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Exploring Participation Processes for Technology Development: Case studies of Biotechnology Research and Development Projects in Thailand

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EXPLORING PARTICIPATION PROCESSES FOR TECHNOLOGY DEVELOPMENT: CASE STUDIES OF BIOTECHNOLOGY RESEARCH AND DEVELOPMENT PROJECTS IN THAILAND

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ABSTRACT

EXPLORING PARTICIPATION PROCESSES FOR TECHNOLOGY DEVELOPMENT: CASE STUDIES OF BIOTECHNOLOGY RESEARCH AND DEVELOPMENT PROJECTS IN THAILAND

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There is increased awareness in the organizational and management literature that participation can make contributions in technology development. One of the problems in developing biotechnology in Thailand is that only a small portion of publicly funded research and development projects directly result in commercial success. Among the reasons cited (TDRI 1992a) is a lack of collaboration between various stakeholders; therefore, an effective technology policy to support their participation is needed. This research explores current participation processes in biotechnology research and development projects in Thailand in which there were different perspectives among various stakeholders. The quantitative and qualitative methodologies developed here address two research questions: 1) *How is participation linked to the success of R&D project development?* and 2) *How do or might various stakeholders in the R&D process participate?*

This research also adopted the case study approach as an alternative to research design. Two projects with success and failure evaluated by their commercial results were methods of data gathering, i.e., interview, document review, and questionnaire were employed. Pattern analysis and explanation building were used to analyze the results.

The results indicate conflicts of interest among stakeholders in research and development. Differences of perspectives on goals and outcomes among the projects' stakeholders are found in both projects, while their patterns of participation do not differ considerably. Participation in research and development teams was developed; however, it was not directed to the commercialization of the research effort. Other stakeholders, i.e., prospective users, and projects' reviewers though responsible for their tasks, did not support commercialization. In addition, the funding agency limited its role in facilitating the participation forwarded to commercialization of the technologies.

This research suggests that participation should take part through all linkages contributing in R&D development. "Dialogue" as proposed by the literature (Lee 1996, Young 1996, and Ellinor and Gerard 1998) acts to enhance participation is a proper mechanism here since it has a power to build shared meaning, partnership, ownership, and leadership among participants. Future research is suggested to explore participation processes in other settings to exhibit the importance of participation and extend the generalizability of this research.

Co-Directors of Advisory Committee: Dr. Derya A. Jacobs

Dr. Charles B. Keating

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Dedicated to the members of my family for their love and support.

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Mr. Sujit Yuktavetya

Mother

Mrs. Rawiwan Yuktavetya

Aunt

Ms. Manida Neeraparn (Deceased)

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CHAPTER 1

INTRODUCTION

This study was motivated by a desire to understand how participation in knowledge processes could play a role in establishing an effective technology policy for biotechnology research and development teams in Thailand. The premise of this effort, as noted from Thailand Development and Research Institute (TDRI 1992a), is that current research and development activities in biotechnology are not sufficient. This includes the commercialization of research and development of initiatives, where the collaboration among research and development teams is vital. This research is an exploration of current participation practice using knowledge processes in biotechnology development in Thailand. This research uses a case study approach to identify how participation among the research and development team facilitates or hinders an active dialogue in the knowledge process. The use of dialogue is an approach for facilitating collaboration and participation among stakeholders as well as proposing a solution for the development of a technology policy.

Background

According to the "Case Studies of Research Development and Engineering Performance in Biotechnology" (TDRI 1992a), commercialization of products and prototypes from research and development (R&D) projects in Thailand has been unsuccessful. The study reports that this was due to a lack of personnel to program and manage the various steps of commercialization--in taking a technical concept from inception to the market application. In addition, the government and the private sector have not worked together to support close collaboration.

TDRI also argues that researchers from the universities and other public sectors do not understand the country's need for technology. Additionally, there are no clear demands or commitments from the private sector on R&D projects (TDRI 1992a). This gap appears to be in the communication between inventor and user. If participation by stakeholders exist, the communication gap should be reduced. Hence, the use of knowledge processes to facilitate participation, is a crucial tool for facilitating understanding between these two sectors.

The Role of Research and Development in Thailand

Research and Development (R&D) is essentially an activity dedicated to science and technology development for establishing a country's higher standard of living, which includes material wealth and welfare benefits. A number of substantive issues of management of R&D processes are explored in the literature (Dean and Goldhar 1980). However. there is no right solution for the effective management of this process because of how R&D is contexted in each organizational setting. For example, R&D in developing countries, unlike their counterparts, i.e., the United States, the United Kingdom, and Japan is conducted mostly throughout the public sectors. Therefore, a mismatch between the R&D requirements in the public sector and the private sector is fairly common in developing countries (Dean and Goldhar 1980).

Thailand, which is considered a developing country, has been involved in R&D in various aspects for a few decades. Biotechnology has been an emphasized priority because of the country's strength in its natural resources. However, "there has been very little modern biotechnology input into commercializing biotechnology-based products in the main potential industrial sectors i.e., agriculture, health care, energy and the environment" (TDRI 1992b, vi). The common mismatch is also identified as a barrier to technology commercialization in Thailand (NSTDA 1992, TDRI 1992a, 1992b, and Chantramonklasri 1997). This problem led to the creation of a quasi-governmental organization to support a continuous process of R&D (including biotechnology) with an ability to interact with other components of R&D to overcome such a barrier. This organization has been providing R&D support in the public sector with the intent to utilize or commercialize research efforts.

How This Quasi-Governmental Agency Works

In Thailand, the nation's universities and research institutions are the major actors in research and development (NSTDA 1992). The universities' research work is mostly associated with academic functions while those of governmental institutions focus on extension activities. The industrial sector, however, does not play a significant role in R&D activities. The technology (under) development in the industrial sectors is characterized by NSTDA (1992):

> Despite the acquisition of modern technology from abroad, many industries and firms have remained technologically static even after many years of existence. Indeed, there is a very high degree of dependency on foreign technologies but a very low level of endogenous activities to compensate for such dependency and to make the best use of foreign technologies (NSTDA 1992, 1).

This lack of technological dynamism has encouraged the Thai government to develop an indigenous capability in science and technology to support economic development, especially industrial development. Governmental policy influences the participation of universities and research institutions to perform R&D to meet the needs of production sectors, by means of research funding and by establishing national laboratories in association with the universities and research institutions (NSTDA 1992).

In addition to the role of education, the universities are the major contributors to R&D in Thailand. There are approximately 20 major state universities in Thailand, whose research areas include different scientific and engineering fields. It should be noted that private universities are rarely involved in the research system because most of them do not have a science and engineering-oriented program.

Research and Development Activities in Thailand

Case Studies of RD&E (Research Development and Engineering) Performance in Biotechnology, 1992, were conducted to *assess* the RD&E capability in Biotechnology in Thailand, with the goal of providing an understanding of what RD&E outputs were producing or expected to produce. The results of this assessment concluded that there were patents, royalties, licensing agreements, demand from users, economic value, and improved products/process, as well as academic results such as the number of papers published, and knowledge learned from RD&E. These assessments also produced various lessons learned. The primary concern addressed the "lack of personnel to program and manage the various steps of commercialization and in taking a technical concept from inception to the market application" (TDRI 1992a, ii). The authors attributed this finding to weak linkages between the research laboratories and the commercial sector, and an inadequate understanding by public sector scientists to the full nature of demand in the market place. The second concern addressed the limited exposure to scientific problems and technologies, by these same scientists. Though Thai researchers are capable of undertaking scientific research in their perspective fields, the total number of qualified scientists is still limited (TDRI 1992a).

Thai Researchers

In Thailand, most researchers in the biotechnology field work at universities and research institutions. Academic research in both of these sectors is poorly dispersed. Problems of dispersing research are caused by many reasons:

1) there is no specified user,
2) technologies could not compete with foreign technologies,
3) there are no existing regulations to control the utilization of some technologies, i.e., the use of genetic engineering microorganisms for waste treatment; therefore, any particular technology could not be utilized, and
4) competition among researcher groups in different institutions acts a barrier to technology transfer.

Due to these problems, several technologies cannot be utilized, though they can demonstrate satisfactory results on a laboratory scale.

The Importance of Technology Development in Thailand

For Thailand, according to the National Science and Technology Development Plan (1997-2006), R&D's objective is the implementation of research results for the benefit of the public. Combining local wisdom and modern know-how also provides a means of achieving maximum benefits to the society. From this perspective, the success of the R&D objective, therefore, is a commercial application.

In Thailand, this policy approach emphasizes the development of R&D capability in the public sector with an expectation to generate useful outputs for utilization. Though R&D can gain concrete results in various ways such as patents, publications, and knowledge learned, technology transfer has commanded the most attention from the policy-makers. From technology policy perspective, most biotechnology R&D projects in Thailand do not succeed because of their inability to transfer the new technologies to users. With the recommendation of the TDRI case study (1992a), the understanding among researchers, industrial, and agricultural sectors may create the environment for the successful transfer of new technology.

The Role of Technology Policy

Technology is invested with meanings and expectations. It is simultaneously helpful and threatening for individual, organizational, and societal levels. More frequently, unanticipated results arise during the R&D process. Furthermore, the relative obscurity of technology concepts is attributable to misunderstandings among people. Technology policy, from a general managerial perspective, serves to mediate the dilemmas in ongoing issues concerning R&D, and the implementation of new technologies. Technology policy can play an important role to reduce uncertainty in the technology development process. It is instrumental in controlling the direction of technology to a satisfactory level. It should act as an interface between technologists and non-technologists and provide strategic benefit (Street 1992).

The differences of values, perspectives, and orientation toward the goals of scientists and management are argued in various literature (Parker 1977, Petroni 1983, Goodman and Lawless 1994, and Bowie 1994). Scientists tend to focus the future value of a new development while understating the underlying technological process needed to deliver such potential. On the other hand, management is concerned with the competitive success of the business.

Though such sources of conflict are observed in industrial organizations, it may be presumed that problems exist in integrating researchers in research organizations also. It is found that some R&D projects are begun with inadequate attention paid to the commercial perspectives of the new technology, and the ability of the organization to exploit these perspectives (Beltz et al. 1980). This finding is supported by the evidence that many Thai biotechnology researchers appeared to be primarily interested in achieving research results without the full awareness on the nature of market (TDRI 1992a). Technology policy should play a linking role to resolve the conflict of coordination among different groups.

Problem Statement

Based on the aforementioned, it may be concluded that a scientist (person, group, or organization) alone cannot control the technology development process. R&D project activities require contribution from various participants, including all stakeholders involved in the process of research and commercialization. The purpose of this research is to explore and understand the role of participation processes in the R&D project development.

Leadership in Technology Development and Policy

Relationships with stakeholders or any form of participation is an effective organizational strategy because it provides an endless source of knowledge. Wheatley (1992) explains this in terms of quantum physics. "An organization swimming in many interpretations can then discuss, combine, and build on them. The outcome of such a process has to be a much more diverse and richer sense of what is going on and what needs to be done" (Wheatley 1992, 65). In short, the more people interact, the more opportunities to provide interpretations of meaning or phenomenon.[1]

Wheatley (1992) indicates that leadership is established through the multi-linkages between all stakeholders, and those who have interest in the current or future of the phenomenon. She also suggests that the leader's task is to communicate organizational principles to stakeholders. In this research context, persons engage in the R&D process, but no one seems to have a sense of "ownership" for the whole process. For example, scientists are responsible at the research stage and expect to have others take their research results to commercialize. "Ownership describes personal links to the organization, the charged, emotion-driven *feeling* that can inspire people" (Wheatley 1992, 66). Without the sense of ownership, a vicious cycle of uncommercializable R&D projects can be anticipated.

The best way to build ownership is to convey the creation process to those who will be charged with its implementation (Wheatley 1992). For R&D projects, multi-

[1] Interpretations are a result of information exchanged between two or more people, and even one's self. These interpretations also provide meanings, viewpoints and also interpretations of these meanings and viewpoints. Wheatley (1992) is saying here, that information irrelevant of its source is subjected to a broad distribution of interpretation.

linkages between interorganizations need to be established to stimulate the sense of ownership among all stakeholders. The funding agency and the researcher can take the leadership role--facilitating a relationship with stakeholders and building them ownership of R&D. Participation generates the reality to which the stakeholders then make their commitment. This is accomplished by dialogue.

When people have different assumptions, there is a trend toward conflict. Two types of conversation may play a role here: dialogue and discussion. A dialogue's primary use is for each person involved, or potentially involved, to learn from each member and build shared meanings that include all perspectives. Discussion produces a win-lose situation since the assumptions are justified and defended. Then the particular assumption can be accepted. Dialogue, in contrast, produces a win-win situation. The connections between those assumptions are perceived, and then the shared meaning among them is created (Ellinor and Gerard 1998). In R&D processes, the stakeholders have different perspectives which should be considered. The important point is how to create organizational forms that facilitates the dialogue. Trust is a core value for continuing dialogue (Wheatley 1992). The primary intent of dialogue is noted: "We are not trying to change anything, but just be aware of it. And you can notice the similarity of the difficulties within a group to the conflicts and incoherent thoughts within an individual" (Lee 1996, 21). Scientists, engineers, users, reviewers should be brought to talk together, with open-minds, and accept their frustrations in order to lead R&D results into their shared-desirable way.

Research Questions

Exploring the participation processes of R&D development and commercialization requires the understanding of these processes in the real events. The interest stems from the prior TDRI's study of weak linkages between the research laboratories and the commercial sector, and an inadequate understanding by public sector scientists of the full nature of demands in the market place. Therefore, the focus of this research is implied by the following research questions:

How is participation linked to the success of R&D project development? and

How do or might various stakeholders in the R&D process participate?

The first research question examines the relationship between participation and the success of transferring R&D project quantitatively. To get the descriptive data, the second research question investigates participation taking place in R&D process, and the stakeholders' perspectives on R&D processes, and on participation.

Purpose of the Study

Despite the fact that R&D is a risky business of which no one can guarantee its success, R&D management is an important activity of organizational concern. Industrial organizations' interest is about the integration among departments, in which the literature indicates some dissimilar viewpoints occur between technical people and businessmen. These viewpoints may be constraints in an industrial R&D organization to develop effective innovation processes (Gerstenfeld 1977, Souder and Chakrabarti 1980, Von Hippel 1980, and Petroni 1983). Such constraints beyond the firm, for example, firm to firm, firm to government laboratory, and firm to university are also studied (Gerstenfeld

1977, Rogers et al. 1998, and Fairweather 1990). However, constraints on R&D that is conducted under firm to university to public funding agency relationships are rarely studied.

To expand knowledge on management of public sponsored R&D, especially in a developing country context, this study aims to investigate participation processes taking place by conducting particular projects supported by a quasi-governmental funding agency in Thailand. Though various factors impact on the success on the R&D implementation, participation processes may be another factor contributing in some R&D projects. The funding agency has been supporting various biotechnology R&D projects in universities and public research institutions. Such R&D projects require stakeholders in various organizations. Participation taking place in projects is an interorganizational mechanism. Exploring participation processes will lead to understanding different perspectives among stakeholders which may help R&D management to organize and motivate scientists, engineers, business people, as well as others involved in the R&D process so as to ensure that it will enhance R&D implementation and be of benefit to the real world.

Significance of the Study

The study aims to facilitate the understanding of participation processes in technology development in a developing country. The R&D projects funded by a funding agency are selected and studied by using a case study approach. It is anticipated that the management strategy on participation processes will help enhance the success of R&D projects in the future. The findings will lead to awareness of the perspectives on and the mechanisms of participation among the stakeholders of R&D projects. Conflicts among stakeholders are identified and analyzed on their factors in the study. Consequently, knowledge processes will be suggested as technology policy to eliminate the conflicts, and to bridge an interorganizational gap. For implementing the use of knowledge processes, writing criticism to develop an awareness of the technology transfer problem is conceived, and suggesting knowledge processes will be proposed. Such performance is called action advocacy (Potter 1996). Action advocacy is argued in some philosophies. From their perspective, researchers should not go beyond description to the point of calling for some sort of action, the purpose of research is not to control others' behavior (Potter 1996). However, the researcher carries two roles in this research: (1) as a researcher who acquires the understanding of the problem, and (2) as a staff member who will be responsible for the R&D development process in the future. The objective of the study is not only understanding the problem of R&D processes, but also generating the recommendations for R&D management for policy makers.

According to Young (1996), the concept of knowledge processes includes the idea of social transformation through dialogic processes.

> Dialogic process is recognized as the predominant mode for creating new action patterns and working relationships through a mutual desire to share information based on experience and expertise in such a way to move toward a synchronicity. In this process, the creation, transformation, maintenance, and dissolution of distinctions occur. Such distinctions are the substance of knowledge (Young 1996, 135).

As suggested, knowledge processes are a choice in technology policy, a dialogic process may be an appropriate tool to encourage participation in knowledge processes among interorganizational members. Therefore, scientists, engineers, users, policy managers, and all R&D stakeholders must be inspired to share information unconditionally. The researcher may be perceived as the "vehicle" of the dialogic process (Young 1996).

Organization of the Dissertation

A central concern of this study is an exploration on the real R&D situation with the objective of contributing knowledge in the technology management domain. This dissertation is organized into 7 chapters. This introduction chapter presents the research background, the problem statement, the research questions, and the significance of the study. Below each chapter will be summarized briefly.

Chapter 2 is the literature review. It presents particular aspects on technology development, a broad overview of the concepts of R&D management in organizations, criteria for R&D assessment, particular models of the technology transfer process, and organizational roles in various sectors. To narrow down all knowledge to the presented cases, the biotechnology development in Thailand is considered. Furthermore, this chapter examines the implication to R&D management. The participation processes section begins with the issues of conflicts on R&D management in various settings and then the interorganizational network approach as a choice of analyzing the participation processes. Then technology policy is considered as a means for implementation.

Chapter 3 proposes a research model used in the study. The conceptual overview frames prior knowledge to the existing study. Research questions are identified in an effort to understand the participation processes in the R&D project development.

Chapter 4 describes the quantitative and qualitative approaches, which are research methodologies for this study. The combination of these two approaches, "triangulation" as a strategy is also explained. In Chapter 5, the research design is proposed. The research design strategy for utilizing the case study method is explained. Sample selection, interview criteria, data collection, measures, questionnaire design, interview guide, and soundness of research design are also described.

Chapter 6 presents the findings of the study. Characteristics of case samples are explained, then the models of analysis are discussed. Four explored perspectives on R&D management which includes goals, outcomes, publication, and participation processes on R&D development are all demonstrated. The last chapter emphasizes a discussion of the findings, contributions, as well as implications and suggestions for future research and technology policy.

CHAPTER 2

LITERATURE REVIEW

The objective of the research is to explore participation processes for technology development by studying biotechnology R&D projects in Thailand. The literature review is designed to provide a framework for understanding the basic concepts of technology, R&D management, and the importance of participation processes. This chapter is divided into two sections: i.e., technology development and management implication.

Technology Development

Technology development has a significant impact on the social world: on the environment, on the way we work, and on our general social interrelations (Smith 1996). It is a technical process, in which R&D is a mechanism taking place mostly in the laboratory. However, this mechanism needs the management process of organizing, and motivating scientists, engineers, and others involved in the technology development process to guarantee that the R&D process and its coordination are effective in meeting the objectives of society (Dean and Goldhar 1980). The review of technology development concepts provides a foundation for understanding the social implication of R&D processes and technology development in Thailand.

Definition of Technology

Technology is defined by various authors. For instance, Burgelman et al. (1996) defines technology as the theoretical and practical knowledge, skills, and artifacts that can be used to develop products and services as well as their production and delivery systems. Brust (1989) also refers to technology as the application of science to the solution of practical problems. With this concept, the state of technology existing at any given time is defined in terms of a production function relating quantities of inputs to quantities of outputs. Also, Mansfield et al. (1982) interpret technology as society's pool of knowledge concerning the industrial, agricultural, and medical arts. Such a pool includes knowledge concerning physical and social phenomena, knowledge regarding the application of basic principles to practical work, and knowledge of the rule of thumb of practitioners and craftsmen.

These concepts perceive technology as a vehicle to utilization. This means technology is seen as a technical process of hardware supply, and the development of knowledge related to specific products and processes (Smith 1996). Actually, technology implies a continuous process involving such activities as management, coordination, learning, negotiation, and so on. The definitions above also bypass non R&D processes, such as exploring user needs, acquiring competence, managing new product development, financial management and so on. At this point, technology is determined in the terms that it might be part of an integral perspective.

> Firstly, technology involves *knowledge* related to production: it implies understanding and competence relevant to material transformations. This knowledge can range from abstract scientific knowledge - codified and widely - available concerning the properties of nature, through to engineering 'know-how' or operative skills. The later are often tacit, unwritten. Secondly, technology involves organization: at the most direct level this means the management and coordination systems which integrate individual activities and through which production takes place, or through which public sector activity is organized. Thirdly, technology involves techniques: that is machines, tools, or other equipment with their rules and procedures of operation, and their ancillary activities such as maintenance, repair, training and so on. Technology can therefore be thought of as *the integration of knowledge, organization, and technique*. However, there is a further essential aspect: technology is produced by and exists within a *social framework*. The social system makes economic and political choices which influence the development and spread of technologies, and which through--

> education and general - culture develop the skills needed to operate technologies. Social values and decisions thus shape the path of technology development. It seems apparent that differences in technological performance between societies have at least some of their roots in social structure and cultural forms, although how these difference operate is as yet far from clear. At the same time, technological development has important impacts on the social world: on the environment, on the way we work, on our general interactions (Smith 1996, 109-110).

This notion provides a basis of understanding that technology is not based merely on technical process or knowledge that transforms input to output. Technology is an integration of knowledge, organization, and technique, existing in a social framework. Smith's term of technology is compatible with Leonard-Barton's definition:

> technology is capability, that is, physical structure or knowledge embodied in an artifact (software, hardware, or methodology) that aids in accomplishing some task. . . . Such knowledge is defined as technology only when it is captured at least partially in some communicable form (Leonard-Barton 1990, 45).

With these definitions, non R&D processes performed by scientists, engineers, and even other stakeholders, also contribute to technology development. Among the processes is the role of R&D management that provides the activity of stimulating, guiding technical people, and also making technology usable. These processes rely on their interpretation of knowledge to and from all participants. In order to determine the R&D management direction, the next section focuses on R&D management context in developed and developing countries from prior studies.

R&D Management Context

Developed and developing countries have different R&D settings. The strong contrast between their R&D spending is observed (Table 2.1). In addition, the proportion of work carried in the industry in developed countries is more than fifty percent. Since industrial R&D shows the greatest portion of their nation's research system, R&D

management in industrial organizations of a developed country, like the United States, is a significant issue that the literature explores (Beltz et al. 1980).

Country	***R&D Spending (percentage of GDP)***		***Business R&D (percentage of total R&D spending)***	
	1992	***1993***	***1992***	***1993***
Sweden	3.00	3.12	68.54	68.89
Japan	2.97	3.00	68.73	68.73
USA	2.62	2.77	68.03	72.64
Germany	2.53	2.48	67.79	66.88
France	2.35	2.41	61.06	62.13
UK	2.12	2.11	62.84	62.84
Korea	1.83	2.08	81.89	72.68
Taiwan	1.74	1.78	53.62	47.79
Singapore	0.88	1.18	59.47	61.05
India	0.88	0.78	10.48	12.57
Mexico	0.21	0.37	0.05	0.27
Thailand	0.21	0.16	9.72	9.72

Table 2. 1. Comparison of R&D spending in selected countries
(Adapted from Rodning 1998)

Public sectors, for example, universities, and some government laboratories perform R&D, however, most R&D conducted is classified as basic research (Beltz et al. 1980, and Williams and Gibson 1990). These outcomes are not expected for immediate use or application. In addition, public applied research with direct commercial aim is conducted often and is initiated by industry sectors that are contract or joint venture (Wigand 1988, and Cohen 1994).

