as narrow. The Philippine engineers who are part of this TTP come from high-ranking universities in the Philippines who are comparable with their Japanese counterparts. Furthermore, in terms of the stage of the technology along the technology life cycle, it can be said that the technology is in the growth stage. Still further, the aim of the TTP is to "globalize" the activity of software design. Given these descriptions about the gap in the technology-related knowledge of the participants and the stage of the technology along the technology life cycle and using Table 1, the rationale can be identified as "Sharing." Furthermore, using Table 2, this research suggests that attention to "People" and "Product" be provided as these are the resources of the TTP that are foreseen to present the biggest challenges.

The recommendation of this research coincides with the actual experience of the TTP as reported by the TTP management.

5.2. JAPAN-PHILIPPINE TECHNOLOGY TRANSFER FOR MANUFACTURING INJECTION-MOLDED PRODUCTS

The TTP in the second case study involves the transfer of manufacturing technology for producing injection-molding products. Like the first case study, the participants are Japan and the Philippines. However, unlike the first case study, the technology involved is relatively mature.

According to the interviews conducted with the management of this TTP, the biggest challenge that was encountered during the first five years was finding the methodology to teach the technology to Philippine engineers and operators. This is similar to the experience in the first case study. However, a remarkable difference with the first case study is that apart from the methodology for teaching the technology, one of the foremost concerns also was finding a methodology to design and to operate the Philippine infrastructure effectively and efficiently to carry out the technology that was being transferred. There were issues of finding the appropriate plant design, machine and equipment operating and maintenance settings to optimally work with the technology.

Like the first case study, the experience of this TTP coincides with the suggestion of this research. Referring to Table 1, this second case study would be classified under the "Teaching" rationale. The "Teaching" rationale, in turn, would be seen within Table 2 to be mapped to have "medium" relationship with the "Plant" resource. Actually, comparing the "Sharing" and the "Teaching" rationales, Table 2 shows that for all of the 5Ps except for "Plant", the same degrees of challenges can be expected. The "Plant" resource can be expected to be more critical for the "Teaching" rationale than for the "Sharing" rationale according to the proposed methodology of this research. This can be due to the more mature technology that the "Teaching" rationale deals with. This will be investigated further in a subsequent study.

6. DISCUSSIONS

Given the results of the empirical study performed on a sample of recently conducted TTPs, the following can be stated regarding the first five years of conducting the TTP:

1. When completely new technologies are being developed, challenges in People and Product, i.e., definition of the technology, will be the most critical.
2. As a technology grows, transferring the technology to other organizations can expect challenges related to all kinds of resources, i.e., all of the 5Ps, although People and Product will remain to be the most critical.
3. When a mature technology is transferred, challenges in setting up the infrastructure, machines and equipment of the transplant will most likely be encountered.
4. Technology transfer projects involving very mature technologies must be ready to encounter challenges regarding external procedures, e.g., government regulations, conflicting regulations or procedures are typical for participants engaged in this kind of TTP.
5. For any rationale or for any TTP, the most significant resource is the People. Thus, proper matching of participants in terms of culture, mindset or thought process capability must be done.

Table 4. Role of the government observed to contribute to the success of the TTP in each of the four rationales

	Developing	*Sharing*	*Teaching*	*Sustaining*
Government Role	Participant	Supporter	Source of Pressure	Definer of Mission
(Please delete this row)				

For the fourth statement, a study is being conducted to link the role of the government with the different rationales identified by this research. For this aim, the scope of the

initially conducted empirical study is being extended. Table 4 shows the tentative results of the study on the role of the government mapped against the four rationales. Details about the results will be provided in subsequent studies by the author.

7. CONCLUSION

Technology transfer has been engaged in by different organizations all over the world. However, although this has been a common undertaking for so many years, technology transfer has been hitherto undertaken on a trial-and-error basis.

Recently, studies have emerged to provide scientifically-based guides for technology transfer. This research is one of these studies. Based on an empirical study conducted on 50 recently implemented technology transfer projects or TTP, this study proposes a methodology for predicting the resource that will most likely encounter challenges during the first five years of TTP implementation. The methodology, referred to as the Four Rationales of Technology Transfer, proceeds as follows:

1. Identification of the rationale of the TTP based on the following factors:
   a. Gap between the technology-related knowledge of the TTP participants
   b. Stage of the technology within the technology life cycle
2. Identification of the critical resource, i.e., People, Product (Technology), Parts, Procedures, Plant that will be critical during the conduct of the TTP.

Two case studies are presented in this paper to compare the actual experiences of two TTPs with the recommendation of this research. Furthermore, a discussion about a subsequent study and its tentative results about the role of the government of the participants of the TTP that can result in the TTP's success is presented.

With the proposal of the methodology of Four Rationales of Technology Transfer and the presentation of the results of the empirical study performed to derive the methodology, it is the hope of this research that future activities of technology transfer will become more successful.

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