In developing countries, the R&D context has a different meaning. The share of private sector in R&D varies from newly industrialized countries and less advanced countries. In more advanced countries, the private sectors accounted for half or most of the R&D investment while in less developed countries, like Thailand, India and Mexico the share of private sector has been very small.

Obviously, in less developed countries, much of applied R&D is performed in public organizations. Although some of these are university-affiliated, the majority depends legally and/or financially upon a ministry, a government department, a national bank, or some other public agency (Rubenstein 1980). R&D conducted in public agencies without the contribution of industry is indicated by the literature (Rubenstein 1980, and Chantramonklasri 1990).

The weakness of performing applied R&D in public organizations is that many of the organizations lack experience with, interest in, and ability to transfer their R&D to industry. At the same time, the industry lacks the "receiving" ability for R&D (Rubenstein 1980, 274). These problems though rarely mentioned in the literature exploring R&D in industrialized countries are the core underlying this research.

R&D Assessment

There are two perspective in R&D assessment. The first perspective concerns the industrial R&D that takes place in the private sector while the role of the federal government seems to be quite limited (Rubenstein et al. 1976, and Cohen 1994). The second perspective, in contrast to the first one, focuses on public-funded R&D, including the ones conducted in either the university's perspective of R&D, or governmental research institutions. Though the R&D efforts aim to commercialize their findings, it is indicated that the government has a direct role in R&D decision making process (Rubenstein 1976, Braunstein et al. 1980, Crow and Nath 1990, Wegloop 1995, Chang and Hsu 1997, and Hee and Soo 1997). However, little research has been devoted to guarantee that government-supported industrial technology R&D projects conducted by non-profit research organizations develop suited generic technologies and disseminate them to domestic industries for commercial application (Chang and Hsu 1997).

The focus of this research is public-funded R&D, which the government controls over R&D assessment. However, in most research systems, the R&D proposal submitted by individuals or groups of scientists are put out for evaluation by others that are in the industry, even in universities (Yearley 1988). The issues in evaluating R&D is not only devoted to scientific merit, but to others, such as economics, commercialization, and social benefit, which may cause conflicts of interest among the government, university, and private industry.

Economics Perspective

Some economists have suggested that fundamental technology underlies the long term pattern of booms and contractions which has characterized the Western economy as a whole. For instance, the creation of small internal combustion engines established the development of a whole generation of lorries, pumps, aircraft and so on. Furthermore, this innovation helped other technical efforts like the elaboration of road networks and the construction of suburban dwellings away from existing railway lines. From this perspective, economic "long waves" are governed by fundamental technical changes (Yearley 1988).

In the United States, the government supports R&D for economic benefits directly and indirectly. Gibson (1981) presents that there are motives for federal funding for

R&D: (1) increasing the size of the pool of scientifically trained individuals, (2) increasing the pool of scientific knowledge, (3) international considerations, (4) providing indirect support for higher education, (5) improving the nation's defense posture, and (6) encouraging the introduction into the nation's economy of new and improved processes and products by the private sector. Only the last item (6) is directly economic, however, all of them will contribute to the quality of life and stability of the nation and thus will have indirect economic benefits. The following mechanisms are the specific ways in which public funded R&D on the introduction of technology by the private sector achieves the goal of providing direct economic benefits.

- Will improve the nation's balance of payments by reducing the acquiring of raw materials or finished goods from abroad.
- Will render the industry better able to compete in the international marketplace.
- Will enhance the quality of the nation by decreasing the dependence on processes and products that involve expensive social costs such as environmental pollution and other externalities.
- Will improve productivity in the private sector.
- Will advocate the introduction of processes and products with a large component of positive social benefits.
- Will speed the introduction of processes and products that will achieve any of the foregoing goals (Gibson 1981).

From such perspectives, both private sectors and the nation would get economic benefits from R&D. Nevertheless, it is argued that an innovation may be profitable for the country in a very long time while firms which undertake R&D are going to suffer by their competitors in the short term (Yearley 1988). This view is supported by the economics studies of Braunstein et al. (1980), and Mansfield (1981) that the social rate of return often exceeds that of the private. A new type of thread development is a good example. This thread allows higher sewing machine speeds, which then reduces the cost of apparel manufacture. Since these saving were very large relative to the costs involved in innovating the thread, the social rate of return was dramatically high--exceeding more than 300%. But most of these benefits accrue to the apparel manufacturers and the buyers of finished garments. The innovator could not appreciate them because competitors could imitate the new thread easily, cheaply and rapidly and did so within six months. Accordingly, the private rate of return was only 27%.

In order to understand the cause of the low private rate of return, the relationship between technological development and economic growth is suggested by the concept of the product life cycle (Wijers 1982). In table 2.2 the product life cycle gives a brief overview of the dynamics of structure conduct and performance of an industry during the product life cycle. However, this is a very schematic overview, and there are many exceptions to the suggested regularities in this framework. It can be seen that the structural economic growth and employment of technology is especially found in industries during the expansion and maturity phases of the life cycle. Therefore, it is not surprising that R&D firms face low rates of return in the introductory phase.

Another concern for the firm is the difficulty of retaining exclusive use of technical knowledge once it has been gained. This difficulty is referred to as "inappropriability" in an economics term. The final reason why the firm would be wary of investing of new technology is that investment of R&D is risky. Firms are likely to be conservative, and not to invest in new technology (Yearley 1988). These reasons cause negative judgment on R&D from the industry side.

Phase	*Introduction*	*Expansion*	*Maturity*	*Stagnation*
Structure	• production process relatively labor-intensive • production on a small scale • national, or regional market	• production process becomes more capital-intensive • vast expansion of production capacity • competition based on imitation • deconcentration • also export market	• production on big scale • production different location • high costs for promotion and service • oligopolistic market structure	• almost no possibilities left for price-competition • strong concentration tendencies • deinvestments
Conduct	• prepared to take high risks • both technical and commercial insight	• much attention to marketing and internal control	• much attention to consolidation of market shares	• tendency to coordinate company behavior • attempts to buy young companies in expanding markets
Performance	• pre-operational losses • many failures • little employment	• substantial profits • substantial creation of employment • growth of exports	• declining profits • some disposal of labor • imports from other countries, loss of market share in export markets	• substantial company closures • substantial disposal of labor • further losses on international markets

Table 2. 2. The main characteristics of the product life-cycle theory (Source: Wijers 1985).

Techno-economic impact is a long term negative effect on the country's economy. For example, some new technologies bring about an increase in automation, machine capacities, and a great extent in industrial development. This may lead to an unbalanced distribution of income between industrial and agricultural (Yuthavong 1997).

In contrast to traditional management, Kealey (1996) argues that government has a negative effect in promoting economic development through technology development. He states that if state funded research really did boost economic competitiveness, then what explains the situations in India and the old Soviet Union? He also argues that the greater the role the state plays in a R&D driven market place, the more inefficient and uneconomic the innovation environment. Such a viewpoint presents a negative insight of the relationship to public-funded R&D and economies.

In summary, because the national economic wealth is the primary expectation on technology development, encouraging R&D for technology development is an important role of governments. However, the economics can be perceived by different views, and in different time frames. Technology may be profitable for people in a long time, while the firm that conducts R&D may be beaten by its competitors. Mostly governments do not contribute in the whole process of the product life cycle, and also they are not production sectors. Sometimes, governmental R&D strategies are unprofitable, which are demonstrated in some countries. Economic assessment on R&D is not a straight-forward task that can benefit to every sector.

Commercialization Application

The commercialization of technology is the process of taking R&D results as they emerge from the laboratory and bringing them to a successfully marketable product (Dorf and Worthington 1989, and Kozmetsky 1990). It is generally assumed that R&D would in one way or another be automatically transferred into viable technology, and subsequently commercialized (Dorf and Worthington 1989). The commercialization task is composed of: defining the product, building a prototype and testing its feasibility, completing product development and design, starting a production phase and finally passing the manufactured product to the marketing and sales departments. This model is sequential, systematic, and slow (Dorf and Worthington 1989). For public R&D, new technology must be transferred from the R&D organization or the university to the industry (Gibson 1981). It is discussed that to a greater extent, the risks in R&D are commercial, not technical (Mansfield 1981). As a result, commercialization issues are required for consideration in R&D assessment.

A team effort in the commercialization process is discussed in the literature (Rubenstein 1980, Dorf and Worthington 1989, and Kozmetsky 1990). Kozmetsky (1990) discusses that the process of commercialization requires the active reciprocation of ideas and opinions that are both technological and market-oriented in nature. The interchange of ideas should become collaborative efforts from government, academia, and business, especially for public funded R&D. However, Dorf and Worthington (1989) argue that working with a government or independent research laboratory or university is difficult for an industrial firm since they are not on the same team. The lack of commercial perspective in scientists is indicated (Souder and Chakrabarti 1980, Blackledge 1985, and Moses 1993). Dorf and Worthington also note:

> Creative scientists and engineers often need the intellectual stimulation and support provided by peer groups, which usually are found in universities, research institutes and some major federal research laboratories. Such people desire the personal satisfaction of seeing their innovative technological idea commercialized, but few want such rewards enough to leave behind the satisfying environment of the solitary, risky entrepreneurial enterprise that may not even be interesting to them (Dorf and Worthington 1989).

On the other side, the industry who sells products operates in an environment anticipated to achieve relatively near-term profits. The organizational frameworks and motives needed to mobilize product teams are rarely found at research institutes, or universities. Furthermore, most researchers perceive such organizational mechanisms as highly limiting and uninteresting (Rubenstein 1980, and Dorf and Worthington 1989).

Such a gap is recognized by the literature. To be unable to reach the joint consensus is one weakness of public-funded projects that leads them to unsuccessful commercialization (Rubenstein 1980, and Dorf and Worthington 1989).

Product development is a process aiming to commercialize. In the study of industrial R&D projects which were conducted in laboratories, their results would aim for commercialization, Cohen et al. (1979) indicate primary factors in product development on successful commercialization:

1. Technical understanding: Main technical issues of technology must be considered carefully before passing R&D on product development. Some R&D failed in commercial application since they were immature for development, and researchers had not assessed the advantages over existing technology.
2. Feasibility: The feasibility implies acceptability to the end user in some cases. Some R&D projects which never demonstrated the feasibility of the research concept because time pressures forced transfer before demonstration could be completed, failed in commercialization. It is suggested that an understanding on what constitutes feasibility should be reached before commercialization.
3. Advanced development overlap: In planning R&D, and especially as they are close to commercialization, careful preparations have to be made for the proper kind of overlap program. Advance development effort is often the answer to problems of scaling-up, marketability or economic feasibility.
4. Growth potential: Several R&D efforts suffered from being too narrowly aimed at a specific need and not having clear paths to technical growth in product applicability. The challenge of a new technology forces an existing one to extend itself, to advance

its goal, to expand its potential in the face of competition. R&D effort must consistently and cautiously look over its shoulder at what is coming along.

5. Existence of an advocate: Properly timed seminars for publicizing and explaining transferable R&D concepts are useful when used. The efficacy of the research champion has been augmented in several projects via a push-pull provided by an external champion.
6. Advanced technology activities in a development laboratory: The presence of "ad tech" activities from people with talent and experience are helpful and often necessary to pick up potential technology to development for commercialization.
7. External pressures: The presence of some form of the same technology in a competitor's laboratory, or a product announcement has helped product development. Competition has helped R&D transfer from development since the creation of external standard against which to judge the R&D progress and achievement. When there is no outside activity, greater difficulty can be expected in making judgments in the technology, and its transferring.
8. Joint programs: Joint programs such as support by money, or by people may increase R&D ability to commercialization. However, it is argued that joint programs are good to have but do not guarantee success.

Teece (1986) argues that the successful commercialization of technology requires that the technology be utilized in conjunction with other capabilities or assets. These complimentary assets are services such as marketing, competitive manufacturing, and after-sale support. For example, the commercialization of a new drug is likely to require the dissemination of information over a specialized information channel. Another example is computer hardware, which typically requires specialized software, both for operating system, and for application. Figure 2.1 summarizes complementary assets schematically.

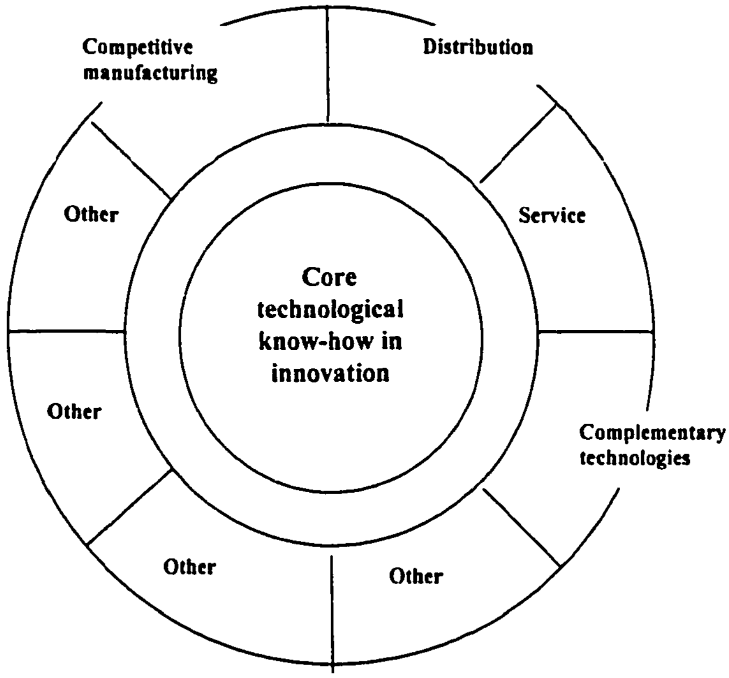

Figure 2. 1. Complementary assets needed to commercialize an innovation (Adapted from Teece 1986)

In Decker's (1988) analysis of the implementation of technology from the federal laboratory in the industry sector, this process is very complicated, involving high risk, long lead times, and opportunities for failure. He debates: "After an idea has been carried through from conception to proof-of-concept, the difficult tasks of identifying and evaluating potential markets, attracting sufficient financial resources, and overcoming scale-up and manufacturing problems must still be undertaken by industry" (Decker

1988, 15). In Decker's opinion, industry must be convinced that the costly technology required for a commercial product or process is worth the risk involved. According to his study, even when the commercialization occurs, the likelihood of success may still be low. Since the technology appears to be relatively attractive to industry and that successful transfers--those that influence directly to profitable commercial products or processes, may require several years and are the exception rather than the rule.

Social Benefits

From an economic perspective, the importance of R&D is recognized as a function of science and technology to increase productivity (Kozmetky 1990); however, productivity is the means not the end. Technology must be judged on the basis of improving well being and health (Kagan 1979). Kagan (1979) argues that only if the effect on productivity nullified the effect on well beings, could technology be regarded as a failure. Accordingly, R&D should be considered on the real basis of benefits and disadvantages to the well beings of the people and the greater society in the future.

Though, the social rate of return from technology can be estimated quantitatively as discussed in the economic perspective section, calculation is difficult because technology has sophisticated effects on the cash flows of many companies and industries (Mansfield 1981). Regardless of the economic calculation, it would be simple to discuss the benefits and drawbacks of technology on the well beings of the population in qualitative terms, possibly in each country's R&D context.

The benefits and drawbacks of science and technology (S&T) for society are summarized as a guideline for R&D assessment in table 2.3.

Desirable	*Undesirable*
Effects of S&T on Industry	
• Creation of new types of jobs	• Elimination of old jobs
• Intelligent machines liberate some workers from job tedium	• Some workers become mere components of the production machinery
• Increase in personal and national income	• Unbalanced distribution of income (industrial vs. agricultural sector)
• Higher productivity, greater economic diversity	• More pollution problems
• Better national infrastructure (physical)	• More urban congestion, disintegration of rural society
• More global integration	• Loss of identity of the society
Effects of S&T on agriculture	
• Higher productivity and more product diversity	• Prices may be depressed by oversupply
• Lower land area requirement	• Greater capital requirement
• Effective pesticides, fertilizers, etc.	• More environmental stress
• New varieties with economic value	• Possible loss of biodiversity
• Greater variety of products	• Some traditional products may disappear
Effects of S&T on health	
• Better prevention and therapy technologies	• Higher health care costs
• Better individual health care	• Community health may be neglected
• Health personnel are better equipped	• Uneven distribution of health personnel/higher wage
• Modern medicine is widely accepted	• Rejection of traditional medicine
Effects of S&T on communication	
• Birth of global information infrastructure	• Decrease of local and personal communication
• Better access to education, arts, etc.	• More opportunities for misuse of technology and to cause damage
• Opportunities that benefit everyone	• Bad policies may enhance the gap between the haves and have-nots
• Lowering costs of services, etc.	• Overload and pollution of information

Table 2. 3. Desirable and desirable effects of science and technology
(Source: Yuthavong 1997)

However, such effects are discussed as the general concern for developing countries only. Yuthavong indicates:

> In the attempt to fulfil the vision for Thailand's future, measures should be taken that would as much as possible allow the desirable components to be realized, while at the same time thwart the undesirable components. It may not be possible to achieve the goals completely: some changes will bring both good and bad news together (Yuthavong 1997, 132).

Krupp appears to agree that technology brings good and bad results. He states: "technology assessment cannot succeed, because it has to rely on subjective choices of variables, indicators, models, assumptions etc.; and typically ends up in political struggle between different interest groups" (Krupp 1985, 77). In order to reduce evil from the technology, a balanced approach using all available tools and innovation in all areas, for instance social, economic, education, and management is required. A reduction of the consumption of pharmaceuticals and better perception of the limitations of health systems by appropriate re-regulation, and by educational measures is a good example.

Technology Transfer Process

Technology transfer definitions are offered in various terms by the literature. For example, it refers to "some source of technology, possessed of specialized technical skills, which transfers the technology to a target group of receivers who do not posses those specialized skills and who therefore cannot create the tool themselves" (Leonard-Barton 1990, 45). Another definition is that technology transfer involves the gaining of creative activity by the secondary users (Van Gigch 1978). Such definitions do not specify the receiver to any entity while some definitions determine it to a country. One of those is Derakhshani's definition which technology transfer is the "acquisition, development, and utilization of technological knowledge by a country other than that in which this knowledge originates" (Derakhshni 1983, 27). Thus, some literatures are developed to determine aspects on international technology transfer, especially from the industrialized country to the developed one (Mansfield et al. 1982, Barrera and Williams 1990, Bozzo and Gibson 1990, Chatterji 1990, and Madu 1992). Such a perspective is excluded from this research since it aims to explore the technology transfer process within the country.

Significantly, technology transfer process aims to commercialize new knowledge into enhanced products and services (Kozmetsky, 1990 and Dakin and Linsey 1991). In an attempt to explain the fundamentals of technology transfer, some models are developed. For example, Dakin and Linsey (1991) illustrate the evaluation of a technology within a life cycle--or the stages through which technology must pass in order to reach a commercial form suitable for marketplace sales (Table 2.4).

Stage in technology life cycle	***Characteristics***	***Opportunity to transfer technology toward commercialization***
Concept	new *breakthrough* scientific knowledge	• disclosing the concept to another individual, or • writing the concept on paper, or • research and development testing
Research	testing scientific principles on which the concept is based	• direct testing toward commercial use to validate research
Development	testing the economic viability of technology	• reviewing the several ways of commercialization to measure different results on profitability
Manufacture	manufacturing of actual end-product	• making enough of the product to satisfy initial market need, and to accomplish the task at a cost that assures profitability over the long term
Distribution	transportation of technology	• shared distribution costs can meet or exceed cost objectives for an established distribution network
Sale	complete product or technology transferred from entrepreneur to end-user	• educating consumer about the benefits of the technology
Use	consumed technology	• educating consumer how to use the technology

Table 2. 4. Evaluation of a technology within a life cycle
(Adapted from Dakin and Linsey 1991).

Dakin and Linsey (1991) discuss that the development and commercialization of a technology seldom moves on from the concept stage to the use stage in a straight-forward, linear fashion. Like Dakin and Linsey, Gruber and Marquis (1969) present the science-technology-utilization topology (Figure 2.2) to examine the relationship among the major channels of activity. From this model, transfer can occur between the three channels or within a channel. This model also gives a good analysis of technology transfer as the communication pattern since it is likely to identify the various loci of transfer that may take place. The idea generation stage as defined as concept stage in Dakin and Linsey's term, is not only from the science stage, but also the technology stage or practical need and use stage. In addition, transfer within technology and transfer between science and technology are concerned.

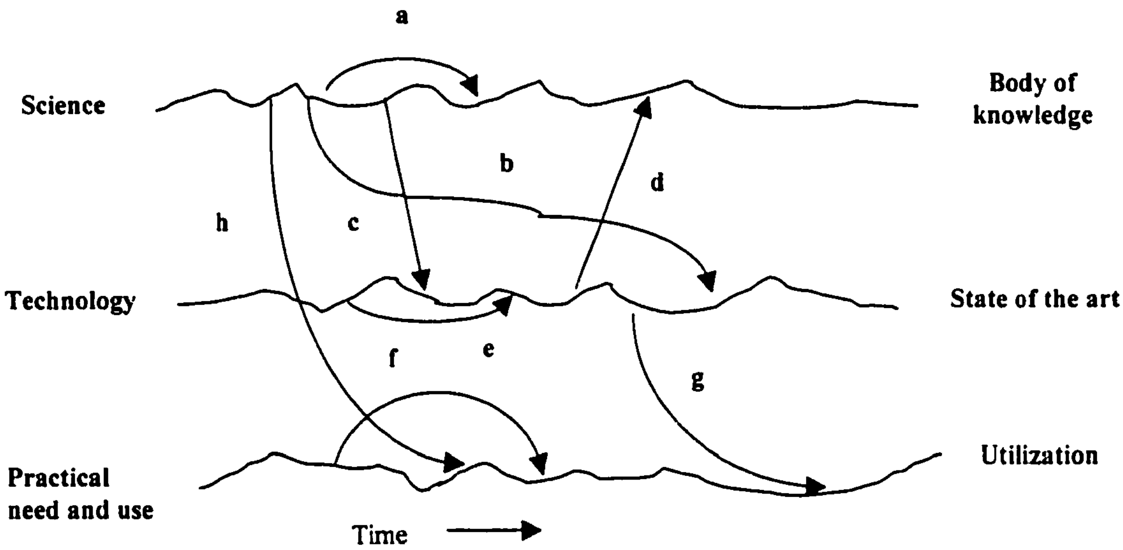

Figure 2. 2. Science, technology, and the utilization of their products, showing communication paths among three streams.

(a) Science to science; (b) Science to technology (slow); (c) Science to technology (fast gap filling); (d) technology to science (e.g., instruments); (e) technology to technology; (f) Use to use (diffusion); (h) Science to use (e.g. cod liver oil treatment of rickets): Adapted from Gruber and Marquis (1969).

Organizational Roles in Technology Development

Three parties: government, industry, and academia, have critical influence on the technology development process (Kozmetsky 1990). Public-funded R&D projects are carried out in universities and colleges, then collaborative efforts between academia and industry can accelerate the commercialization of R&D into emerging industries (Beltz et al. 1980, and Kozmetsky 1990). Several nations carry such an approach in developing their research system (Beltz et al. 1980). The roles of these three parties and other organizations which may be involved in technology development will now be discussed.

Government

Despite the fact that the percentage of governmental R&D budget to total R&D budget of advanced and developing countries are dissimilar (Mansfield 1982, Yearley 1988, and Chantramonklasri 1997), their government sectors actively participate in R&D (Beltz et al. 1980, and Cho and Kim 1997).

Among the roles of government in technology development is to fund R&D to academic, industry, even public organizations. However, the commercial technology development is the most important goal that government needs to take action (Brown et al. 1991). Several mechanisms for R&D commercialization that government agencies should consider are discussed in the literature (Brown et al. 1991, and Chang and Hsu 1997). Brown et al. (1991) review six alternatives which may be used individually or in combination with one another. The description of each strategy with its unique vantage points and drawbacks are summarized in table 2.5.

Strategy	*Characteristic*	*Vantage points*	*Drawbacks*
1. Contracting R&D to industrial partners	Government supported R&D subcontracted to private-sector firms	• overcome "not invented here" syndrome • allows protection of proprietary information • potentially technology transfer cost • enhance resources through cost sharing	• may be difficult to select a partner • risk and equitability problems associated with reliance on a single firm or partner
2. Working with industrial consortia	Managers of governmental R&D programs and laboratory scientists work closely with group of firms to develop a particular R&D	• focuses on market needs leading to more transferable technologies • gain access to enhanced resources through sharing of equipment, funds, and expertise • disseminates information quickly to industry	• may require special organizational units to be established which may be expensive • proprietary interests may discourage the sharing of information
3. Licensing to industry	Technologies developed with government support is legally protected then licensed to industry	• provides reward for effective technology transfer • allows many firms to benefit when the market is large	• may select inappropriate licensees
4. Influencing key decision makers	Targeting information and incentives for industrial key decision makers	• can achieve greater impact than broadcasting untailored information • provide logic for designing specific marketing approaches	• may be expensive to conduct necessary background research • may be expensive to complement
5. Working with broker organization	Trade, professional, and regulatory entities as "brokers" represent interests to various industries	• often provides an effective channel for assessing the needs of the industry and sharing R&D results • can be inexpensive • enhance resource through cost sharing	• may be ineffective or inequitable if organization's membership is limited • legal interests of the organization may distort or limit information transfer • loss of control over information transfer

Table 2. 5. Alternative commercialization strategies for government-sponsored R&D (Adapted from Brown et al. 1991)

There are several governmental strategies to support R&D, for example R&D tax credits, investment tax credits, R&D-related loans, and monetary policies, etc. However, the study on the Japanese industry indicates that those strategies are not critical influences in technology development (Crow and Nath 1990).

Universities

Universities assumed the role of the primary source of basic research in research system (Beltz et al. 1980, and Yearley 1988). Their roles in training of students and researchers, disseminating scientific knowledge through participation in conferences and publication of journals are also indirect contributions to technology development (Stankiewicz 1985, and Brust 1989). It is often argued that the contribution of universities by such indirect knowledge transfers to industry is quite effective and need not to be supplemented by more direct relationship to any significant extent. These findings support the premise that universities should focus on what is described as their principal goal, which includes the broadening of a common knowledge pool, and pass the transfer and application of knowledge to other systems more suited for the purpose (Stankiewicz 1985).

However, as society has evolved, universities need to adapt to the changing environment (Brust 1989). According to Solo:

> In the modern world, the function of the university must surely be expanded far beyond the classical ideal. Its vision must encompass the creative thrust of science-based activity outside the academic demand. It has a role to play in the system of technological advance and in economic growth, in the process of social innovation and policy formulation, and in other functional systems also (Solo 1972, 177).

A growing number of applied R&D conducted at universities is indicated in several countries including the United States (Beltz et al. 1980), European countries (Stankiewicz 1985), Japan (Rogers et al. 1998) and most developing countries (Rubenstien 1980). In addition, universities are becoming actively involved in the actual process of technology development by various mechanisms which are similar to the governmental processes. Those mechanisms are summarized in table 2.6.

Strategy	*Characteristic*	• *Advantages*	• *Drawbacks*
1. Consulting	Academic scientists and engineers are "trouble shooters", advisors, or gate-keepers for firms.	• inexpensive, and rapid mechanism • not involve extensive demands on university personnel and material resources so it leads to few institutional tensions.	• sometimes unsatisfactory to companies because consultants have limited time and specific technical knowledge.
2. Industrially sponsored R&D in university disciplinary departments	university offers R&D emerging expertise	• technologies require knowledge inputs from a large number of scientific and technological disciplines.	• university persons are not very flexible in adapting to industry's demands • high cost in time and effort required.
3. University-industry consortia	groups of companies established collective link to a university or a group of universities	• creating a very intimate long-term link between industry and university • bringing the appropriate matching of the industry's needs with the opportunities offered by the university	• it works well only when relatively few highly sophisticated companies are involved.

Table 2. 6. Alternative technology development strategies for universities (Adapted from Stankiewicz 1985)

In addition, Brust (1989) indicates that universities are becoming actively involved in the actual process of technology transfer by negotiating licensing agreements with manufacturers, by establishing subsidiaries to market new products, and by developing programs to encourage entrepreneurship among students and faculty members. Faculty business start-ups appear to be increasing in frequency and popularity as technology transfer mechanisms, in some advanced countries, as a result of this trend (Roberts 1966, and Waugaman 1990). Such roles help the university to accomplish its objectives of education and technology movement as well (Roberts 1966).

Industry

Although government and university laboratories existed earlier, it is indicated that the first specialized R&D laboratories were established in industries in the United States in the 1870s. Since then, a much greater part of the technological progress has been attributable to R&D work in specialized laboratories or pilot plants in industry (Freeman and Soete 1997).

Firms usually have rather a short-term or medium term perspective for their R&D investment. It is unlikely that firms will finance much in basic research which is often very long term by the time scale and is difficult to predict the ultimate benefit to them (Braunstein et al. 1980, and Freeman and Soete 1997). Absolutely, some firms support basic research because the huge spread of their product portfolios is more likely to yield results of interest to them. Still other firms need to gain access to and understanding of the results of research conducted elsewhere or to recruit good scientists. These trends have developed in the European and United States industries (Stankiewicz 1985, and Freeman and Soete 1997). However, it is argued that the recruitment of university graduates with an up-to-date knowledge of scientific instruments, mathematical and computer techniques, derived from recent university research, was often as important or more important than the results of the basic research itself (Freeman and Soete 1997).

Furthermore, the evidence shows an apparent decrease in long-term R&D and basic research in industry itself, and steady growth of industrial support to academic research at least in the United States. It is explained that while becoming increasingly aware of the importance of basic research for technology development, industry realized more clearly its own limitations within this domain. With a few exceptions, the industrial research laboratories have not proved themselves to be good environments for the pursuit of fundamental knowledge. As a result, many firms have started to seek direct links to the universities and to use their in-house basic R&D as transmission mechanisms (Stankiewicz 1985).

At the same time technological potential of universities increases as the result of environmental changes, there is a growing concern with its effective utilization. A better coupling needs to be established between academic technology and private industry (Stankiewicz 1985). This suggests the role of industry technology for utilization in R&D collaboration.

Despite the fact that industry is the technology recipient, either from governmental sponsored, or university-cooperative R&D in which several mechanisms are already discussed, it carries particular roles as well.

One important role among those is providing inputs to its partner. Fusfeld believes that:

> There will be areas where it is not economical for the private sector to conduct research and development either because the market may not justify the probable costs, or because the required technical effort is too large for private resources. Both situations define an inherent imbalance between research and development and the ability to convert it to use. The function of the industrial community in these cases is to provide recommendations to minimize the mismatches by involving the private market development capabilities in the first case, and so structuring the technical program in the second case that effective involvement of private sector research and development can aid the transfer process.

> In other words, there are necessary inputs from the industrial research community in the planning, conduct, and exploitation of any active government programs intended for the civilian sector (Fusfeld 1979, 240).

Thus it is a crucial role for the industry to add an understanding of marketing and economics along with the ability to engineer (Fusfeld 1979, and Hecker 1988). In addition, in his study on technology transfer from the federal laboratories to the industry, Hecker (1988), asserts that the strength of the industry as having "developed ideas much beyond initial expectations and, in turn, spawned new ideas and innovations" (Hecker 1988, 27).

Biotechnology Development in Thailand

Biotechnology is categorized as high technology which over the past decade tremendous amounts of time and money have been invested in exploring techniques (Eisenberg et al. 1993). The commercial potential of biotechnology was greatly expanded by a series of scientific advances that culminated in the development of genetic engineering techniques during the mid-1970s (Pisano 1990, and Leopold 1993). Biotechnology is a revolutionary technology that provides opportunities for emerging industries. The commercial success of many products derived from biotechnology are demonstrated in the advanced countries such as the United States, Japan, the European countries, and Canada where innovative steps are taking by biotechnology industries themselves. It is recognized that such industries must rely on government and academia to help fulfill the scientific and technical challenges upon which their viability counts, and also tackle the obstacles of all sort (Kozmetsky 1990, and Leopold 1993). However, there have been no major commercial successes in biotechnology in Thailand, even in the newly industrialized countries (NICs) of Asia (TDRI 1992b).

Definition of Biotechnology

Biotechnology is a word that was invented on Wall Street (Teitelmen 1989). Biotechnology has been defined as "any technique that uses living organisms (or part thereof) to make or modify products, to improve plants or animals, or to develop microorganisms for specific uses" (OTA 1984, 3). Biotechnology has broad applications to create or improve products in agricultural, health, and industrial sectors.

Biotechnology R&D Implication in Thailand

Thailand is a country traditionally rich in natural resources, advancement in technology as biotechnology, complemented with innovative management practices, is believed to be a means to raise the value of agricultural products (Sriwatanapongse 1997). In the health and medicine field, great demands for pharmaceutical products namely antibiotics, vaccine, and diagnostic reagents are imported. This is due to the lack of technology and know-how for the production of these items. Biotechnology R&D can play a role here to develop the technology to apply the country's rich raw materials such as rubber, rice, tapioca, cotton, livestock, and aquatic animals (TRDI 1992a).

In the industry sector, biotechnology R&D activities can also help the development of production processes to transform plentiful bioresources to value-added products. For example, instead of importing a substantial amount of enzymes from abroad each year, through biotechnology process, Thai firms will be able to produce such enzymes using raw materials in Thailand (TRDI 1992a).

Prior Case Studies on Biotechnology R&D

Among the main conclusions of Thai R&D capability in biotechnology, TDRI (1992b) argues that:

> Commercialization of products and prototypes has not been successful. It was found that there was a lack of personnel to program and manage the various steps of commercialization, in taking a technical step from inception to the market application. The Government and private sector have not worked together to support close cooperation. Training and information dissemination was generally not a key component of the projects (TDRI 1992a, vi-vii).

In 1992, the case studies on biotechnology R&D projects in Thailand were conducted to evaluated completed biotechnology projected funded by the government agency. The projects included the three main branches of biotechnology; (1) agriculture, (2) health care, and (3) energy and waste treatment. The research groups working on these projects extended from highly experienced to relative novices. A wide geographic distribution in the institutions where the R&D activities were carried out are also indicated (TRDI 1992a).

Interestingly, from the technical perspective, the outcome of the projects evaluation was valued to be positive. The Thai researchers on the projects were capable of producing solid technical outcomes, given experience and a critical mass of qualified personnel. In addition, the R&D outputs i.e., patent, scientific papers in both international and national journals, graduates students, and trained people demonstrate the achievement of the projects. However, there was no project that has yet produced satisfactory results for any concrete utilization (TRDI 1992a).

Though most projects evaluated were capable of supplying various concrete results in terms of products, process prototypes, and technical know-how. TDRI (1992b) argues that the development and marketing of such products was inappropriate though some usefulness was obtained from them. However, the downstream impact of these outputs was inadequate. For example, they could not be produced at a price that would match that of imports or, could not meet what the market was willing to pay. In addition, effective demand in the market is weak, or did not exist in some project. The limited impact appeared to result mainly from a deficient understanding of the full nature of demand in the marketplace for such products and from weak linkages between the research laboratories and the commercial sector. Even though in several cases, contacts between individual researchers and the private sector had been made, no concrete institutional linkages appear to have been established between research institutional and industry.

It should be noted that commercialization is the most significant step for the type of biotechnology R&D in these case studies. TDRI's recommendation reflects the need of participation processes among R&D stakeholders toward commercialization which is the core of this study:

> It is recommended that there should be a concerted and planned effort by various parties, including researchers, government agencies and the private sector, to ensure successful commercialization and technical projects. Each of these entities has an important role and set of inputs to contribute to in the commercialization process. At a first step, these various parties need to jointly develop project concepts and designs and develop well-conceived project plans. Research teams can then work primarily on their own until results have been developed to the point where pilot testing can be carried out. Industry then needs to become more actively involved, both in implementation and in financing. The role of the Government agencies should be in establishing incentives and in facilitating and developing mechanisms to establish appropriate linkages.
>
> At the policy level there is also a need for more concrete initiatives in order to make high-technology research outputs more marketable. One reason for non-marketability is the tendency to emphasize achievable scientific and technical goals

rather than commercial goals. In order to prevent the hitherto relatively ad hoc and scientifically-oriented proposals initiated by researchers, mechanisms must be put in place whereby commercializable areas are identified, and steps to promote proposals with a great commercial orientation need to taken and well-coordinated. Cooperation and collaboration can be enhanced by having researchers from different institutions and the private sector critique potential research work presented at open forums and convened by the funders. Familiarity with one another arising from such forums may bring about greater trust and mutual benefit (TRDI 1992a, viii-ix).

Management Implication

The overview of several perspectives about technology development indicates the need for effective management of R&D especially at the interorganizational level. This section presents the concepts of participation processes and technology policy to address the management implications of this research effort. These concepts will be the basis for the research model and research design of this research.

Participation Processes

As suggested in the technology development section of this chapter, three main parties involved in the R&D process in technology development are government, university, and industry. Thus, individuals from these sectors contribute to the R&D process. It is unlikely that all stakeholders have the same perceptions about technology because technology has different meaning or value to each stakeholder (Gruber and Marquis 1966, Allen 1977, William and Gibson 1990, and Fairweather 1990). This section provides an analysis about the conflicts of R&D management to underline the importance of participation. Concepts describing organizational network and knowledge processes will be discussed as the framework for the research model, and research design of this study.

Conflicts on R&D Management

With the continued and rapid growth of collaborated R&D in government, universities, and industry, scholars of organizational behaviors have been increasingly interested in the management and internal social relationships of R&D organizations. One major trend of this interest is based on the assumed divergence of perspectives occupied by scientists, engineers, and managers (Marcson, 1960, La Porte 1965, and Alexander 1981).

The existence of conflict between scientists and management is caused by their contrasted views on goals, organizational structure preference, procedure constraints, incentive, authority relations, and time frame (La Porte 1965). An image of the scientist in a research organization is a professional who seeks to expand an understanding of nature. A professional orientation means that the scientist seeks both sufficient freedoms to explore his/her curiosity, and proper facilities for that exploration. He/she has spent much time gaining the necessary knowledge and learning the tools of his/her discipline to ensure technical expertise, and he/she places a high standard on conducting research with dedication and rigor. The scientist is committed to a career seeking scientific discoveries that will bring recognition and endorsement from the small group of peers whose opinion he/she accepts. Most often he/she prefers funded research that encourages the development of scientific knowledge, i.e., more basic or fundamental research, rather than research that is based to the application in order to solve industrial problems (La Porte 1965, and Alexander 1981). Because of his/her lengthy professional training, the scientist develops such needs as recognition, involvement, and self-realization, which in time, come to define his/her goal (Marcson 1960).

Such a stereotype seems to be more typical for the academic scientist. For scientists in the academic world, prestige is at a premium. This system values prestige for publications derived from research (Connolly 1983 and Yearley 1988). As a result, their professionally oriented rewards are freedom to publish, funds for attending professional meetings, and promotion based on technical competence (La Porte 1965). Regarding the transfer of their research results, scientists in universities are not likely to experience or have training in requisite engineering and business development, furthermore, their interests most often lie in the intellectual challenges of research rather than devoting themselves to the commercialization of their work.

Unlike the scientist, the engineer is relatively more concerned with contributing to the goals of the work institution, gaining recognition from hierarchical superiors, conducting research in order to gain personal rewards of status, salary, etc. The engineer's self image is that one trained with a special expertise that is necessary to transfer technical and scientific knowledge to that of goods and services to meet societal needs. Business and industry sectors are engaged in precisely that activity. Therefore, the engineer's attribute seems to be more adjacent to the management line in the industry (Alexander 1981).

Some analysis of engineers in the industry discusses some behavioral traits of engineers whose expertise does not provide value to the manager. These traits which include structured, linear thinking, thing or object oriented versus people oriented, specialist versus generalist, rigid, low tolerance for ambiguity, and the tendency toward perfection indicate the convergent personality of the engineer. On the other hand, the manager traits are inclined to the divergent scheme. The difference is on the preferred mode of learning, teaching, problems solving, and indeed the approach toward life. While the convergent personality seeks to move from general to specific, and deal with the tangible, orderly, here and now, the divergent mind would be bored with the situation for which a "solution" was known in advance. Although most people may demonstrate convergent and divergent personality at the same time, the majority of mindset of each career group represents its different personality (Gibbon 1981).

At the organizational level, the differences of culture between academic institutions and industry are discussed by the literature. Such differences are reflected by distinctions in mission, methods of operation, and emphasis on freedom of inquiry (Fairweather 1990). The goal of a business corporation is to make a profit (Marcson 1960, La Porte 1965, and Fairweather 1990). Specifically, it strives to meet competition, to increase its share of the market, to enter new markets with new products or services, and to bolster its position and prestige in its broad field of activity (Marcson 1960). On the contrary, the universities' desire is to produce and disseminate knowledge (Beltz et al. 1980, Yearly 1988, and Fairweather 1990). To achieve these different goals, universities are more inclined to emphasize basic research and open publication of research results whereas industry focus is product development and proprietary rights (Fairweather 1990, and Wigand 1990).

Academic missions including education, training, research, scholarship, and service are complex and often contradictory. It is difficult for universities to pursue them with equal fervor, or to choose between them under scarce resources. It has been discussed that a university and a corporation may have an overlap of mission in one area.

For example, medical research directly conflicts with other academic missions, such as instruction (Fairweather 1990).

The concept of the time frame for completing tasks also differs between industry and the universities. Universities assume that practical applications of basic research results will benefit society in the long run. On the other hand, industry needs to minimize the lag time between research and application since it needs to seek a profit (Fairweather 1990).

The government seems to have moderate capacity for commercializing technology. Hisrich (1988) indicates that few innovations resulting from government-funded, technologically sound scientific research that eventually reaches the commercial market. The government's bureaucracy style seems to conflict with its counterpart in industry.

> Since much of this government-funded research has limited application to any social need, any commercialization that results require a significant amount of modification and technical application in order to achieve market appeal. Although the government has the financial resources to transfer a technology successfully to marketplace, frequently the necessary business skills (particularly marketing and distribution) are lacking. The bureaucracy and red tape often prohibit the new industry from being formed in the timely manner necessary for success. Also, anachronistic impediments deter effective performance and commercialization (Hisrich 1988, 62).

The lack of "demand pull" in the government side is also indicated by Beltz et al. (1980). From their analysis, governments do not generally have the capability either to demand or absorb sophisticated technology/scientific techniques or information. While industry is more active to employ a "demand pull" strategy, the assistance from government for commercializing R&D without such a strategy is difficult to accomplish.

At the administrative level, the public officers usually want quick, simple answers, and analyses according to their format to present to public audiences (Folger and Orwig 1976). From the universities' perspective, this attitude demonstrates "incremental mentality" which is a restraint for researchers who receive the grant. As Folger and Orwig explained:

> . . . in the sense that legislators and other officials want presentations that are simple and in a familiar form. Complex answers have a hard time getting an audience among state-level policy makers, even when there is a complex problem involved. As long as the ultimate decision makers (whoever they may be) don't react favorably to complicated or quantitative analyses, there will be a very strong tendency to keep them simple and not waste time on research or multivariate procedures which don't get hearing anyway (Folger and Orwig 1976, 25).

Government policies in linking academic research and industry may obstruct the university's missions if carried out or implemented in an extreme style. They can distort and undermine the research by accommodating universities to focus excessively on short-term research that could be carried out in other forms of institution. This may be disturbing to the traditional mission of universities to conduct long-term, curiosity-driven research and to convey knowledge to new generations of students (OECD 1998).

The need for integration of such different attitudes among stakeholders at either a organizational or interorganizational level is embedded in the need for collaborative R&D toward commercialization. Participation among stakeholders should play a linking role to resolve conflicts through coordination among different groups.

Interorganizational Network Approach

Interorganizational network approach offers a means of an analysis of an interorganizational relationship. Such an approach is based on the interaction between two organizations affected, in part at least, by the nature of the organizational pattern or network within which they find themselves. For instance, the interaction between two department stores of a given size will be somewhat different if there are only two department stores in a medium-sized city from what it would be if they constitute two out of twenty different department stores of approximately the same size in a city (Warren 1967). A network can be defined as all the linkages between actors in a system. Therefore, network analysis is an analytical tool; however, it has been grounded fundamentally in theories of exchange, power, and resource dependence. According to Auster (1990), the key assumption underlying this network approach can be summarized as follows:

- Actors attempt to establish linkages in order to acquire resources or information about their environment, coordinate competitive interdependence, or reduce competitive uncertainty and thereby increase their power.
- Action is viewed as intentional; thus, ties between actors are established, maintained, or broken because of their perceived value.
- Networks represent interconnected flows of resources and resources dependencies (power relationships) between actors. The flow, its causes and consequences are the focus of network analysis.
- Networks are dynamic, their configurations shift and change as actors attempt to gain or balance power by redisturbing resources.

A network perspective can be applied to organization sets as well. An organization set is a set of linkages of one local organization. The linkages of Toshiba, General Electric, and General Motors shown in figure 2.3 are examples of organization sets of new linkages formed for that time period. Many dimensions used for structural analyses of networks are suggested as organization sets as in table 2.7.

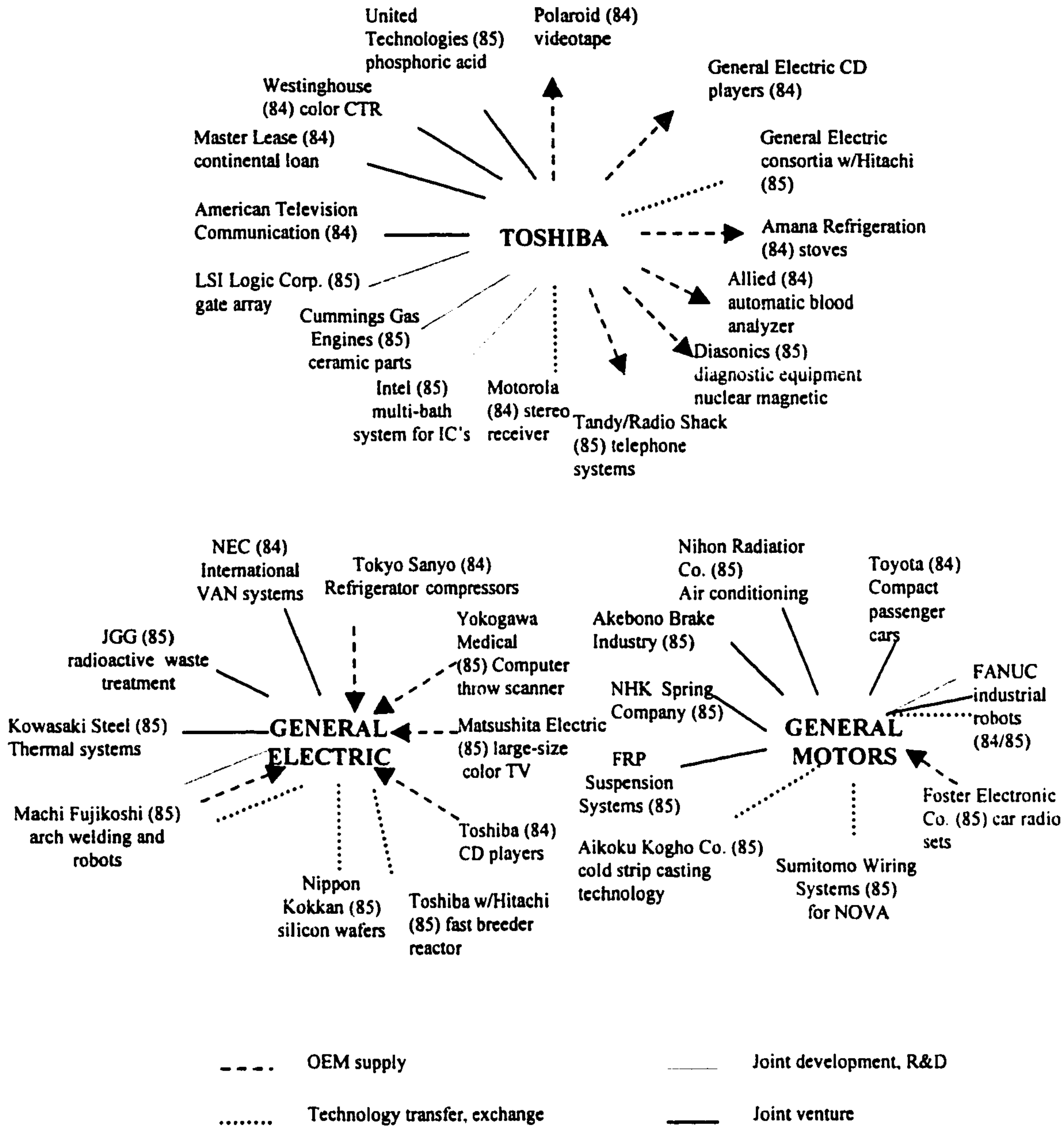

Figure 2. 3. A comparison of the organization sets.
(Adapted from Auster 1990)

A comparison of the organization sets in figure 2.3 for instance, demonstrates several interesting patterns. From the number of linkages, General Electric was slightly less active than Toshiba (12 vs. 16), the proportions of different forms of linkages are roughly the same (4 vs. 4) except in the joint R&D category where General Electric had half as many as Toshiba (8% vs. 19%). They present a contrast in the strategy of a large auto company in the United States and a large auto company in Japan conceptually.

Network as Focus of Analysis	
Size	• number of organizations in the network
Density	• number of linkages in the network
Diversity	• linkage: number of different types of linkages in the network • organizational: number of different types of organizations in the network
Stability	• linkage: whether the form of linkage in the network remains the same over time • organizational: whether the organizations in the network remain the same over time
Frequency of change	• how often linkages or organizations change
Magnitude of change	• how many linkages or organizations change

Table 2. 7. Structural dimensions of networks.
(Source: Auster 1990)

An organizational field is a functionally integrated system of interacting populations. The study of an organizational field focuses on phenomena that cut across multiple populations and institutions to achieve common or mutually supportive interests (Warren 1967). Interorganizational network across academic, business, and government organizations which motivates the formation of high-tech centers, provides an example of research applications of a network perspective in the literature (Auster 1990).

In analyzing interorganizational relations, Evan (1963) also identifies strategic dimensions of an organizational field as input vs. output organization- field, comparative vs. normative reference organizations, size of the organization-field, concentration of input organizational resources, overlap in membership, overlap in goals, values, and boundary personnel. The identification of these dimensions leads to the formulation of some hypothesis about how organization fields are needed for various interorganizational-processes, such as coordination, cooperation, and conflicts which are the core of this research.

Knowledge Processes

Theoretically, the concept of knowledge processes includes the idea of social transformation through dialogic processes. As Young proposes:

> Dialogic process is recognized as the predominant mode for creating new action patterns and working relationships through a mutual desire to share information based on experience and expertise in such a way to move toward a synchronicity. In this process, the creation, transformation, maintenance, and dissolution of distinctions occur. Such distinctions are the substance of knowledge (Young 1996, 53).

The concept of knowledge processes is an important theme in R&D management context. Drongelen et al. (1996) define that "knowledge is information internalized by means of research, study or experience, that has value for the organization." Therefore, it is that part of the information used explicitly or implicitly in the R&D process. The decision made in the R&D strategy determines the possibilities and barriers to sift, store, open-up, convey, inquire, and apply potential knowledge. Many R&D strategy's characteristics that influence the performing of these activities are identified in table 2.8.

Management measures can be derived from the most influential management characteristics in the R&D strategy which are listed in table 2.8. To map them with those characteristics would identify the bottleneck of knowledge processes, and act as an aid in formulating improvement plans for the R&D in the future (Drongelen 1996).

R&D Performance Criteria	*R&D Process Design*	*R&D Technology Design*	*R&D Organization Design*
Financial criteria	*R&D process-* innovativeness, complexity, size of time, and budget, project phase	*People*-number of people, personal networks, drivers of motivation, personal qualities, traceability and accessibility of people	*Structure*-physical distance between units/team members, project coordination mechanisms, transfer mechanisms, group constitution
Customer satisfaction criteria	*Strategic, adaptive and operational (R&D) management process*	*Tools-* communication tools (e.g. QFD)	*Culture-* interfunctional climate, informal contacts, communication, people role
Internal process performance criteria	*Supporting process*	*Equipment-* kind and volume of IT equipment (e.g. database, E-mail), functionality of IT equipment, accessibility of equipment	
Innovation and learning performance criteria			

Table 2. 8. Influential characteristics of the R&D strategy on knowledge accumulation and dissemination

(Source: Drongelen 1996).

Technology Policy

Why is technology policy important? In a process of technological development appropriate interrelation among a large number of factors needs to be discovered. It is a process that organizations enter when it is not clear priori, that any successful combination of variables actually exists (Goodman and Lawless 1994). Technology policy can play an important role to reduce an uncertainty during the technology development process. Organizational top management requires information and experiences to make appropriate technology strategy and to decide the direction of technology development in the future.

Formulation of Technology Policy

Technology policy is a general managerial perspective that serves to mediate the dilemmas in ongoing issues concerning the research, development, and implementation of new products and technologies. "Technology is invested with meaning and expectations, and any account of its role in modern society must recognize the implications of this process" (Street 1992). However, technology is simultaneously helpful and threatening for individual, organizational, and societal levels. More frequently, unpredictable results arise during technology development. In addition, the relative obscurity of the technology "concept" is attributable to misunderstandings among people. Technologists tend to emphasize the future value of a new development while understating the underlying technological process needed to deliver such potential (Goodman and Lawless, 1994). Therefore, some people experience a sense of disappointment from technology. Technology policy is an instrument to control the direction of technology satisfactorily. It should act as an interface between technologist and non-technologist and provide strategic benefit. The importance of technology policy is obvious at all management levels where long range decisions have to be made both with respect to R&D. Therefore, technology policy has to be considered at the national level and corporation levels. In the case of technology policy at the national level, a policy or a strategy aims at the general technological performance of industry, or the technological needs of society as a whole (Smith 1996). In the case of corporate strategy, it is considered in integral solutions regarding partners for raw material supplies and for exports in selected markets (Pelc 1980).

Implication of Technology Policy in Thailand

It is recognized that the key problems mentioned in the prior case studies (TDRI 1992a) are associated with the difficulty in collaboration process among several technological subsystems. One major difficulty is the limited access to industrial information, even at a basic level because much of information is not published (TDRI 1992a). Insufficient linkages among universities, government, and the private sectors are observed (Yuthavong et al. 1985, and TDRI 1992a). Yuthavong et al. (1985) also discuss that to overcome problems related to promoting science and technology and their applications, Thailand require some attributes. Two among of them are:

- a climate needs to be creative--favoring the scientific and technological approach to solving problem in development, and
- public appreciation of capabilities and limitations of science and technology needs to be cultivated.

These two attributes need the involvement of participation, particularly knowledge processes. As Young's suggests "participation, like knowledge processes, must be encouraged at all levels of the organization through *dialogue*, where the creation of new action patterns and the mutual desire to share them provides the basis for social transformation" (Young 1996, 137).

Summary

The first section of this chapter presents the overview of technology development. Technology is not only established by the conception of knowledge, but also communicated to the utilization. As R&D is a tool of technology development, it is important to focus R&D management roles to make effective communication of knowledge in the R&D process. The literature reviewed in this chapter presents the issues of R&D management, for example, the perspectives on R&D assessment, also the organizational roles in supporting technology. However, the contexts of R&D management in developed and developing countries are dissimilar. The focus on biotechnology development in Thailand narrows the research to the specific context. This particular makes the research filling the gap of understanding of R&D processes in the developing country. In the second section, the managerial implications regarding technology development provides a framework for thinking about participation processes and technology policy. Conflicts in R&D management are evident at either individual level or interorganization level due to the different perspective on R&D process and management style. The overview of the interorganizational network approach provides an alternative to analyze the relationship among the stakeholders at the interorganizational level. This tool is used in the research model to facilitate the understanding of the participation in the R&D process. The background of knowledge processes presented in this chapter exhibits their significance in participation processes, which is useful in the formulation of a technology policy for the R&D development.

CHAPTER 3

RESEARCH FRAMEWORK

This research applies a classical model of technology transfer proposed by Gruber and Marquis (1966), as well as an interorganizational network approach proposed by Auster (1990). These models are formulated to explore participation in R&D project development, among stakeholders in each channel of technology transfer and to determine how participation leads to success in term of technology transfer and product commercialization. The technology transfer model (Gruber and Marquis 1966) exhibits, through time, the flows of science, technology, and the utilization of technical outputs. This will help identify stakeholders in each channel of technology transfer. At the same time, the interorganizational network approach (Auster 1990) offers a tool to consider interorganizational relationships. Also, participative approaches (Wheatley 1992, Leonard-Barton 1995, and Ellinor and Gerard 1998) are applied here to explore the relationships of the stakeholders. Finally, the research model is formulated.

Technology Transfer Model

As discussed in chapter 2, technology transfer can occur between the three flows of science, technology, and utilization. According to Gruber and Marquis (1966), the model (Figure 2.2) provides a topological view of the relationship between these three channels. By using this model, it is conceivable to identify the various loci of transfer that may take place. It is also possible to consider the communication pattern in any channel that facilitates technology transfer. However, the success of technology transfer identified in this research context is consistent with the reviewed literature (Dakin and

Linsey 1991, and Kozmetsky 1990) in which the aim of technology transfer is the commercialization of usable product or process.

Technology Life Cycle

The technology life cycle is composed of 7 stages; Concept, Research, Development, Manufacture, Distribution, Sale, and Use (Figure 3.1). In each stage, there is an opportunity for its actors to contribute in the transfer of technology for commercialization (Dakin and Linsey 1991). Some actors may be active in more than one stage, and the technology life cycle sometimes does not progress in a linear fashion. Thus, the actors or stakeholders in each stage of the technology life cycle, as well as their contribution are ordinarily identified as scientist, engineer, industry, and user.

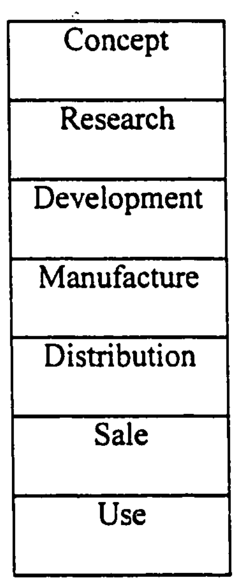

Figure 3. 1. The technology life cycle.
(Source: Dakin and Linsey 1991)

Generally, scientists are the main actor of the concept stage. To initiate any technology, scientists have to come up with new scientific knowledge. This knowledge at first is best described as an idea, or assumption, that is intangible. This knowledge or assumption requires further development and/or insight. This develop or insight is done in the next phase, called the research stage. Scientists need to test or prove the scientific principles on which the concept or idea is based. The concept of new technology becomes more tangible at this stage. Engineers may aid scientists in the research stage at some points, however, participation is primarily seen during the development stage. The development stage tests the hypothesis underlying the technology, and tests the economic viability of the technology/product. The technology represents a prototype with cost estimates and economic data that is necessary to bring the product and/or technology to complete commercialization. Industry has the main control in the manufacturing, distribution, and sale stages since industry needs to invest a lot of money in the technology within these stages. Finally, end-users are involved in the use stage, during which the technology is actually consumed. This view presents classical actions of each stakeholder in the technology life cycle (Dakin and Linsey 1991).

Contribution of Stakeholders in the Technology Life Cycle

However, there are other stakeholders involving in the technology life cycle. The government plays a role in granting funds for R&D projects. In addition to funding opportunities, the government also provides technical advice in the research and the development stage. Other organizations may contribute in the technology transfer process by providing consulting and training (Allen 1977). Furthermore, regulation control organizations may be involved in the issue of the application of appropriate technology (Brenner 1993, and Beardsley 1994). These stakeholders are identified assuming that they have a chance to participate or communicate their idea during the R&D process in some stage of the technology life cycle, and their ideas may influence the commercialization (Table 3.1).

Possible Stakeholder	***Stage in Technology Life Cycle***	***Contribution***
scientist	concept, research	invent something from a new concept (research, **R**)
engineer/extension agent	development research	develop or scale up an invention into a product/process with an estimate cost (development, **D**)
initial users • industry sector	development manufacture distribution sale	adopt an available product/process to utilize or substitute existing technology
end users • public at large	use	consume a final product
funding agency • policy manager and experts in any particular area	research development	sponsor, select, and evaluate **R&D**, disseminate information.
other professional organization • within country • abroad	research development	strengthen **R&D** by technical service, training, consultant, etc.
regulation control organization	development distribution sale	facilitate or inhibit the utilization of technology by the power of law.

Table 3. 1. Possible stakeholders of technology transfer and their contribution in the R&D project sponsored by the funding agency

As reviewed in chapter 2, the literature identifies the conflicts among stakeholders at the individual level, i.e. scientists, engineers, management, and also at the organization level, i.e. universities, government, and industry. Therefore, technology transfer is often a chaotic, disorderly process involving individuals and groups who may view the potential use of technology differently. This research was conducted so that the linkage by the participation process may reduce the various perspectives' gap among various stakeholders with the expected result of the success of technology transfer.

Participation as a Source of Knowledge

Vision is the "need for organizational clarity about purpose and direction" (Wheatley 1992, 53). Given different stages of contribution, the stakeholders are likely to have their own vision of R&D processes. In addition, they have differences of culture and value described in chapter 2. To encourage them to hold the same vision is a challenging management task presented here. Also addressing the increasing conflict when there is an attempt to integrate the diversity (Ellinor and Gerard 1998). Field theory provides a way to explain how we can take advantage of the integration of the diversity. According to Wheatley (1992), the field performs as a geometrical influence shaping behavior. When people interact or meet up with other fields, it turns people' energy into behavior for the organization. All organizational members' behavior could be shaped as a result of "field meetings," where their energy would combine with the field's form to produce behavior congruent with the organization's goal. She also concludes that creating the field through the dissemination of organizational members' idea is essential. In order words, vision of the R&D must move around and through every linkage of R&D contributors.

Participation by dialogue provides a means to disseminate the stakeholders' idea through the interorganizational linkages. Because diversity is necessary for creativity, in a quality dialogue, suspending judgment is required to extend our idea. When judgment is suspended, we are seeing the whole picture.

> We have all been on the losing end of an equation set up by judgment and have been in circumstances where it seemed impossible to find any win-win alternative because we could not see past the conflicting judgments of those involved. A "you or me" world does not inspire collaboration. Creating collaborative partnerships at work requires a high capacity for both/and thinking, to explore ways of working with conflictual situations and learn to truly value and leverage diverse perspectives (Ellinor and Gerard 1998, 69).

The idea of wellsprings of knowledge supports the creation of the understanding among partnerships of R&D processes. The wellsprings of knowledge is a process of disseminating and managing knowledge through an organization, or an entity. In her book, Leonard-Barton (1995), wellsprings of knowledge require managers who have 6 characteristics to rechannel partnerships' energies to support their technology. They includes: 1) enthusiasm of knowledge, 2) drive to stay ahead in knowledge, 3) tight coupling of complementary skill sets, 4) iteration in activities, 5) higher-order learning, and 6) leaders who listen and learn. When the wellsprings are in place, all stakeholders believe in their organizations as a source of knowledge institution and have concern about nurturing it, they will continuously contribute to the capacities that sustain it (Leonard-Barton 1995). This is a focus of this research that attempts to create the wellsprings of knowledge in the interorganizationship among R&D stakeholders.

Research Questions

This research was conducted to determine how the participation process enables product design, development and implementation in the R&D context in Thailand. This research proposes that: Participation processes in R&D project development involve the project's success in term of technology transfer. In other words, the first research problem is:

How is participation linked to the success of R&D project development?

Also, in order to understand the nature of participation processes taking place in R&D projects and compare it to the involvement of R&D projects, the second research question is examined:

How do or might various stakeholders in the R&D process participate?

In order to answer these two questions the research model and the contributing factors in the research are identified and described in the next sections.

Research Model

An interorganizational network approach proposed by Auster (1990) is applied here to measure the participation of R&D development. An R&D project is designed as a local organization forming linkage to other organizations. Figure 3.2 shows an organization set of an R&D project supported by a funding agency. Assuming that the R&D project is mainly performed by scientists in the research stage, to identify how it needs participation by others at the individual and organization levels, the linkages are made. The aim here is to make a connection for relevant stakeholders involved.

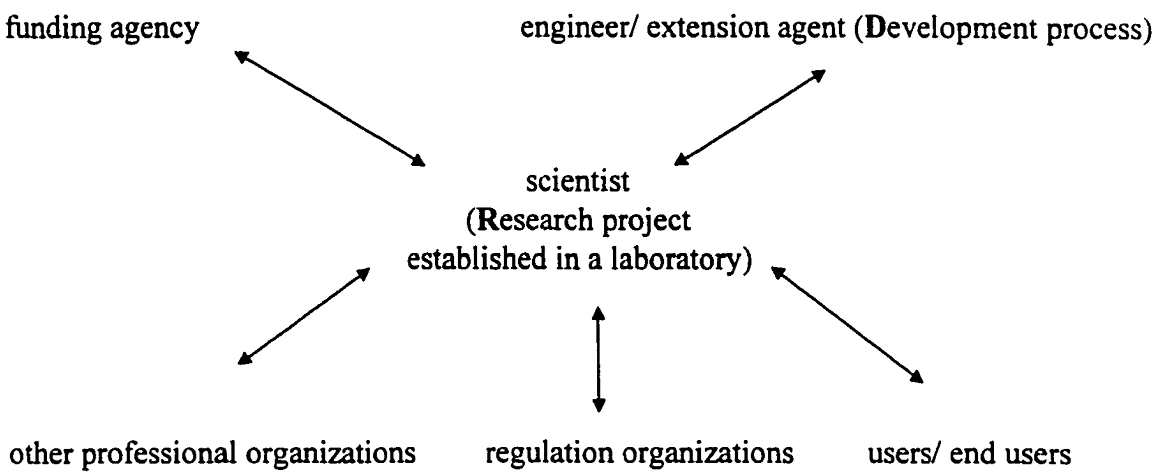

Figure 3. 2. An organization set of an R&D project supported by the funding agency

This model represents an organization set that is characterized by a set of linkages of one local organization (Auster 1990). Linkages are made to other stakeholders identified in Table 3.1. Within a set, a local organization consists of a university or a research institution where a scientist or a principal investigator conducts his/her R&D project. The first linkage is made to the funding agency, an R&D sponsor that appoints technical committee or peer-review body to monitor the R&D project. The second linkage is connected to the engineer's organization that contributes mainly in the development stage of the R&D project. The third linkage shows how organizations provide support, i.e. technical information, service etc., to the scientists conducting the R&D project. The fourth linkage is connected to the regulation organization that has authority to facilitate or inhibit the technology transfer by the power of law. The last linkage is made to the user, either the initial user or the end user of the technology. This model represents ideal linkages, however, some R&D performing group may have more or less linkages. According to the hypothesis, participation processes may have a relation to the success of the R&D project. Thus, participation processes and the success of the project are contributing factors to the research.

Contributing Factors

As TDRI (1992a) argues, commercialization of products and prototypes from R&D projects in Thailand has been successful since the gap appears to be in communication between stakeholders. This TDRI's argument provides the rational to conduct this research. It is hypothesized that participation should be a crucial tool to facilitate the understanding among them, and then support the commercialization of R&D projects' efforts. The participation processes and the success of the project are contributing factors that are measured in the research. The participation processes are the presumed cause of the success of the project according to the hypothesis, thus the participation processes are contributing factors of the success to the project. The measured operational definitions of participation processes and the success of projects are described as the following.

Dimensions of the participation processes

The participation processes cannot be measured directly. The interorganizational approach reviewed in chapter 2 provides an alternative to analyze the participation processes of R&D projects. This research model is applied from Auster's (1990) interorganizational approach and Allen's (1977) communication concept. As demonstrated in figure 3.2, while a scientist's organization is a local organization connecting its linkages to other organizations, participation processes are measured from the different dimensions of the network namely, size, density, diversity, and frequency.

These dimensions affect different features of each organization set, therefore, they are measured to compare each one between different R&D projects.

Size

The size of a network is measured by the number of organizations in the network.

Density

The density of the network is measured by the number of linkages in the network .

Diversity

There are two categories of diversity; linkage and organizational. The linkage diversity is measured by the number of different types of linkages in the network. For example, Auster (1990) suggests that three major linkages in interorganizatonal linkages created between top US electronic companies and top Japanese electronic companies. There are 8 linkages which constitute knowledge transfer in this context. Each linkage is seen as either one way (for example, receiving technical advice) or two-way (for example, technical discussion). Types of knowledge transfer include: 1) direct technical advice, 2) indirect technical advice, 3) other information advice, 4) technical discussion, 5) other information discussion, 6) joint seminar/conference/training, 7) participation in the other's seminar/conference/training, and 8) accepting staff from the other to one's own seminar/ conference/training.

The organizational diversity is measured by a number of different types of organizations in the network. Auster (1990) suggests that the diversity could be measured along a number of characteristics including industry or size. In this research context, the types of organization are classified by the contribution in three flow of technology transfer; research, development, and utilization.

Frequency

The frequency is measured by how often a linkage happens. This number is simply counted as the linkages happening during the R&D process.

Level of success

The success of R&D projects is questioned in this research whether it involves participation processes. Like participation processes, the level of success of R&D projects cannot be measured directly. Given the background of the analysis of technology transfer by the topological view of the relationship between science, technology, and the ultimate use of science and technology in figure 2.2, there are sequences of new ideas transferred between channels, for example, science to technology, and technology to utilization. R&D project results may contribute a body of knowledge; however, it may not be transferred to technology and/or practical need and use channel(s). This idea provides an operational definition of the success of R&D projects with an ultimate result of commercialization. The level of R&D success is operationalized by a five point scale in this research context (Table 3.2).

Degree of R&D Achievement					*Success*
Point Scale	*Basic Scientific Principle*	*Large Scale Development*	*Utilization*	*Customer Acceptance*	
1	no	no	no	no	no
2	yes	no	no	no	no
3	yes	yes	no	no	yes
4	yes	yes	yes	no	yes
5	yes	yes	yes	yes	yes

Table 3. 2. The level of R&D achievement operationalized by a 5 point scale.

As shown in table 3.2, the point scales 1 and 2 are defined as no success, while 3, 4, and 5 are success. These point scales are assigned according to the project's degree of R&D achievement as the followings.

- *1* is assigned to R&D that is unable to explore the basic scientific principle.
- *2* is assigned to R&D that is able to explore the basic scientific principle.
- *3* is assigned to R&D that is able to explore the basic scientific principle, and is able for the development to a larger scale.
- *4* is assigned to R&D that is able to explore basic scientific principle, and is able for the development to a larger scale, and is available for utilization.
- *5* is assigned to R&D that is able to explore basic scientific principle, and is able for the development to a larger scale, and is available for utilization, and is already accepted.

The values of the contributing factors measured in this research are quantitative data. The use of standardized measures is required from the quantitative perspective (Patton 1990). The measurement of these contributing factors provides the prediction of the pattern of their relation.

Description of Participation Processes

The technology concepts as well as technology transfer models and the science-technology-utilization topology reviewed in chapter 2 focus the importance of linkages between various components in technology development and R&D processes. In this research context, participation is described in terms of knowledge conveying in the R&D project. In order to have the "thick description" of the participation processes, the qualitative data is collected. The particular perspectives of relevant R&D projects' stakeholders identified in table 3.1 and figure 3.2 are accessed. The perspectives of the stakeholders toward R&D are constructed and categorized to make sense of what was going on during the R&D projects. The phenomena observed from the sources of data, i.e., the document, the interview, and the questionnaire are explained to extend the understanding on those perspectives. Then the actual participation processes are probed and explained of how they hinder or facilitate knowledge conveyance among stakeholders who hold similar and different perspectives, and how the processes hinder or facilitate the success of the R&D project. Finally, the participative approaches from organizational scholars such as Wheatley, Ellinor and Gerard, and Leonard-Barton will be applied to make research implementation.

Summary

This chapter provides the overview and the research questions to construct the research model for analysis. Two problem statements, 1) *How is participation linked to the success of R&D project development?* and *2) How do or might various stakeholders in the R&D process participate?* guide the formulation of the research model to find the relation of the contributing factors and the explanation of the phenomena for the answers. Basically, the technology transfer concept of Gruber and Marquis (1966) is applied to construct the operational definition of the success of R&D. The interorganizational network approach of Auster (1990) is applied to determine participation processes of the R&D project, as well as to construct the operational definitions of their dimensions, i.e., size, density, diversity, and frequency of each network or project. The definition of the organization diversity is assigned following the concept of Gruber and Marquis (1966). The description of the participation processes in the R&D project is constructed from the qualitative data, in order to make the understanding of the relationships of the stakeholders in the qualitative sense. Also, participative approaches from organizational scholars will be applied to the data to make research implementation.

CHAPTER 4

RESEARCH METHODOLOGIES

"Methodologies provide the blueprints that prescribe how the tool should be used" (Potter 1996). There are two dominant methodologies in favor of social science research; quantitative and qualitative. Considering the research questions; (1) *How is participation linked to the success of R&D project development?* and (2) *How do or might various stakeholders in the R&D process participate?* leads to the consideration of combining the two research methodologies; quantitative and qualitative. The first research question requires the finding of the relationship of the two contributing factors, participation processes in R&D project development and the success of R&D. The quantitative methodology prescribes an appropriate systemic method to collect quantitative data, and develop quantifiable schemes for coding the data set (Jick 1979), therefore, it is an appropriate alternative to use in the inquiry of the first question.

On the other hand, the second research question requires that the study of participation processes be searched in depth and detail. The qualitative methodology prescribes the methods to produce "descriptive data" (Bogdan and Taylor 1975, 2). "Qualitative analysis is addressed to the task of delineating forms, kinds of social phenomena; of documents involved in detailing the things that exists" (Lofland 1971, 13). Consequently, the qualitative methodology is suitable to the research regarding the second question. These two methodologies can be combined in the research since mixing two methodologies or "triangulation" provides strength to the research (Jick 1979, Bryman 1984, Patton 1990, Tebes and Kraemer 1991, and Potter 1996). The issues lead to the selection of each methodology and the concept triangulation are illustrated in this chapter.

Quantitative Methodology

The quantitative methodology contrasts with the qualitative methodology in several issues. Among of them are the basic beliefs, the analysis, the role of researcher, and the kind of information (Table 4.1). Materialism and objectivity, deduction, independent researcher, and measurable data are the research dimensions relating to the quantitative methodology. These four dimensions are reviewed to give the basis of selecting the quantitative methodology to the particular part of the research.

Research Issues	***Quantitative Methodology***	***Qualitative Methodology***
Issue of Beliefs		
Ontology	materialism	idealism
Epistemology	objectivity	subjectivity
Analysis Approach	deduction	induction
Role of Researcher	independent	interactive
Kind of Information	measurable	textual

Table 4. 1. The contrasts between the quantitative and qualitative methodologies in particular research issues

Basic Beliefs: Materialism and Objectivity

The quantitative methodology is addressed to the task of assigning numbers to the data (Schwartz and Jacobs 1979). The background on selecting the methodology of doing research is based on the thinking issues of fact and belief. Two philosophical issues, ontology and epistemology are the concerns in the nature of research (Potter 1996).

According to Potter (1996), ontology is the concern about whether the world exists, and if so, in what form. The quantitative methodology directs to materialism on the ontological continuum. From the materialism stand point, it is believed that there exists a material world of anything whether it is perceived or not. Epistemology is the concern about our grasp of reality in order to have explanation on scientific knowledge. The epistemological issue poses the questions of knowledge such as "How can we acquire knowledge in the first place?, By what channels do we come to know and understand the world?, and Why supposed, indeed, that we know anything at all?" (Barnes 1982, 22) To answer such questions, the epistemological position is determined by the ontological position (Barnes 1982, Guba and Lincoln 1994, and Potter 1996). In other words, materialism belief leads to objectivity positioned on the epistemological continuum. The researcher believes that the thing exists independent of people, therefore, the objective interpretation can be made by the systematic method.

In this research, the first research question "*How is participation linked to the success of R&D project development?*" seeks the relation among phenomena. The systematic view of phenomena needs to describe by the relation of the contributing factors. The materialism belief is presumed that the phenomena exists independent of the researcher, therefore, the objective belief is checked by assigning a number to the contributing factors, measuring, and presenting them systematically.

Analysis: Deduction

Deduction is the process of starting with general principles, then constructing an argument exhibiting that the evidence supports those general principles. The general principles may be a formal theory, a scheme, a model, or an ideological position (Potter 1996).

The reasoning deduction is a nature of the quantitative methodology (Kerlinger 1992, and Potter 1996). In the quantitative analysis, the consequences of the hypothesis are deduced to arrive at the problem. The hypothesis is allowed to be formulated with some clues (Kerlinger 1992). With such an assumption, the hypothesis presumed in this research can be formulated since the relation of the factors argued in the literature is recognized. The analysis may reject or conform the hypothesis (Kerlinger 1992), which guides to the prediction and the understanding of the relation of the two factors; participation processes and the success of R&D project.

Kerlinger (1992) supports the power of deduction. When a hypothesis is deduced, the consequences may arrive at a problem quite different from the one the researcher started with. On the other hand, the reasoning-deduction step may help the researcher to believe that the problem cannot be solved with present technical tools. Reasoning may change the problem. The initial problem may be a special case of a broader, more fundamental and important problem, then the research may restart with a narrower hypothesis. Reasoning-deduction can help lead to wider, more basic, and thus more significant problems, as well as provide operational implication of the original hypothesis. Reasoning-deduction suggests narrowing of the hypothesis to this research. Since the prior case studies (TDRI 1992a) were already conducted with the broader problem of technology transfer in a specific context, the present research hypothesis is narrower and focused on participation processes problem within the same context.

Role of Researcher: Independent

The relationship of the researcher and phenomena in the quantitative methodology is reflected to the basic belief of objectivity and materialism. The researcher is independent of the thing being researched. Theoretically, the researcher views events from the outside (Bryman 1984, and Sandelowski 1986). If the researcher believes something is so, he/she must somehow or other put his/her belief to a test outside himself/herself (Kerlinger 1992). Through questionnaire items concepts can be operationalized: objectivity is maintained by the distance between observer and observed along with the possibility of external checks upon one's questionnaire; replication can be carried out by employing the same research instrument in another context (Bryman 1984).

The use of the operationalized research instrument instead of the collaboration of the researcher is advocated in the quantitative study. Kerlinger (1992) argues it as the "method of science" along with the Peirce's statement.

> To satisfy our doubts, . . . therefore, it is necessary that a method should be found by which our beliefs may be determined by nothing human, but by some external permanency-- by something upon which our thinking has no effect . . . .The method must be such that the ultimate conclusion of every man shall be the same. Such is the method of science. Its fundamental hypothesis. . . is this: There are real things, whose characters are entirely independent of our opinions about them . . . (in Buchler 1955, 18).

The characteristic of "self-correction" allows built-in checks along the way during the research. The checks are anchored as much as possible in reality lying outside the researcher's personal beliefs, perceptions, biases, values, attitudes, and emotions (Kerlinger 1992).

In this research the quantitative data is gathered by the instrument. Then the evidence which is classified, and measured systematically is ultimately viewed from the outside by the researcher. The relation of the contributing factors that is tested quantitatively can be checked by other researchers. In this respect, the research is bias-free because of its independence on the researcher.

Kind of Information: Measurable

As discussed the objectivity view is essential for the quantitative methodology, by the philosophers' believe in the power of measurement. As Glassner and Moreno (1989) note:

> At one point in the *Republic* Socrates considers the conditions that can provoke reflection, as 'when perception yields a contradictory impression, presenting two opposite qualities with equal clearness. . . ' Sight cannot satisfactorily distinguish between the sizes of one finger and another, for example, for 'sight perceives both big and little: only not as separate, but in confused impression.' In response, intelligence invokes 'the help of reason with its power of calculation. . . ' Socrates goes on to note that 'number is the subject of the whole art of calculation and of the science of number' and that 'the properties of number appear to have the power of leading us toward reality' precisely because they are more reliable than the properties of mere perception (Plato 1772, 239-241).

From objectivity we can come to knowing the true nature of things with mathematical knowledge, while "knowledge of qualities is superficial and vain" (Grassner and Moreno 1989, 3). At the extreme point on the epistemological continuum, the philosophers in the Eighteenth century thought they knew more or less what the shapes of the good society were, and were certain that mathematically expressed knowledge was at least a necessary condition of its become a reality (Glassner and Moreno 1989).

In this research, two types of data are established in formulating the first research question. The first type of data, participation processes, defined as the dimensions of the network i.e., size, density, and frequency is basically the numerical data. On the contrary, the second type of data, the success of the R&D project, is the characteristic of the project. With the quantitative methodology, this type of data can be operated in a measurable form for the analysis.

The technology transfer theories reviewed in chapters 2 and 3 provide the basis to operate the data in the second type. The operation of data requires operation thinking which is usually determined from the experiment or a well-developed theory (Kerlinger 1992). In this case, Kerlinger affirms the benefits of the operational thinking that implies the strength of the measurable data.

> The benefits of operational thinking have been great. Indeed, operationism has been and is one of the most significant and important movements of our times. Extreme operationism, of course, can be dangerous because it clouds recognition of the importance of constructs and constitutive definitions in behavioral science, and because it can also restrict research to trivial problems. There can be little doubt, however, that it is a healthy influence. It is the indispensable key to achieving objectivity - without which there is no science - because its demand that observations must be public and replicable helps to put research activities outside of and apart from researchers and their predilections. And, as Underwood has said:
>
> . . . I would say that operational thinking makes better scientists. The operationist is forced to remove the fuzz from his empirical concepts. . . .
>
> . . . operationism facilitates communication among scientists because the meaning of concepts so defined is not easily subject to misinterpretation (Kerlinger 1992, 40).

With the power of the operational thinking, the second type of data is converted numerically. Then the information of both two types of data is measurable. One is in an explicit numerical form and the other in an operated numerical form. The quantitative methodology provides a good practice to the first research question.

Qualitative Methodology

The four issues; the basic beliefs, the analysis, the role of researcher, and the kind of information along the qualitative methodology are dissimilar to those by the side of the quantitative methodology. Qualitative is idealistic, and subjective, where as quantitative is materialistic and objective; qualitative is inductive, compared to quantitative being deductive, interactive, not independent; textual, not measurable. The following is an overview of each issue relating to the research.

Basic Beliefs: Idealism and Subjectivity

The qualitative methodology emphasizes the task of delineating forms, kinds of social phenomena; of documenting in the detail the things that exist (Lofland 1971), in the "natural language" (Schwartz and Jacobs 1979). In contrast to the quantitative research, the qualitative research focuses discovering novel or unanticipated findings (Bryman 1984). The basic philosophies of the quantitative methodology are ontological materialism, and epistemological objectivity; however, the philosophies of the qualitative methodology are ontological idealism, and epistemological subjectively.

On the ontological continuum, idealism is on the other end against materialism. Potter (1996) defines that idealism is the belief in one's mind; nothing exists apart from the mind apprehending it. With the idealists, the subject and object become one and they therefore "perceive no reality independent of the shaping of creating efforts of the mind" (Smith 1983, 8). Philosophers who maintain an idealist ontological position do not believe in an objective way of knowing. They believe that the world is subjectively constructed by the meanings that people assign to observations. Therefore, the empirical world is not independent of people's observation (Lazarsfeld 1972, and Potter 1996).

> . . . what is "known," cannot be the result of a passive receiving, but originates as the product of any active subject's activity. This activity is, of course, not a manipulating of "things in themselves," that is, of objects that could be thought to possess, prior to being experiences, the properties and the structures the experiences attributes to them (Von Glasersfeld 1982, 30).

In this research, the second research question "*How do or might various stakeholders in the R&D process participate?*" needs an interpretation of the attributes of participation processes and perspectives of individuals. Such an interpretation of the phenomena is never objective, but must be subjective, because it is the researcher's own interpretation. In addition, "there are no standards that can be used to judge the value of the interpretation in comparison to the interpretation of others, because all interpretations are subject and have value" (Potter 1996, 42). Therefore, to tie the knowledge directly to the second research question, the basic beliefs of qualitative methodology, idealism and subjectivity are its preferences.

According to Schwartz and Jacobs (1979) and Bryman (1984), two methodologies are stemmed from two divergent epistemological bases. Gubrium (1988) also supports that qualitative sociology is usually distinguished from a positivism issue on the position of objectivity. In addition, when Lofland and Lofland (1984) introduce the qualitative methodology to social sciences research, they stress that this methodology reflects a certain epistemology. They maintain that the central attributes of this approach are; (1)

that face-to-face interaction is the fullest condition of participating in the mind of another human being, and (2) that the researcher must participate in the mind of another human being in order to acquire social knowledge. These attributes are associated with the notion of constructivism. Therefore, it is comprehensible that subjectivity is the fundamental to Lofland and Lofland's concept.

However, currently there is no settlement for the debates. There is no limited epistemological and ontological position for quantitative and qualitative inquiry. For example, Potter (1996) argues that researchers can take all three positions; objectivity, intersubjectivity, and subjectivity on the epistemological continuum. First, researchers can develop objective data-gathering and analytic procedures, and provide value-free description without bias. Second, researchers can demonstrate their intersubjectivity, the middle position of objectivity and subjectivity, by the use of language, methods, and standards to converge the interpretations to the others'. Third, researchers hold the subjective position since their interpretation are subjected only by researchers.

On the contrary, Patton (1990) has another perspective about the basic beliefs of conducting research. Neither subjectivity nor objectivity is useful any longer for understanding how the researcher should approach research. "Quantitative methods are no more synonymous with objectivity than qualitative methods are synonymous with subjectivity" (Patton 1990, 55). Thus, Patton's suggestion is to avoid using either word and to stay out of debates about subjectivity versus objectivity.

These arguments seem to exhibit a blurring of the lines between the two methodologies at the epistemology. As Bryman's (1984) debates "there is no necessary 1:1 relationship between methodology and technique in the practice of social science.

There may be a case of saying that techniques are neutral in respect of epistemological issues and debates." It may be summarized that though there is the divergence between the two methodologies derives from a tendency for philosophy issues, technical issues are likely to be treated disconcertingly. Furthermore, this research is question-focusing, it is more benefit to take advantage from both methodologies in order to answer the research questions.

Analysis: Induction

Inductive analysis is an "immersion in the details and specifics of the data to discover important categories, dimensions, and interrelationships; begin by exploring genuinely open questions rather than testing theoretically derived hypothesis" (Patton 1990, 40).

Such a definition indicates that this kind of analysis does not match the quantitative methodology that focuses on the testing of hypothesis. Induction is a theme of qualitative methodology. In conducting qualitative research, the researcher begins the observation without making prior assumptions, and expects categories or dimensions of analysis to emerge from open-ended observations (Patton 1990).

The idea that analytic induction is a mandate principle of qualitative methodology is presented in some literature (Boudon 1970, and Van Maanen 1982). From the subjectivity position, qualitative work begins with the closely detailed observation. The specific and local are sought as a primary data base with which patterns may or may not be found. To this degree, the researcher is initially uncommitted to a particular theoretical model, the more ideal the uncovered data (Van Maanen 1982). A logic of "no a priori" is generally thought to be the characteristic of the qualitative methodology (Lazarsfeld 1972).

In this research, the second research question is "*How do or might various stakeholders in the R&D process participate?*" The aim of inquiring the knowledge about participation processes taking place in the R&D project, is to look for natural variation in the data. There is no hypothesis to develop prior to the analysis. Though some different perspectives among R&D stakeholders are observed in previous studies, there is no hypothesis about this aspect, or any aspect which is formulated to the second research question. As Patton (1990) suggests, the analysis insights and interpretations emerge during data collection. Therefore, it was expected that some patterns of participation processes would emerge during the data collection of the research.

However there is some argument that deductive analysis can be included in qualitative methodology. For instance, Potter (1996) presents that some analytical methods such as feminist and hypothesis testing are deductive construction methods. Because such methods start with general principles, then construct an argument, shows that the evidence supports those general principles. Patton (1990) also suggests both analytic approaches in conducting qualitative research. The inductive approach is used when observation begins; hence, the researcher may have a chance to discover whatever emerges from the data. When patterns and major directions of research are revealed, the deductive approach is appropriate because research could begin to focus on verifying and elucidating what seems to be emerging. It may be concluded from such arguments that there is a variation of deduction/induction degree of the qualitative methodology in each step of the analysis. However, the main theme of the analysis discussed here is the hypothesis formulation. Qualitative methodology focuses on the induction because no hypothesis is formulated, whereas quantitative concentrates on the deduction because of a hypothesis being formulated.

Role of Researcher: Interactive

The researcher has the direct personal contact in conducting qualitative research. Participant observation is a major theme of the inquiry in the qualitative methodology (Schwartz and Jacobs 1979, Bryman 1984, Lofland and Lofland 1984, Patton 1990, and Harper 1994). According the Bryman (1984), participant observation is a rather broad term. It covers a wide range of observational practices and a fieldwork strategy that involves general interviewing, usually of a relatively unstructured kind, the perusal of documents, and the interviewing of key informants. However, it is the ability of the participant observer to get close to his/her subjects and so see the world from their perspective that is its prominent attraction.

As Patton (1990) indicates there are many ways of talking about the methods for gathering the data, including participant observation, field observation, qualitative observation, direct observation or field research. "All these terms refer to the circumstance of being in or around an on-going social setting for the purpose of making a qualitative analysis of that setting" (Lofland 1971, 93).

The participant observation is the theme related to epistemological principle of the quantitative methodology. From the subjectivity position, qualitative work begins with the closely detailed observation. The world is subjectively constructed by the meanings that researchers assign to observations. The participant observation requires the researcher to interactive to the research. "The researcher is the instrument of data collection and the center of the analysis process" (Patton 1990, 461) is the notion of qualitative inquiry. Since empathy is the focus in qualitative methodology. Empathy involves being able to take and understand the stances, positions, experiences, and world-views of others. Therefore, participant observation that develops from close contact between the researcher and people being researched is crucial for qualitative research (Patton 1990).

Interpretive assumptions in participant observation refer to the basic belief of subjectivity. When the researcher attempts to see the situation from the point of view of those who are being studied, he or she cannot escape from providing his/her own interpretation of the situation. Researchers must use subjective methods and their own interpretation to understand what is happening in the social settings they observe (Potter 1996).

The notion that the researcher is interactive with the subject being investigated is impressive to this research. The participation observation offers the appropriate techniques such as the unstructured interview and the review of documents, which grants the researcher a depth of knowledge about participation processes in R&D development as part of the second research problem. In addition, the participant observation provides various values for the research; (1) to facilitate the understanding of the research context, (2) to rely on an open, discovery oriented, and inductive approach, (3) to discover things which may be routine in the system, (4) to learn something beyond the interview, (5) to allow the researcher to add more comprehensive views to the research, and (6) to allow the researcher to have reflection and introspection on the research (Patton 1990). The questionnaire which is the traditional tool of the quantitative data is typically seen as deficient in this respect.

Kind of the Information: Textual

Qualitative findings are long, detailed, and diversified (Bryman 1984, and Patton 1990). The data has a great deal of depth (Bryman 1984), provides rich insight into human behavior and contextual information (Guba and Lincoln 1994).

According to Potter (1986), researchers who undertake a qualitative methodology have the goal of increasing our understanding about human construct and share meaning. The findings must be shared in a written form. Patton (1996) also addresses that one assumption about qualitative methodology is that researchers avoid reducing complex reality about human interactions to a few variables. The qualitative methodology emphasizes on the study of how language and interactions are used to construct reality in social situation. According to Lindlof (1991, 26):

> (It) conceives of humans as uniquely able to account for past and future actions of themselves and others in coordination present behavior. Language is the primary medium in which this accounting is done. It is the means by which intentions are expressed and generalized to routine social situations. Language and other symbol systems also enable humans to invent new models of being. . . . The main task and accomplishment of all social life is making meanings.

Qualitative methods comprise three kinds of data collection; (1) in-depth, open-ended interviews, (2) direct observation, and (3) written documents. The data from interviews consist of direct quotations from people about their experiences, opinions, feelings, and knowledge. The data from observations consists of detailed descriptions of people's activities, behaviors, actions, and the full range of social interactions and organizational processes that are part of observable human experience. Document analysis in qualitative inquiry yields citations, quotations, or entire passages from official and personal documents, and open-ended written responses to questionnaires and surveys (Potter 1996).

It can be seen that all types of data are descriptive. Telling the story in the literal form is typical in qualitative study. Such a data type is required in this research. The purpose of the second research question "*How do or might various stakeholders in the R&D process participate?*" is to have description, interpretation, and explanation on the subject of participation processes. The data presented must be in the textual form, rather than in the measurable form with respect to the quantitative methodology.

Triangulation

Caws determines the law of quantity and quality:

> Qualitative and quantitative do not divide up a territory, they both cover it, overlapping almost totally. But one is basic and the other optional. Everything in our world is qualitative; but virtually is capable - given suitable ingenuity on our part - of generating quantitative determinations. Whether we want to expand our ingenuity in this way is up to us (Caws 1989, 26).

To combine two methodologies; quantitative and qualitative, in the same study is supported by the literature (Jick 1979, Patton 1990, Tebes and Kraemer 1991, and Guba and Lincoln 1994). Mixing methodologies, "triangulation" is believed to advance the knowledge and to increase validity of research in some research settings (Patton 1990, Tebes and Kraemer 1991, Jick 1979, and Guba and Lincoln 1994).

Definition and Classification

Triangulation is broadly defined as "the combination of methodologies in the study of the same phenomena" (Denzin 1978, 291). The triangulation metaphor is from navigation and military strategy that use multiple reference points to address an object's exact location. Given fundamental principles of geometry, multiple standpoints allow for greater accuracy. In the same way, the accuracy of the researcher's judgment can be enhanced by collecting different kinds of data pertaining to the same phenomenon (Jick 1979).

Triangulation is classified as a "between methods" type or "within method" type (Jick 1979). Patton (1990) also proposes four methods of triangulation in the qualitative analysis as follows:

- checking out the consistency of findings produced by different data-collection methods, that is methods triangulation;
- checking out the consistency of different data sources within the same method, that is, triangulation of sources;
- using multiple researchers to analyze findings, that is, analyst triangulation; and
- using multiple perspectives or theories to interpret the same data, that is, theory/perspective triangulation.

Though all strategies have the purpose to reduce systemic bias in the data, there is some inconvenience to peruse them. Generally, the difficulty of triangulation is that the data cannot be apparently converged. Different kinds of data from different methods or different sources have captured different things so it is difficult to have reasonable explanations. Similarly, there are variations of analysts' opinions so they cause bias in the analysis. Divergent multiple theoretical perspectives are also a basis of the difficulty in the analysis (Patton 1990). Therefore, the challenge of triangulation is to overcome such practical bias to gain its advantage.

Debate Issues on Triangulation

Among the four strategies of triangulation, methods triangulation seems to be most controversial issue since each of the two methodologies; quantitative and qualitative; "holds a radically different view of the nature of reality, values a different kind of knowledge, and promotes a different set of standards for evaluating knowledge claims" (Schwandt 1989, 379). There are six ways that philosophers deal to the problems of conflicts between the two methodologies, however each has failed. According to Schwandt:

> First, there is denial that there is a problem. Second, there is co-optation where scholars acknowledge that there is a difference but attempt to argue that the two are complementary when the quantitative methodology is assimilated into the quantitative approach. Third is the position of supremacy where scholars argue that quantitative approach is more powerful and is therefore superior. Fourth is the replacement of both approaches with a third one that is a synthesis of the two. Fifth is the primary of method, which ignores the foundation issues of ontology, epistemology, nature of evidence, and so on, and tells researchers to use a method that is best to solve each individual research problem. And six is anarchism, which is an "anything goes" position that allows for relativism (in Potter 1996, 306).

Schwandt (1989) rejects all of these solutions to the problem of conflict between the two approaches and argues that researchers must decide the debate for themselves by selecting methods that fit their values and research needs.

Bryman (1984) appears to agree with Schwandt that the choice of methodologies should be taken in the light of an appreciation of philosophical contexts. Quantitative and qualitative methodologies exhibit distinctive epistemologies and that particular methods of research are suitable to each. However, since a clear symmetry between epistemological positions and associated techniques has not been established yet. His conclusion is that it is skeptical about the extent to which a neat correspondence can currently be established.

On the contrary, some scholars advocate to the notion of triangulation. As Potter questions: "Is convergence a possibility?" (Potter 1996, 303), he has a strong argument that convergence is likely in some degree. The synthesis in table 4.2 demonstrates the holistic assessment of the degree to which convergence is possible.

	Type of Synthesis		
Issues	***Coexistence***	***Complementary***	***Integration***
Foundational issues			
1. The Phenomena		x	
2. Purpose		x	
3. Ontology-Epistemology		x	
4. Axioms		x	
Issues of evidence			
5. Nature of the evidence		x	
6. Level of evidence			x
7. Enumeration	x		
Issues of gathering evidence			
8. Expectations		x	
9. Researcher Activity			x
10. Sampling		x	
Issues of analysis			
11. Process of analysis		x	
12. Conceptual leverage		x	
13. Generalizability		x	
14. Contextualization		x	
15. Locus of argument		x	
16. Form of expression		x	
17. Self-reflexibility		x	
Standards for judging quality			
18. Internal quality		x	
19. External quality		x	

Table 4. 2. Synthesis level by element
(Source: Potter 1996)

Potter (1996) categorizes the degree of convergence into three levels. The first degree is coexistence. Only one topic that demonstrates the degree of coexistent of quantitative and qualitative methodology is enumeration. Two methodologies focus different notions in only one sub-issues. Enumeration, the typical quantitative method, is the violation of the qualitative methodology. Though qualitative researchers use numbers, such as citing figures that have mathematical properties, they do not translate quality of a person into a number.

The second degree is complementary, i.e. the two methodologies are not only coexist, but the existence of one might serve to enhance the function of the other (Potter 1996). Both methodologies, quantitative and qualitative are complementary in assessing every topics of the foundational issues, the issues of analysis, and the standards for judging quality, as well as one and two topics in the issues of evidence and the issues of gathering evidence, respectively. One among those several topics is ontology-epistemology, which is argued by Schwandt (1989) and Bryman (1984) as already discussed.

Potter (1996) believes that the complement of two methodologies in epistemology and ontology issues is indicated by the notion of reality. There is no real subjectivity since interpretation and description presented by qualitative researchers have existence. Researchers communicate to readers by words which is a form of existence. Therefore, the qualitative methodology demonstrates an acceptance in the material existence of artifacts of communication. At the same time, the quantitative methodology illustrates an intersubjective epistemological foundation. Since they are not naturally occurring objects that are waiting to be discovered. Human interpretation creates communication and culture, therefore, it is unlikely that quantitative researchers do not believe in human constructions. Though, the topic of epistemology and ontology seems to be characterized as a major difference between the two methodologies, really is not much of a difference in practice.

The last degree is integration. Quantitative and qualitative methodologies can integrate in two sub-issues, level of evidence and research activity. The degree of convergence for the level of evidence is integration since both methodologies, quantitative and qualitative allow focusing at individual level, but generalizing the pattern of analysis at broader level. Likewise, both methodologies allow wide range of research activity, i.e. passive, and active. Accordingly, from this standpoint, the quantitative and qualitative are integrated (Potter 1996).

It can be seen that there are many points that two methodologies are complementary. In addition, there appears to be a fair degree of overlap and synthesis. In sum, Potter's analysis provides a sound perspective of complementary between two methodologies.

In like manner, Jick (1979) agreed that the use of complementary methods is generally thought to lead to more valid results. In addition, methods triangulation may be used to enrich our understanding by allowing for new or deeper dimensions to emerge. Complementary means the compensation between the two methodologies, quantitative and qualitative. The effectiveness of triangulation depends upon the premise that the weakness in each methodology will be compensated by the counter-balancing strengths of another. That means multiple and independent measures do not share the same weakness or potential for bias. The integration of fieldwork and survey method, and the combination of interview and survey methods illustrate the examples of triangulation. There is a balance of weaknesses and strengths in both triangulation designs. Since survey method, the quantitative tool, contributes to greater confidence in the generalizability of results while no qualitative tool is developed to this purpose. Vice versa, fieldwork and interview, the qualitative tools provide rich data to contribute the interpretation of statistical relationship and clarifying of obscure findings.

Jick also questions "Putting it all together: is there convergence?" (Jick 1979, 606). Since Jick focuses triangulation in practice, convergence is emphasized on the result of the finding of mixing two methods. Triangulation can provide the convergent result when the findings from both methods are compatible. Where there is convergence, confidence in the results grows substantially. Conversely, when different methods yield deviant results, the divergence emerges. However, where divergent results emerge, alternatively, and likely more complicated, explanations are generated, and can lead to an enriched explanation of research problem. It can be concluded from Jick's standpoint that the use of triangulation is a suitable strategy for practical research given an appropriate manner.

Patton (1990) too believes in the power of triangulation of quantitative and qualitative data in a form of comparative analysis to increase research validity. Like Jick's, Patton's discussion is on a practical basis. He highlights the importance of the researcher in deciding whether the results of two methods converge. Since the possibility of anyone or any method being totally objective is doubtful, while subjectivity is inevitable. From his perspective, concerns about objectivity and subjectivity are dissociated to the notion of triangulation.

Tebes and Kraemer (1991) also address the significance of triangulation in research design. One methodology is complemented to its opposite one. The philosophy issues do not have impact on the combination of the two methodologies, quantitative and qualitative. Tebes and Kraemer (1991) do not believe that quantitative knowing is sufficient to advance scientific understanding. They state: "In opposition to this implicit logical-positivist view, we maintain that *no* amount of specification - not even in theory - can overcome inherent !imitations in quantitative research" (Tebes and Kraemer 1991, 741). They argue that social experimentation requires monitoring of local conditions. The qualitative methodology such as participant observation should be incorporated in the quantitative design since it provides the understanding of the context of the study.

Also, in their critiques of the quantitative methodology, Guba and Lincoln (1994) argue that the qualitative methodology can compensate some weakness of the quantitative methodology. The four weaknesses are:

- Context stripping
- Exclusion of meaning and purpose
- Dysfunction of grand theories with local contexts: the etic/emic dilemma.
- Inapplicability of general data to individual cases.

A first weakness is context stripping. The quantitative methodology does not focus on providing context of the study, for example, the laboratory experimental study. This causes a problem in its applicability of generalizability because its outcomes can be applied only in other similarly truncated or contexually stripped situations such as another laboratory. Qualitative data, it is argued, can adjust that imbalance by providing contextual information. A second weakness of the quantitative methodology involves exclusion of meaning and purpose. Since human behavior can be captured with reference to the meanings and purposes associated by human actors to their activities. Qualitative data can convey rich insight into human behavior. A third weakness is dysfunction of grand theories with local contexts: the etic/emic dilemma. While the quantitative methodology offers the etic perspective, there is no meaning within the emic view of studies on the human side. Qualitative data is useful for uncovering emic view; theories, to be valid, should be qualitatively grounded. A fourth weakness is inapplicability of general data to individual cases. Quantitative data does not have available data to explain individual case, however, qualitative data can provide such a case with complete data. A last weakness is exclusion of the discovery dimension in inquiry. Since "a priori" hypotheses is established in the quantitative methodology, the problem is in specific dimensions. Quantitative methodology is thus privileged over the insights of creative and divergent thinkers.

Given several viewpoints from the literature, the notion of the availability of triangulation seems to go beyond its deviation to the basic beliefs of the philosophical issues. As Tebes and Kraemer (1991) argue that the limitation of the quantitative methodology cannot overcome by the pro-quantitative theory, and as Potter (1996) convinces that the notion of reality indicates the complement of two methodologies; quantitative and qualitative, in epistemology and ontology issues, it is reasonable to consider triangulation to this research. The summary of literature debate issues is shown in table 4.3.

Authors	*Triangulation feasible*	*Relation of triangulation and the basic beliefs*	*Potential importance of triangulation*
Jick (1979)	yes	not mentioned	complementary
Bryman (1984)	question	question	not available
Schwandt (1989)	no	conflict	not available
Patton (1990)	yes	no relation	comparison
Tebes and Kraemer (1991)	yes	no conflict	complementary
Guba and Lincoln (1994)	yes	not mentioned	complementary
Potter 1996	yes	complementary	complementary

Table 4. 3. The debate issues on triangulation

Summary

The two methodologies; quantitative and qualitative are shaped to the inquiry of this research. They were selected to fit this question-driven research. As Potter states: "Scholars who focus primarily on the question can make a greater contribution" (Potter 1996, 332). The quantitative methodology is selected to the first research question "*How is participation linked to the success of R&D project development?* ", whereas the qualitative one is to the second research question "*How do or might various stakeholders in the R&D process participate?*" The selection is based on the appropriate attributes of each methodology to the research question. These four attributes compose the basis of the basic belief, analysis, role of researcher, and kind of information. The first research question is fit to the prescription of the quantitative methodology emphasizing on materialism and objectivity beliefs, deduction, independent researcher, and measurable data. On the other hand, the second one is suitable to the prescription of the qualitative methodology emphasizing on idealism and subjectivity beliefs, induction, interactive researcher and textual data. The notion of triangulation is the rationale of selecting of hybrid tools to this research. Since the conclusion from the literature is that availability of triangulation is outweighed by its deviation from the basic philosophy beliefs. It is believed that mixing two methodologies or triangulation is a good practice to expand our understanding about participation processes in R&D development.

CHAPTER 5

RESEARCH DESIGN

The design is the logical sequence that correlates data to a study's research questions and finally to its findings (Yin 1994). Yin's definition of a research design is "*an action plan for getting from here to there,* where *here* may be defined as the initial set of questions to be answered, and *there* is some set of conclusions (answers) about these questions" (Yin 1994, 19). This chapter aims to provide the understanding of such an action plan on this research. Since the idea of the research is to explore the participation processes of R&D development, an R&D project is considered a case of the study. The case study design is not limited to the quantitative or the qualitative approach (Lee 1989, and Yin 1994). Consequently, the case study design that is appropriate to this research combines both approaches. The basis of selecting case study as a research design and the design components are explained in this chapter.

Case Study as a Research Design

Case study is an exploration of a "bounded system" or a case (or multiple cases) over time through detailed, in depth data collection involving multiple sources of information rich in context (Creswell 1998). In comparing the research strategies applied in the study of social phenomena, case study and other strategies are distinguished by several factors (Table 5.1).

Strategy	*Form of Research Question*	*Requires Control Over Behavioral Events?*	*Focuses On Contemporary Events?*
experimental	how, why	yes	yes
survey	who, what, where, how many, how much	no	yes
archival analysis	who, what, where, how many, how much	no	yes, no
history	how, why	no	no
case study	how, why	no	no

Table 5. 1. Relevant situations for different research strategies
(Source: COSMOS Corporation, Yin 1994)

Practically, those five strategies i.e., experiment, survey, archival analysis, history, and case study are different in three conditions; (1) the type of question formulated, (2) the extent of control a researcher has over actual behavioral events, and (3) the extent of focus on contemporary as opposed to historical events (Yin 1994). Each strategy is appropriate to research that matches its condition. Yin (1994) concludes that the case study design is appropriate to research when it:

- investigates a contemporary phenomenon with its real-life context;
- when the boundaries between phenomenon and context are not clearly evident; therefore, the researcher has no control over behavior events;
- and in which "how" or "why" research question is being posed.

The characteristics of the research met the requirement of doing the case study. First, this research investigates participation in the technology development process which is the real event. The biotechnology R&D project funded by the organization was selected as a unit of analysis. Participation processes among the stakeholders of each project (case) were explored. The data was collected by interviewing such stakeholders who were existing, therefore, the data collected were real world events.

Second, the phenomena, participation processes, could not be separated from the context that was real life. This can be explained by comparison with the laboratory experiment. In the experiment, we can observe the phenomena in different context by changing context condition(s), and observing our interest phenomena. In this research. both phenomena and context are real life activities, and therefore, we cannot separate an existing R&D project from its real condition.

Third, in doing a case study the researcher has no control over behavioral events. This is due to the second characteristic of unseparable phenomena and context. In a laboratory experiment, subjects are forced to enter in the laboratory-- that is, an environment controlled nearly completely by the researcher (Yin 1994). In contrast, in doing case study, researchers could not manipulate the behavior event. Both the phenomena and the context in this research were real life events. Moreover, in the data collection process, the researcher could not force the respondent to participate. For example, when the interviewee refused to answer some question because of his/her own personal reason, the researcher could not force her/him.

Last, the question "*How do or might various stakeholders in the R&D process participate?*" is posed in this research. Three research strategies prescribed this type of "how" question research; (1) history, (2) experiment, and (3) case study (Yin 1994). Since the research interest is the contemporary event of participation processes of R&D project development, the history strategy is not appropriate. In addition, these processes were the real-life event that could not be manipulated. For that reason, a laboratory experiment is not feasible. The case study is therefore a more appropriate choice to conduct this research.

The survey or the use of questionnaire was included in this research since the aim of the first research question needed to know "what" the relationship between participation and the success of R&D was. As exhibited in table 5.1 a "what" research question prefers the survey strategy. However, in this research the case study was the main strategy because the questionnaire was used within the boundary of the case. Since the various strategies are not mutually exclusive, a survey within a case study is acceptable (Yin 1994).

As a result, the unit of analysis is a main dimension of conducting the case study. Since participation processes of R&D projects were of this research interest, there was the need to study the pattern of the processes, and the relation between the pattern and the success of the R&D project. Each project was assumed as individualized in several characters. Therefore, the R&D project was identified as the unit of analysis of the research.

Case Selection

There are two main issues in selecting the project in this research. Multiple- versus single-case design was a concern. Also, probability versus purposeful sampling raised another concern in selecting an appropriate case. The two issues are considered to outline an appropriate design to the research.

Multiple-Versus Single- Case Design

Four models are suggested in conducting the case study (Figure 5.1). The researcher needs to select a model that is going to be used to address the research questions (Yin 1994).

	Single-case designs	***Multiple-case designs***
Holistic (single unit of analysis)	Type 1	Type 3
Embedded (multiple units of analysis)	Type 2	Type 4

Figure 5. 1. Basic types of designs for case studies
(Source: Yin 1994)

As Yin (1994) indicates the single case study is appropriate for three situations. First, a single case represents the critical case in checking an existing theory. Second, a single case represents an extreme or unique case so it is worth documenting and analyzing. Third, a case is the revelatory case. This happens when the researcher has an opportunity to access the phenomena previously inaccessible. Therefore, the decision to select a single case in the analysis is grounded from one of these rationales.

Yin (1994) defines the difference between holistic and embedded as the number of subunits of analysis. Holistic design is developed when the case study examines only the global nature of a unit, for example, a program, or an organization. On the other hand, embedded design is formed when subunits, for example meetings, roles, locations in an organization, are focused.

As Yin (1994) argues the decision to conduct the multiple-case design is to extend the study to various conditions. The rationale for single case-designs usually cannot be met by multiple cases. An unusual or rare case, a critical case, and a revelatory case are all likely to involve only single case, by definition.

The questions of this research are to explore participation in R&D projects. The need to address the first question influenced the decision of selecting multiple-case design to this research. The first question is to observe the relationship between participation and the success of R&D. Conducting only a single case or project is unlikely to interpret the pattern of the relationship. Three reasons of conducting single case-design are not related to this type of research. First, there is no well-formulated theory about the relationship of participation and the success of R&D projects. Second, the objective of the research is not to analyze the unique case. Third, R&D projects are definitely accessible phenomena; therefore, the revelatory case is not necessary.

Multiple-case design is definitely appropriate to this research. In addition, it is categorized into a type 3 "holistic, multiple case-design" in figure 6.1 since each R&D project is examined as a whole, not as an integration of sub-units. Thus, multiple projects were studied individually. The decision to select a project in this research is that "every case should serve a specific purpose within the overall scope of inquiry" (Yin 1994, 45). To understand the strategy of selecting the case for this research, the next section will discuss the differences of two sampling alternatives: probability versus purposeful.

Probability Versus Purposeful Sampling

Probability sampling has a purpose of generalization, whereas purposeful sampling has a purpose of obtaining information rich cases, which one can learn a great deal about issues of central importance to the purpose of the research from it (Patton

1990). These two types of samplings rely on different principles. The probability sampling is derived from statistic techniques. Its logic and power relies on a truly random and statistically representative sample that will allow confident generalization from the sample to a large population. In contrast, the logic and power of the purposeful sampling accommodates selecting an information rich case for study in depth (Patton 1992).

Since the in-depth study on the issue of participation is the main focus of this research, the purposeful sampling is a suitable strategy to select the case. The probability sampling may offer the random samples that are a representative of a pool of R&D projects funded by the agency. By doing that, the number of projects must be large enough to avoid a research error. Because, following the statistical rule of the probability sampling, the larger the sample size, the smaller error of the population value (Kerlinger 1992). However, it is impractical to this research to conduct the in-depth study to a number of projects. On the other hand, the power of the purposeful sampling is to select relatively small samples, even single cases, with the rich information of the case (Patton 1992). Therefore, it is an appropriate alternative to this research that needed to study the small size of sample.

A "replication logic" is a challenge of the purposeful sampling for multiple case-design. As Yin explains, the replication logic is the logic for case selection that the case either "(a) predicts similar results (a literal replication) or (b) produces contrasting results but for predictable reasons (a theoretical replication)" (Yin 1994, 46). Hersen and Barlow (1976) present that the replication logic is analogous to that used in multiple experiments.

A proposition is supported by the same results from multiple experiments in the same condition, also by the contrasting results in different conditions.

The replication logic is used in the design to reply to the first research question. Since the predicted result is that participation involves the success of R&D project development, the project had a high level of participation that was supposed to be successful and vice versa. Thus, the replication logic offers four choices of selecting the cases in this research as summarized in table 5.2.

Case Selected For Multiple- Case Design	*Expected Result*	*Type of a Replication Logic*
1. successful cases	similar pattern of a high level of participation in all cases	literal replication
2. unsuccessful cases	similar patterns of a low level of participation in all cases	literal replication
3. successful and unsuccessful cases	two different patterns; a high level of participation in the successful case(s) and a low level of participation in the unsuccessful case(s)	theoretical replication and literal replication*
4. case(s) presenting every level of success	variation of levels of participation	theoretical replication, and literal replication*

Table 5. 2. Alternatives to the cases

* literal replication logic is the rationale when there are multiple cases in each level of success

The third choice is conforming the "maximum variation sampling " strategy suggested by Creswell (1998) and Patton (1990). The maximum variation sampling is a strategy to represent diverse cases to fully display multiple perspectives about the case (Creswell 1998). It attempts to capture and describe the central issues or principal outcomes that cut across a number of cases' variation (Patton 1990). According to Patton:

> For small samples a great deal of heterogeneity can be a problem because individual cases are so different from each other. The maximum variation sampling strategy turns that apparent weakness into a strength by applying the following logic: Any common patterns that emerge from great variation are of particular interest and value in capturing the core experiences and central, shared aspects or impacts of a program (Patton 1990, 172).

As operationalized in chapter 3, the success of R&D projects are classified on a five point scale by the level of R&D achievement in each channel, science, technology, and utilization. In order to follow the replication logic, and the maximum variation sampling strategy, the two types of a project with the opposite levels of success (1 vs. 5) were selected (Table 5.3).

Point Scale	*Degree of R&D Achievement*				*Level of Success*
	Basic Scientific Principle	*Large Scale Developmen t*	*Utilization*	*Customer Acceptance*	
1	no	no	no	no	no
5	yes	yes	yes	yes	yes

Table 5. 3. The characteristics of the two types of a project selected in the research.

However, the rationales on the multiple case design, the replication logic, and the maximum variation sampling do not provide a precise number of a case or a project in this research. It can be seen that any number of projects which is greater than one satisfies the rationale. Creswell (1998, 63) notes that "the more case an individual studies, the greater the lack of depth in any single case." Therefore, two cases were selected; one project has a point scale of 1, the other a point of scale 5 as defined in table 5.3. The overall strategy of selecting the case in this research is illustrated in table 5.4.

Concern for Case Selection	***Strategy***	***Alternative***
Multiple-versus single case • multiple versus single • holistic vesus embeded	 need to compare the patterns of participation each case was examined as a whole unit	 multiple case study holistic
Probability versus purposeful sampling	desire of in-depth study • replication logic • maximum variation	purposeful sampling • four alternatives (table 5.2) • one alternative (two cases: success and failure)

Table 5. 4. The case design framework for the research

Criteria for Case Selection

Apparently, the strategies for case selection provide the idea of selecting two projects with opposite level of success. However, the likelihood for projects having these attributes was common. In selecting the two particular projects, four criteria were used to determine which two cases would be studied:

- cases are domain specific
- cases are geography related
- cases demonstrate time consistency
- cases have few unique attributes

The first criterion determined that the two projects were domain specific. According to the organizational database, the projects are categorized into six mission areas, including (1) plant biotechnology, (2) animal biotechnology, (3) biotechnology for small rural development/small farmers, (4) sustainable development, (5) health improvement, and (6) novel product/industrial process improvement. The projects in missions 3 and 6 were considered from two reasons. First their processes were supposed to enhance either industrial and agricultural products or both. Second, they should be readily accessible to customer requirements. To share the same mission is to assume that the projects have common attributes, i.e. scientific data. This will enhance the generalizability of the research if the population of interest also share these cases' common attributes (Kennedy 1979).

The second criterion determined that the projects were geographically related. The research design focused on the projects conducted in Bangkok in which most universities, research institutes, and the funding agency are located. Collecting data in the single area should be therefore convenient, also facilitate the in-depth investigation. In addition, this geographic relational attribute contributes to strengthen the generalizability of the research if the population of interest share the same geography.

The third criterion provided a basis of time frame of the projects. The projects started in 1994 were candidates for the case study. This is due to an assumption that their R&D period was three years, and to be completed before 1998. If the project was success, it would demonstrate its potential for commercialization at the time of conducting this research.

The fourth criterion determined to avoid projects with unique attributes. For example, a project that was terminated because of the death of a scientist should not be included for the research. As Kennedy (1979) suggests it would be preferable to not defining unique attributes at all since these attributes interfere with generalizability.

These criteria were designed prior to the data collection process to focus on particular projects. The advantages to have such criteria are obvious. First, it was practical to squeeze all projects with these guidelines, rather than to select them from a pool of projects without any guidelines. Second, using these criteria enhanced the research generalizability. As discussed, the findings of the research can be generalized to the population of interest that share their common attributes, i.e., scientific area, and geography.

Data Collection Methods

Since the research relies on the two approaches, qualitative and quantitative, it required two types of data; measurable and textual data. The measurable data responds to the first research question, whereas the textual data responds to the second research question. In addition, the particular data was needed to formulate the case study. For example, the selection of the two cases required the information about R&D projects in the first place. According to Yin (1994), multiple sources of evidence is a principle of conducting the case study. "The multiple sources are intended to be used in a converging fashion, so that data should triangulate over the 'facts' of the case. Quantitative and qualitative data are both considered potentially important and relevant" (Yin 1992, 131). The purposes of "data triangulation" are to: (1) gather complementary data (Yin 1994), and (2) compare and cross-check the consistency of information (Patton 1990). This research design followed this prescript. Three methods of data collection: questionnaire, document review, and interview were employed in this research (Table 5.5).

Method of Data Collection	*Data collected*	*Data Form*	*Objective of data*	*Respondent*
Questionnaire	size, diversity, frequency of a network	measurable	address to question 1	R&D principal investigators
	perspectives and patterns on participation processes	textual	address to question 2	R&D principal investigators
Document	R&D information	textual	select the case	-
	list of stakeholders	textual	identify stakeholders	-
	achievement of R&D	measurable	address to question 1	-
	patterns on participation processes	textual	address to question 2	-
Interview	names of stakeholders	textual	identify stakeholders	R&D principal investigators
	perspectives, and patterns on participation processes	textual	address to question 2	R&D principal investigators and R&D stakeholders

Table 5. 5. The data collection methods, types and form of data collected, their objectives, and the respondents

Questionnaire

Questionnaire information includes factual information, opinions, attitudes and reasons for behaviors (Kerlinger 1992). Generally, a questionnaire is a tool for data collection regarding the quantitative approach (Bryman 1984). However, open-ended written responses to a questionnaire are considered a tool regarding the qualitative approach (Potter 1996).

The questionnaire items (Appendix 1) were designed to direct both of the questions in this research. The first research question "*How is participation linked to the success of R&D project development?*" required the measurable data to interpret the relationship between participation and the success of R&D. The questionnaire was a suitable tool to gather the factual measurable data on the dimension of participation (Table 5.6).

Dimension of Participation	*Questionnaire Items*
• number of organizations in the network	Questionnaire (questions # 6, 8, 10, 12, 13, 14, 15)
• number of linkages in the network	Questionnaire (question # 17)
• number of different types of linkages in the network	Questionnaire (question # 17)
• number of different types of organizations in the network	Questionnaire (questions # 6, 8, 10, 12, 13, 14, 15)
• number of the linkages happening	Questionnaire (question # 17)

Table 5. 6. Sources of the dimensions of participation

According to Kerlinger (1992), factual information includes what respondents knew about the subject under the investigation, such as what respondents did in the past, what they are doing now, and what they intend to do in the future. The dimensions of the organization set of the R&D project, defined as participation, were measured by the size, density, and frequency. By an assumption that the respondent who was a principal investigator of the R&D project knew about the dimension of his/her project, he/she could provide such measurable data.

The questionnaire also helped gather the textual data addressed to the second research question, *"How do or might various stakeholders in the R&D process participate?"* The questionnaire item numbers 18 and 19 (Appendix 1) were designed for this purpose. The questionnaire with open-ended written questions is considered an unobtrusive method. Asking the respondent to write statements about his/her thoughts is to get his/her insights, served this requirement. By this way, the researcher can maintain marginal status within a situation so as not to exercise excessive influence on the respondent (Potter 1996).

Document Review

Document review is valuable to this research since documentation is a data source with the strengths of being stable, unobtrusive, exact, and having broad coverage (Yin 1994). The types of documentation in this research included the administrative documents, i.e., R&D proposals, progress reports, assessments as well as other organization's internal documents. Since such documents were internal data belonging to the funding agency. This data proved to the valuable and necessary for formulating the case study. Though some documents were confidential and could not be viewed by the public, they were reviewed by the researcher after receiving permission.

The document review contributed four functions in this research. First, documents played a role in the project selection. As designed, two R&D projects, successful and unsuccessful were selected to be studied. The list of projects funded by the organization and the individual project files were the primary sources to select the two projects. Second, documents helped identify stakeholders of the project. Since the names of most R&D stakeholders were revealed in the internal organization documents, they were easily accessible. Third, documents were a prime source of the measurable data addressed to the first research question. The achievement of the project must be gathered from the individual project files before it can be converted to a measurable form. Fourth, documents were a source of textual data, which served the second research question.

Some patterns of participation processes were examined from relevant documents, such as project assessments and correspondence between the investigators and others.

Interview

One of the most significant sources of case study information is the interview (Yin 1994). In this research, the interview is central to all data addressed to the second research question. The respondents were two R&D principal investigators and the stakeholders of both R&D projects. The required data were about the pattern of participation taking place during the project, also their perspective on the processes. The interview was conducted in structured and unstructured styles. The structured interview followed an interview guide (Appendix 2) which served as a checklist to make sure that all relevant topics were covered (Patton 1990). Questions were translated in the Thai language (Appendix 4). In order to increase the accuracy of data collection, a tape recorder was used in the interview (Patton 1990).

On the other hand, the unstructured style referred to as a conversation-like interview was used since it adopted the open-ended approach to interviewing (Patton 1990). The questions flowed by the context of the conversation. The data gathered from the unstructured style-interview was different for each respondent (Patton 1990). Combining two interview styles was planned to get full advantages from the interview. Since the structured interview served to provide required data while the unstructured interview served to provide expanded data.

Data Collection Strategies

Four bottlenecks in data collection were anticipated; namely accessibility to data source, vertical collaboration, length of data gathering, and dependence on retrospective data. However, the advance strategies may help overcome or reduce these bottlenecks. These strategies included known sponsor approach, trust gaining and equal partner, interviewee selection, and data triangulation (Table 5.7).

Anticipated Bottlenecks	*Data Collection Strategies*
• accessibility to data	• known sponsor approach
• vertical collaboration	• trust gaining and equal partner
• length of data gathering	• interviewee selection
• dependence on retrospective data	• data triangulation

Table 5. 7. Data collection strategy to tackle the bottlenecks

Known Sponsor Approach

Known sponsor approach is the tactic that researchers use to establish legitimacy and creditability of another person and their own legitimacy and creditability (Patton 1990). This approach was applied to this research to deal with the problem of accessibility to data sources. As designed, the three data sources for this research were documentation, the questionnaire, and the interview. Having the permission of the director of the organization allowed the researcher accessibility to the organizational documents. The questionnaire was sent to the principal investigators of the projects whose names, addresses, and telephone numbers were recorded in the organizational document. Since the researcher was responsible for R&D projects, the researcher was well versed and fully functional with most of them. Consequently, the access to these two data sources was not anticipated to be a problem. On the other hand, the access to some interviewees was anticipated to be a critical problem. The interviewees were several stakeholders of the projects. Their names were identified by the principal investigator in the questionnaire. Some of the interviewees were industrialists, and staff members of any organization whom the researcher probably had not coordinated with. The known sponsor approach was planned to deal with this problem by finding referees who were accepted by the interviewees so the researcher was able to refer those referees' names to the interviewees. In this research, the referees were the project principal investigators and the director of the funding agency. However, as Patton (1990) indicates, when using this approach it is important to know that the "known sponsor" is indeed a source of legitimacy and creditability. In this research, there was no doubt about those selected as referees.

Trust Gaining and Equal Partner

Trust gaining and equal partner is a tactic used to have vertical collaboration between the researcher and the interviewee. To answer the research question, "*How do or might various stakeholders in the R&D process participate?*", it was necessary to gain the insight from the interviewees. According to Potter (1996), if the researcher simply interviews them, then this is not collaboration. He terms the relationship between the researcher and the subject "vertical collaboration" because two players were on different level in terms of power, expertise, and motives. Thus, the flow of discussion is across levels. Due to unfamiliarity with some interviewees as discussed above, the vertical collaboration may be complicated to build.

To gain trust and make equal partner, it helps to have vertical collaboration. The identification as a doctoral student at Old Dominion University and a staff member of the funding agency was expected to increase the researcher's creditability in order to gain acceptability from the interviewees. Moreover, there was a plan to check back with the interviewees at some time after the completion of the interview or go back to confirm their perspectives. As Potter (1996) argues, true vertical collaboration takes place when the researcher regards a subject as an equal partner in the analysis. Though the interviewee does not make the analysis by his/herself, checking back or confirming with him/her will establish vertical collaboration.

Interviewee-Selection

Interviewee selection was planned in order to control the length of data gathered. Since there were several stakeholders involving in each project, to interview all of them would have taken a long time to complete. Therefore, the interviewees were selected based on their significance on the project.

Data Triangulation

Data triangulation is suggested to reduce the problems caused by the dependence on retrospective data (Yin 1994, and Lorsuwannarat 1995). Due to the nature of the research questions examined, the researcher could not investigate the R&D project over time. The information gathered depended on retrospective data, therefore, the problems of bias, poor recall and inaccurate articulation can be anticipated (Yin 1994). The data gathered from the three methods, the document, the questionnaire and the interview were expected to be converged by the notion of triangulation. For example, the data of participation processes were collected from the principal investigator who completed the questionnaire and was interviewed. In addition, the document was expected to contain some related information about participation. Therefore, it was expected that the use of multiple sources of data or "data triangulation" in this research would reduce the conceivable problems caused by dependence an retrospective data.

Soundness of Research Design

Since this research adopted "triangulation" methodology as a basis of doing research, two methodologies, quantitative and qualitative were mixed, in order to formulate the case study and answer the research questions. However, the criteria of research merit are viewed differently from one methodology to another one. As Sandelowski cites Morgan's (1983) argument:

> . . . applying the criteria of one research tradition to another is nothing more than self-justification, since these criteria inevitably favor the research tradition that generated them. More over there is a basic law in the belief that any research method can be judged without bias even by its own tests of rigor (Sandelowski 1986, 23).

Therefore, the soundness of this research is viewed by two different kinds of logic, quantitative- and qualitative- focusing. In addition, the use of the case study as a basic design implies the distinct viewpoint in considering the soundness of the research.

Generalization

The first consideration is generalizability. Generalizability is the ability of the research findings to be uniform across the organization or events (Bailey 1992). Generalizability from the quantitative sense refers to how well the research findings can show a representation of the population interest. This notion cannot apply to qualitative research (Sandelowski 1986, and Patton 1990). The selection of subjects in qualitative research is based on the purposeful sampling approach, which is used to determine in what social domain the researcher wants to make analyses (Patton 1990). Therefore, "any subject belonging to a specific group is considered to represent that group" (Sandelowski 1986, 32). From a qualitative standpoint, generalizability refers to establishing "the position of all subjects in relation to the group of which they are members and the meaning of their slices of life" (Sandelowski 1986, 32).

In the quantitative methodology, sampling is typically statistical in that it is intended to reflect the distribution of certain variables in the population from which a sample is drawn (Sandelowski 1986). On the other hand, the adoption of purposeful sampling in this research caused the selection of the two cases. Too small samples were unable to ensure the proper use of statistical tests of inference in the quantitative sense. However, it is argued that generalization is not simply a function of the number of units the researcher investigates. More important are the kinds of unit of analysis, that is, the range of characteristics of the units investigated and the range of conditions under which the investigation occurs (Kennedy 1979). According to this argument, a wider range of generalization is not necessarily achieved by increasing sample size. The researcher can demonstrate the degree of confidence of generalization when he/she can identify the many attributes that are common between the sample and the interested population.

One way to achieve generalization is by adjusting the research design to exclude uniqueness as much as possible (Kennedy 1979, and Bailey 1992). In addition, many common attributes between cases are necessary for generalizing (Kennedy 1979). In this research, these strategies were already discussed in the case criteria selection. The replication may be made based on a case's (project's) common characteristic of setting such as getting support from the same funding agency, applying the same technology, and conducting R&D at the same location, etc.

Furthermore, generalization cannot be claimed automatically. Replication in other settings is very important to generalization (Yin 1994). If the findings are similar in other settings to a given situation, the generalization will be accepted. Even though the findings from this research may not be generalizable in the quantitative sense, they were in the qualitative sense.

Guba (1978) reviews in depth three basic positions that might be taken in regard to the generalizability of the qualitative inquiry findings;

1. Generalizability is a chimera; it is impossible to generalize in a scientific sense at all. . . .
2. Generalizability continues to be important, and efforts should be made to meet normal scientific criteria that pertain to it. . .
3. Generalizability is a fragile concept whose meaning is ambiguous and whose power is variable (Guba 1978: 68-70).

Thus, Guba (1978) proposes a resolution that acknowledges the diminished value and changed meaning of generalization. The generalization should be mandated to the researcher as the "working hypothesis" to the next study. This notion matches the one proposed by Bailey (1992). He supports that a study's findings can be generalizable beyond the immediate case study, to a theoretical proposition, and not the to population or universe. However, a theory from generalization must be tested through replication. This "analytic generalization" is the ability of the case to expand and generalize theories. This is different from "statistic generalization" which has generalized results from samples to the population (Bailey 1992, and Yin 1994). Therefore, it is possible to replicate this research study, and test its findings. If we can get the same results on the pattern of the participation process from other settings, the case study can be generalized to establish a theory.

It can be summarized that the research adopted the criteria of the qualitative methodology to consider its generalizability. Two issues about generalization were considered and compared to the criteria of the quantitative methodology. Table 5.8 summarizes the comparison between the two methodologies and the research design focusing to generalization.

Issues of Concern	*Quantitative*	*Qualitative*	*Research design*
Representativeness	Yes, if having statistical span connecting the sample to a population	Yes, if having a relation to a group where a unit of analysis is a member	1. Purposeful sampling 2. Having common attribute between a unit of analysis and population of interest
Inference	Population of interest	1. Population of interest, <u>or</u> 2. Theory	1. Other R&D projects with common attributes 2. Theory of participation processes in R&D processes

Table 5. 8. The comparison between two approaches in the issues about generalization and the research design

Validity

According to Potter (1996), in the quantitative sense validity means the accuracy (or the truthfulness) of the data. In the qualitative methodology there are no straightforward tests for validity (Patton 1990). Some qualitative researchers adopt this notion to make the research acceptable by reframing and accommodating it to increase the quality of their research (Sandelowski 1986, Yin 1994, Potter 1996). According to Yin (1994), three kinds of validity are ordinary to all social science methods; construct validity, internal validity, and external validity. Since the external validity involves generalizability (Sandelowski 1986, and Yin 1994), it was previously discussed. The remaining; construct validity and internal validity are discussed as follows.

Construct validity

According to Yin (1994), construct validity is the ability to determine correct operational measures for the concept being studied. It is the ability to link measurement notions and practices to theoretical notions (Kerlinger 1992). Similarly, Sandelowski (1986) refers to the construct validity as the "truth value" of an instrument that is increased when the researcher can demonstrate that the test results are congruent with theoretical explanations of the phenomenon. In the quantitative part of the research, the success of a project was scaled by the ability of technology diffusion. In the same way, the dimensions of participation processes were measured by the size, density, diversity, and frequency of the organizational network. Since the measurements were developed from the established theories of technology transfer and organizational network, it is considered to have construct validity.

It is argued that construct validity criteria may not be applicable for the evaluation of research design in qualitative part-- the truth value is evaluated by validity in the quantitative sense cannot be evaluated in qualitative research. According to Sandelowski (1986), the truth is subject-oriented rather than researcher-oriented. Since the true value in qualitative study is determined by the researcher--and the researcher is an instrument in his/her own research, it is suggested that researcher's credibility instead of validity is a criterion to evaluate the truth value from qualitative findings. In this matter, the finding was recognized to interpret in a way that other researchers can recognize as they experience the findings on their own. By doing so, the credibility of the research is enhanced (Sandelowski 1986).

From some viewpoint, multiple sources of evidence is a tactic to increase construct validity of the case studies in a manner of assuring converging lines of exploration (Kerlinger 1992, and Yin 1994). As discussed in the beginning of this chapter, the notion of data triangulation, which aims to gather complementary data (Yin 1994), was applied to this research. Three methods of the data collection; questionnaire, document review and interview were designed to collect the quantitative data and qualitative data in an overlapping fashion. For example, the interview probed the people's perceptions of the participation and what real actions people did for their participation in the technology development process in order to succeed in technology transfer. At the same time, the document revealed some patterns of participation in the written form. Thus, combining those two methods increased the research's construct validity when their findings converge to the same result on the patterns of participation in R&D development.

Internal validity

Yin (1994) defines that internal validity is an ability to demonstrate a causal relationship, whereby certain conditions are shown to lead other conditions, as distinguished from spurious relationship. In dealing with internal validity of the case study research, the analytic of "pattern matching" is applied to demonstrate that causal relationship. This analytic method compares an empirically based pattern with a predicted one. If the patterns coincide, the results can help a case study strengthen its internal validity.

To answer the first research question, "*How is participation linked to the success of R&D project development?*," the participation process is needed to determine whether it leads to R&D success. Participation defined as the dimensions of the organizational network, i.e. size, density, diversity, frequency, and the degree of R&D success are measured. Table 5.9 is formulated to shows the ideal data. By assuming that X_1, X_2, X_3, relate to Y in each case, also there is a sharp difference between X_1, X_2, X_3, and Y in each case can indicate a theoretical replication across cases. Such a result shows that the greater extent of participation, the greater degree of success of R&D project commercialization. Since the ideal patterns match the proposition, they enhance the validity of the research.

Project	***Level of Success Y***	***Number of Organizations X_1***	***Number of Linkages X_2***	***Number of Different Types Of Organizations X_3***	***Number of Different Types Of Linkages X_4***	***Number of Linkages Happening X_5***
1	1	3	3	2	NA	NA
2	5	35	75	5	NA	NA

Table 5. 9. Ideal Quantitative data of the research

In summary, table 5.10 summarizes how the research design strategies were defined to increase the validity of the research.

	Research design strategy to increase validity	
	Construct	***Internal***
Quantitative approach	establishing measurements from the existing theories (direct to question 1)	-
Qualitative approach	clarifying interpretation (direct to question 2)	-
Case study approach	data triangulation (direct to both questions)	pattern matching (direct to question 1)

Table 5. 10. Research design strategy to increase construct and internal validity

Reliability

Sandelowski (1986) refers reliability to the consistency, stability, and dependability of the research procedure. To pass test on reliability, the result from the research procedure must be the same every time.

According to Kerlinger (1990), high reliability of the research depends upon the decreasing value of variances. He suggests three steps of the "Max-micon principle" to increase reliability of research: indicating the items of measurement unambiguously, expanding instrument items of equal kind of quality, and writing the instruction clearly.

In this research, the operation definition of the contributing factors associated to the first research question including the success of technology, and dimensions of the organization network, were already indicated. By using the same data and the same methods, similar results should be obtained in other studies.

In addition, questions in the questionnaire and the interview were designed to check the reliability of the research result. The questionnaire was exclusively distributed to the two project's principal investigators. Then the interview was conducted subsequently. The identification of the participants of a network from the questionnaire (Appendix 1, Questions # 6, 8, 10, 12, 13, 14, and 15) led to the naming of the interviewees in the subsequent step of data collection. Therefore, the dimensions of participation including number of organizations, number of linkages, number of different type of linkages, and number of different types of organizations of the network, which were derived from the questionnaire, were confirmed by the implication of the interviews. For example, if the principal investigator of project 1 states in the questionnaire that Mr. X in the organization A informed him the technical information about the project, the interview of Mr. X in organization A can confirm this answer. Therefore, the questionnaire's result can be checked back whether the organization A had the linkage with the principal investigator. This "data triangulation" tactic with variance reduction was designed for high reliability of this research.

Obviously, the data in the quantitative part was explicit; it can be judged for reliability. In contrast, the second research question, the qualitative part, focused on people's perspective. Variation on people's perspective can occur because of various factors such as time, emotional, as well as the relationship between interviewer and interviewee. Moreover, the analysis was based on a subjective interpretation. To increase reliability, the value of variances in the qualitative part was reduced and subject to a different principle.

Yin (1994) argues that the general way of approaching the reliability problem of case study is to document the operational steps to conduct research as much as possible. Therefore, if someone wants to repeat the procedures, he/she will arrive at the same results. Sandelowski (1986), too, believes that researchers can provide consistency qualitative findings by clarifying "decision trail" which other researchers can follow. Then they could reach the same or comparably but not contrary conclusions. It is recognized that the explanation of the operational steps in the qualitative part was clear enough to increases the reliability of this research.

Summary

This chapter presents the rationales of the research design. The case study was the appropriate research design since the research investigated a contemporary phenomenon with its real-life context, the boundaries between phenomenon and context were not clearly evident, the researcher had no control over behavior events, and "how" research question were posed. The principle of selecting the case was multiple-case design since there was the need to compare the patterns of participation. In selecting the case, the random sampling would provide a number of cases which were not practical to study qualitative data. On the other hand, the purposeful sampling was more appropriate since its application of the replication logic acknowledged selecting some specific types of a case to get the desired result. Then, maximum variation was the research strategy in order to select the two types of cases: successful and unsuccessful. The number of the cases was ultimately two, because of the need to focus on each case in depth.

Three methods of data collection; (1) the document review, (2) the questionnaire, and (3) the interview were used in this research. Both types of data, quantitative and qualitative were collected by the three methods in a "data triangulation" style. In addition, known sponsor approach, vertical collaboration, trust gaining and equal partnering and data triangulation were strategies in data collection. Finally, the soundness of research design suggests that the design compiled with the research standard of generalizability, validity, and reliability.

CHAPTER 6

DATA ANALYSIS

The data analysis was composed of three parts. The first part discussed how two case studies were selected. The document review was used to select the case. The second part was to analyze the quantitative data collected from the questionnaire. The third part was to analyze the qualitative data collected from the open-ended items of the questionnaire, the document review, and the interview. The objective of the second part of analysis is to answer the first research question, "*How is participation linked to the success of R&D project development?*", whereas the objective of the third part was to answer the second research question, "*How do or might various stakeholders in the R&D process participate?*" The analysis in both parts was developed in a comparative style in order to cross-examine between the two projects.

Case Selection

The document review provided the idea of selecting the cases for the research. In the research design step as described in chapter 5, the preliminary analysis of the organizational database determined the criteria for the project selection, including similar domain specific, convenience for accessibility, and time consistency. The processes of selecting and the characteristics of the cases will be explained as follows.

Processes of Project Selection

In the research design, two projects with the maximum variation were determined as the cases to study. The first project was unable to explore basic scientific principle, unable to gain support for development on a larger scale, and not available for industry utilization. The second project, on the other hand, was able to explore basic scientific principle, gain support a larger scale development, available for utilization; and was already accepted by customers. As determined by the criteria for project selection in chapter 6, two projects were selected based on their common attributes. First, the domain of two projects was specified in novel product/industrial process improvement process or biotechnology for small rural development/small farmers. Second, the projects were convenient for accessibility. Both projects should be based in Bangkok, the capital city of Thailand, for the convenience in accessing data. Third, two projects should be time consistent.

Preliminary Selection

The funding agency provided funding 20, 22, 13, 26, 28, and 14 projects in 1992, 1993, 1994, 1995, 1996, and 1997 respectively. Each project was usually completed within two to three years. Such R&D projects were grouped according to their mission area as shown in table 6.1.

Mission Area	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*
1. Plant Biotechnology	5	1	1	7	12	3
2. Animal Biotechnology	5	10	0	4	12	6
3. Biotechnology for Small Rural Development/Small Farmers	1	0	2	1	1	0
4. Sustainable Development	5	2	1	2	8	1
5. Health Improvement	3	5	5	7	13	2
6. Novel Product/Industrial Process Improvement	1	4	4	4	6	2
Total	20	22	13	26	28	14

Table 6. 1. R&D projects categorized by the mission area

Time Frame Consistency

By the assumption that each R&D project would be completed in two or three years and be implemented within one or two years, projects started before 1995 were suitable for case selection. Such projects could be expected to demonstrate their application in 1998 when conducting this research. Most projects beginning in 1994 and lasting through 1997 did not have final reports submitted for review and subsequently, excluded as possible case studies. The only cases considered therefore, were started in 1992-1993.

Mission Area Specific

Since main interest was to investigate the application or technology transfer of the R&D projects. Thus, the projects in mission area 3 (Biotechnology for Small Rural Development/Small Farmers) and 6 (Novel Product/Industrial Process Improvement) were candidates because of their high potential for commercial or agricultural application. However, the number of projects started in 1992-1993 in mission 3 was one (Table 6.1), which was very limited and unacceptable for this research effort.

Location Specific

Among the leaving five projects in the mission 6, three of them were performed outside of Bangkok, one project was successful in term of technology transfer in level 4, whereas another was successful at level 2. Their levels of success were not sharply different. Therefore, these two projects were not appropriate to do comparatively case studies.

Results of Primary Selection

It can be concluded that the preliminary attributes were not appropriate to select the cases (Table 6.2). Though determining their time frame, mission area, and location may define that project 2 and 6 seemed to be the candidates for the cases to study, their outcomes (project successes) were not explicitly different. The attributes for selecting cases were improved and described in the next section.

Project	*Time frame*	*Mission Area*	*Location*	*Level of success*
1	1992-1995	3	Bangkok	
2	**1992-1995**	**6**	**Bangkok**	**4**
3	1993-1996	6	Chieng-Mai	
4	1993-1996	6	Chieng-Mai	
5	1993-1996	6	Songkla	
6	**1993-1996**	**6**	**Bangkok**	**2**

Table 6. 2. Preliminary cases from tentative attributes

Improved Criteria for Selecting Cases

Health improvement was another promising mission area for the case selection since there were eight projects in the pipeline starting in 1992 and 1993 (Table 6.1). In addition, while conducting the research in Thailand, the funding agency was paying attention to help commercialize a project in this mission area. Since there was a company that was interested to invest in technology resulting from the project. The product was already utilized and accepted by the customer. Then the project can be categorized in the level 5 since it was able to explore scientific principle, support a larger scale development, available for utilization and was readily accepted by customers.

In order to select another project that had an opposite level of success, the remaining seven projects in the same mission were investigated. Among them, one project was considered at the level 1, in terms of success because it was concluded without consequential scientific knowledge. Furthermore, its principal investigator changed his interest to a different subject. Therefore, it was unlikely that this project result would be considered for technology transfer or commercialization. Projects at level 1 and 5 were selected for this research. Regarding the geographical attribute, both projects were conducted in Bangkok; therefore, they conformed to the criteria of selection (Table 6.3). The next section will describe the characteristics of each project in detail.

Project	***Time frame***	***Mission Area***	***level of success***	***Location***
1	1992-1995	5	1	Bangkok
2	1992-1995	5	5	Bangkok

Table 6. 3. Actual case selection

Case 1

The first case has a level of success of 1 because it was unable to explore basic scientific principle, unable to support development on a larger scale, and not available for consumer utilization. The objective of this project was to produce pharmaceuticals derived from a biotechnological process. Currently, almost all of the required pharmaceutical products are imported because of the lack of technology for their production. This project was planned to develop two types of pharmaceuticals at an intermediate stage. Another objective was to gain engineering know-how for the pharmaceutical production at the pilot plant level, as well as, an approximate production cost. However, merely a small quantity of products, some engineering data for a laboratory scale, and an incomplete economic evaluation were obtained when the project was ended. The products were extracted from medicinal plants, which are not native to Thailand. The project could not illustrate any new scientific principle or new technique. In addition, there was a lack of application of R&D efforts. The principal investigator (PI) did not continue an R&D project in this field; moreover, his interest changed to other plants and other applications.

Case 2

The second case had a level of 5 because it was able to explore basic scientific principles, support a larger development, and available for consumer utilization. The project was planned to develop the rapid diagnosis of a specific tropical disease. The use of this biotechnology product would be cheaper, simpler, and more accurate than to use the conventional method. The diagnostic test had been produced at the laboratory bench level; however, this production was large enough for distribution to hospitals throughout Thailand. The customers' satisfaction with the product was acknowledged. Furthermore, several companies had been interested in investing in this product, as well as other products obtained by the principal investigator of this project (PI-2). Currently, PI-2, the funding agency, and one other company had been negotiating for the commercialization of this product. This exhibits that the product would be available for a larger scale of production and commercialization.

Quantitative Analysis

The pattern of participation processes as organization sets are shown in table 6.4.

	Project 1	***Project 2***
Size	9	10
Density	6/9 = 67%	NA
Diversity- linkage	6	NA
- organizational	6	4
Frequency	NA	NA

Table 6. 4. The organization sets of Project 1 and Project 2.

Table 6.4 presents the organization sets for Project 1 and Project 2. The data was collected from the questionnaire items filled by the principal investigator of each project. The size of the organization set is the number of the organization in the network. PI-1 indicated that nine organizations/individuals participated in the project. The six types of linkages were: (1) to be informed of technical evaluation concerning the project, (2) to be informed of related technical information concerning the project, (3) to be informed of other information, (4) to discuss the technical issues concerning the project, (5) to discuss other project issues (i.e., business, regulation, etc.), and (6) to hold joint seminar/conference training. Six types of organizations were (1) co-R&D, (2) extension (up-scale process), (3) development (engineering), (4) user, (5) evaluation process, (6) and others. The density is the number of types of linkages divided by the size of the network, so it is equal to 67%. The frequency of linkages is not available since the PI-1's answers were "regularly" in almost all items asking for the frequency of the linkages (Question # 17).

The size of the organization set for Project 2 was 10. However, PI-2 did not identify the type of linkages that the project had during the R&D process. Therefore, the linkage diversity is not available, which also causes frequency, and density of the network to be unavailable. Four types of organizations indicated by PI-2 were (1) co-R&D, (2) extension (up-scale process), (3) user, and (4) others.

Since the analysis is not a means for statistical purposes, all available data should provide an explanation for the differences in how each project was conducted. The difference in size of the network between Project 1 and Project 2 indicates that Project 2 had a slightly higher number of the participants in the R&D activity. On the other hand, Project 1 had more types of linkages than Project 2. These incongruous numbers explain the difference of R&D activities. Project 2 did not require an engineering process. In addition, the evaluation process did not have an impact. On the other hand, Project 1 involved those two processes. Interestingly, PI-2 indicated three international organizations involved in R&D activities, whereas PI-1 did not. These occurrences may provide an explanation concerning participation processes to the success of Project 2.

In summary, it may be determined that this data is not appropriate to the pattern matching analysis planned in the research design. The patterns of two projects did not illustrate theoretical replication as expected. Incomplete questionnaire was a main cause of insufficient data for the comparison between the two projects. However, some available data shows slight differences between two projects.

Qualitative Analysis

The qualitative finding highlights the explanation of participation processes taking place in each project where qualitative data are helpful. To get at the meaning of participation processes, the explanation building of each case is appropriate. Explanation building is a type of pattern matching strategy that can build a general explanation that fits each of the individual cases, and create cross-case analysis (Yin 1994). Three themes of perspectives were emerging while conducting the case studies, namely the goals of the R&D project, outcome of R&D projects, and publication. The details of participant's perspectives on R&D were analyzed. Finally, the explanation was made toward the participation process in each case.

Case 1

PI-1 identified the stakeholders of R&D activities in all stages of technology transfer. This indication was consistent in all sources of data gathering: the document review, questionnaire, and the interview. While performing a main part of R&D; i.e., growing the plants, and extracting the chemicals, PI-1 shared various R&D activities with other stakeholders. A team of university's engineering professors was responsible for the engineering part of the project. A team of agronomists was in charge of micropropagating of plants. Also, an entrepreneur who had a business of agrochemical products helped grow the plants at his farm. In addition, there was one firm that promised to make investment to this research effort. This type of contribution was supposed to ensure Project 1 to would succeed to commercialization, however, it ended without any application. Furthermore, PI-1 changed his research interest to another plant and another application.

Ten stakeholders including PI-1 were interviewed because of the significance of their participation to Project 1. Their anonymous labels and their roles are presented in table 6.5. To avoid a gender bias, the pronoun "he" or "him" regardless male, or female of the stakeholder is used throughout the analysis.

Interviewee	*Profession*	*Role*
1. PI-1	university faculty	principal investigator
2. Engineer	university faculty	co-investigator
3. Agronomist	director of a non-profit organizational laboratory	co-investigator
4. Entrepreneur	owner, and manager of an agrochemical firm	co-investigator
5. Manager	owner, and manager of a pharmaceutical firm	co-investigator/ prospective user
6. Businessman	chief of R&D division of a pharmaceutical firm	reviewer
7. Professor I	university faculty	reviewer
8. Professor II	university faculty	reviewer
9. Supervisor	director of a division of a state enterprise	prospective user
10. Director	director of the funding agency	fund provider

Table 6. 5. Professionals and roles of Project 1' stakeholders

Goal of R&D

The stakeholders' perspectives on the goal of R&D exhibit their compatibility and conflict. PI-1's had knowledge-oriented goals on R&D. PI-1 set up Project 1 with the knowledge gained from conducting his dissertation abroad. A variety of medicinal plants used in Project 1 are native to a foreign country. It provides a source of chemicals with the pharmacological effects. PI-1's previous work investigated an appropriate method of growing the plants in Thailand demonstrated that the plants have the potential to regenerate by the micropropagation technique, and are able to produce required chemicals. Therefore, the project was conducted to pursue the PI-1's self-interest on this kind of plants, and to extend the scale of the chemical extraction.

The goal was adjustable to accommodate other professionals, i.e., an engineer, a university faculty, who designed and constructed an extraction tank, and wanted to obtain data from a small-scale production. From his perspective, extending the production to a larger-scale would be another step that would require investments from industry. However, how to establish the mechanism for receiving the industry investment on R&D was not the project issue. Engineer stated:

> . . . end users have to consider R&D from the business perspective. Therefore, they have to perceive R&D benefit in a long run, not at a current position. Let's assume if a company would like to invest in R&D, its question would be "Are you sure?" We must answer 'yes'. However, by such a scale with a limited R&D budget, we can't answer 'yes'. The company would ask when we could answer 'yes'. So we need to convince the company to do R&D with us to know the answer together. The company would say: "If I have to take risk, I don't want to pay. I would pay when the money could definitely come back." In the meantime, the researcher would think that because the experiment is at this stage, the company should make investment. Consequently, the story never ends. This is a national problem.

It can be seen that the application of R&D efforts to the industry was not a concern to PI-1 and Engineer. In the same way, Agronomist did not value the application of R&D efforts. Agronomist identified two barriers to the application. First, this kind of plants is not native to Thailand. Second, there is a problem of the drug formulation, which is rigorously controlled by the Thailand Food and Drug Administration (FDA). This control has probably caused the diminishing on the advance of R&D relating to medical plants in Thailand. In India, and China, for instance, the discovery of drugs derived from medicinal plants has been carried on for a long period. On the contrary, the study on medicinal plants in Thailand has been banished for almost a century because potential drugs have been acquired from other industrial countries. Presently, the concept to develop drugs from medicinal plants has been revived. Unfortunately, some developed countries are prohibiting such development by issuing regulations, which would prohibit the development of a Thai drug formula. As a result, the development of drug formulas from medicinal plants has been suspended. Although these hurdles on its application were recognized, Agronomist did not hesitate to participate in Project 1.

In this respect, Agronomist considered PI-1 a competent researcher who was enthusiastic to conduct R&D. Therefore, Agronomist was pleased to participate in the project. His purpose was to utilize the existing facility in his laboratory with its full capacity. This generosity was due to his experience. Agronomist argued:

> . . . Such facilities belong to the country. We can see that several organizations understand that facilities belong to them. They believe that they own facilities and are unwilling to let outsiders access them. Then they are not utilized effectively. They have no value to their cost. Sometimes I needed to use the facility in some organization; however, it was not convenient. Therefore, when I have a facility that is necessary for someone who has faith to work for the country, I am willing to help.

The lack in interest of an application of Project 1 was not exhibited by all participants of the project. On the contrary to the three participants above, Entrepreneur's goal is market-oriented. Entrepreneur was engaged in this project because of the economic potential of the pharmaceutical products derived from the research effort.

Entrepreneur's business was related to agricultural products, and he had experience with the use of foreign plants in his business. Therefore, he was interested in the foreign plants studied in Project 1. From Entrepreneur's perspective: "Presently, medicinal plants are attracted to many people. For this kind of plants, in particular, the production resulted per a rai[2] was relatively high. They have the potential to be accepted by farmers in my opinion. Of course, I believe it is possible."

Since his profession involved plant growing and harvesting, his concern was that the plant improvement could increase a yield of chemicals. Though Entrepreneur recognized the economic potential of the Project 1's products, he made the evaluation from his experience. He had not received any detailed financial information from PI-1. "I haven't obtained any numbers, I don't know how much chemical, is needed to produce the product to gain the return on investment. I haven't had any number, but I believe these plants are likely to make a profit."

However, Entrepreneur did not have an intention to complete the commercialization of these products. Instead Entrepreneur argued "Enforcing PI-1 to continue Project 1 is a role of the pharmaceutical firm that has its own R&D."

Actually, there was an attempt of PI-1 to collaborate a pharmaceutical firm to the project. However, the collaboration was not a means to push Project 1 to commercialization stage. PI-1 contacted Manager for a funding purpose. First, he needed the data of the pharmaceutical products to confirm their economic feasibility. Second, he needed the industry's proof of having a prospective user.

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[2] A rai equals to 4 acres.

PI-1 believed that having an indication that the project's efforts would turn to industry would persuade the funding agency to grant the project. In this case, PI-1 asked for a Manager's contribution. Therefore, Manager provided PI-1 an official letter presenting his determination to undertake the technology afterward. It was also understood that to provide such a letter gave Manager's firm an opportunity, but not a constraint to invest in the technology.

Obviously, Manager's emphasis was mainly on the business. His firm's current operation was to formulate various kinds of medicine from import materials. An R&D division took into account the development of the formula, for example, to extend the drug stability, but not to invent new medicines. To participate in R&D was a means to have an opportunity to take benefit from producing the drug if the project was a success. In his opinion, innovation such as a new drug, however, is ideal for Thai investors because of several factors. For example, he argued:

> Investment in drug recovery is highly expensive, though a very large company that has high financial venture cannot make it . . . . Lack of expertise was another hurdle. The most Thai firms can do is to collaborate with universities, for example, to provide them a grant to conduct R&D projects.

There were a variety of project reviewers' perspectives. From Businessman's perspective, the goal of an R&D project was basically the application. In his opinion, PI-1 did research to gain the knowledge, but did not plan for the application. For example, there was no concern on the amount of the plants, which would produce enough chemicals for the production scale. From his perspective, the goal of an R&D project should be technology transferring to the industry. However, in order to make an investment, the industrial sector must focus on the cost-effectiveness of the product that was related to four components of projects namely, sale price, time, management, and technical certainty. In his opinion, though PI-1 was not expected to be involved in the technology transfer process to the industry, PI-1 supposedly had enough data for the industrial scale production.

On the other hand, a commercial application was not a concern from an academic view. From Professor I's perspective, the goal of Project 1 was to strengthen the basic science; indeed it was not accomplished. He argued that in the national research context the basic science was essential for the technology development. Professor I argued:

> Research efforts do not need to be commercialized in the first place. Technology generated from applied science must have enough knowledge that is acquired from the understanding of basic science. . . . If we look at developed countries, for example, England, it had the industrial revolution. How did it happen? There had been basic science research conducted for a very long period, then the knowledge reached at one level. As all fundamental knowledge was understood, commercialization could be introduced. In contrast, we haven't had basic science yet; however, we seek for commercialization. We skip over a step.

It should be noted that while collecting the data, Thailand was facing the economic crisis. This was opposite to the situation over the past few years, when the country had the impressive economic growth. Accordingly, Professor I related the good economy to the quality of R&D projects. He argued:

> When Thailand had a buoyant economic climate, many people who never had done research, or had done it without purpose, and direction were required to do research because of their university faculty position. They conducted research to get their promotion, and then they began to create technology. It is not sound that anyone can do technology, because they must have brains. As a result, they conducted research by their style. First, they had no idea on their research, but promised, and out-promised. This kind of researchers is risky because politicians and public don't accept the research. Anyway we gave those researchers authorization but there were no results from them. Second, the researchers who also had no idea; however, they consulted their former advisor abroad. Otherwise, they proceeded their dissertation research. This was a problem. If I have an authority, I wouldn't support such a kind of project.

According to this perspective, PI-1 appeared to be categorized in the second type of researcher. Moreover, Professor I objected to the methodology of Project-1. From his perspective, it was risky to grow exotic plants in Thailand. There were several projects that attempted to take advantages from exotic plants. As a result, every project ended up with a low yield of required chemical. Project 1 was not an exception. The basic understanding of the plant was necessary as a foundation of research. A project should go step by step from Professor I's approach. Professor I stated:

> If we give support for such a project, there should have been an experiment of plant growth and chemical extraction. When a good result is present, we would determine the yield and whether Thai industry would implement the technology. If no, we would discontinue the project. If yes, we could consider the large-scale approach.

Another viewpoint was provided by an academic reviewer. Professor II recognized the importance of Project-1 in terms of the reduction of dependence on import drugs. From his perspective, though the chemicals were utilized in Thailand in a small amount, the concept of reducing the import was quite acceptable. However, he realized that Project 1 was done at an experimental scale. It needed two further steps: a prototype step and an industrial step, in order to be commercialized.

PI-1 defined a state enterprise to prospective users of Project 1's results. However, Supervisor focused mainly on an economic view of the project. He did not perceive a value of Project 1 since its products would not be feasible and accepted by the market. He claimed "For developing countries, setting up a plant to extract the purified compound is unfeasible. Since the investment is very expensive. If the expected sales are less than 1,000 million Bahts[3], no one invests. In addition, if it can't be exported, it is useless to be produced."

Since the products obtained from Project 1 were purified compounds, Supervisor was not convinced that the technology would be appropriate for the commercialization. The investment would be tremendous. "Expecting international companies to invest is fanciful because Thai's know-how is not competitive." His opinion was that there were some countries that had high technology in this research area such as India. Supervisor said:

> For example, India has diversified indigenous plants. Indian chemical engineers are highly capable. Such a country has readily downstream and upstream processes. Such competent resources, which would be attracted to industrial countries, however, are not sufficient in Thailand.

According to him, a market feasibility study is a prior mechanism to initiate any R&D project. Obviously, Supervisor realized the difference between industrial and academic viewpoint on the R&D goal. Supervisor explained:

> Universities, industry, and the funding agency hold incompatible concepts. It is understandable that the funding agency appreciates R&D for academic excellence--to encourage new researchers. This is good. However, a time period should be limited for such encouragement. When will R&D projects be materialized, and applied at an industrial level? Food industries, like the fermented food industry, are OK since there is nothing complicated. Pharmaceutical industries; however, are different. The investment is more expensive. . . . Therefore, at the beginning of an R&D project, a question must be asked-How much does the market need? R&D projects must be market-oriented, yet not be academic-oriented. Though we want to do the project, we must determine what its result is. Our budget is from the citizen's tax.

On the contrary, Director accepted that to strengthen the researcher's capability was also an objective of the R&D project. Since one among several mandates of the

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[3] 36 Bahts equal to 1 US$.

funding agency is to be a "driving force" to R&D. According to Director, the selection criteria of an R&D project for funding had been varied upon each R&D project's framework. From his perspective, the fact that PI-1 was an amateur researcher was a reason that Project 1 received the support. Director explained:

> To encourage and give an opportunity to researchers to conduct the R&D project is also important. This is the issue of creating researchers' competence. . . . At that time the agency was at the stage that we wanted to promote various activities to construct the confidence of researchers. The R&D project for financial return was not only one option.

In summary, the perspectives of the participants of the goal of Project 1 can be categorized into three groups. The goal of the first group was oriented toward knowledge in perceiving Project 1. While PI-1 pursued his research interest without the aim of the application, his research effort was accepted by Engineer, Agronomist, and Director. Also, Professor I who even though, he disagreed on the research methodology supported the idea of acquiring new knowledge. The goal of a second group was oriented toward technology. Businessman was only a member of this group since the R&D project must be proved to be ready in development from his perspective. However, he perceived the commercialization to be a next step. In contrast, the goal of a third group was oriented toward market. The participants in this group; i.e., Entrepreneur, Manager, Professor II, and Supervisor expected resulted from Project 1 in the long term. Their anticipation toward the R&D Project was merely on its ability of commercialization. These perspectives can be summarized in table 6.6.

Goal	*Stakeholder*
Knowledge-oriented	PI-1, Engineer, Agronomist, Professor I, Director
Technology-oriented	Businessman
Market-oriented	Entrepreneur, Manager, Professor II, Supervisor

Table 6. 6. Perspectives on R&D's goal of Project 1's stakeholders

Outcomes of R&D

Deviated and similar perspectives on the outcomes of R&D were observable among the stakeholders of Project 1. PI-1 expected to gather information of the development of the plant propagation, and chemical extraction at an experimental scale. An extraction tank was designed and some factors were studied by Engineer's team. Such information needed to be investigated in future research if the technology would make it through its entire life cycle. Though the Project 1's proposal indicated that the technology would be transferred to Manager's company, there was no actual attempt to accomplish it. Actually, PI-1 did not think about approaching research efforts to the industry. PI-1 stated:

> The manufacturing scale is nonsense. R&D must be a step by step process. Those chemicals are already imported. The country needs to develop its own technology. The application should start from acquiring the basic information at the experimental scale, which can be used on a pilot scale, then on the manufacturing scale.

Though PI-1 had proposed to develop a pilot plant to produce the chemicals, this objective was revised and reduced to produce the chemicals at the laboratory scale. However, to analyze the cost of the production was another objective that was proposed to meet the requirement of the funding agency. PI-1 explained: "I proposed cost-benefit analysis in the project because of the requirement of the funding agency. The cost that was analyzed in the final report was calculated from the experiment data. It should be reduced because of the raw material and harvesting costs, for example."

PI-1 believed that there should be a policy of some organization to decide whether to produce chemicals in order to substitute imports. However, he had no idea which organization should pursue his belief. By assuming that other components of technology transfer may come from other organizations, as a scientist PI-1 limited his role to gain scientific knowledge. PI-1 argued:

> Scientists are not supposed to think about the economic perspective on R&D projects. A scientist's work is supposed to provide scientific knowledge. The indication of users is mandated for the principal investigator, and it should be sound to get support from the funding agency. Economics is another discipline besides scientists' knowledge.

Engineer seemed to agree with PI-1 that Project 1 was a way to establish a new knowledge. Moreover, he translated research consequences to an education direction. One R&D outcome was to build "new blood" researchers. Engineer argued:

> We are in an academic environment. There are various ways for R&D projects to spin-off. For example, when a graduate student finds something new, but it is out-of-plan, we can't put on a constraint. He may have a chance to practice or to gain more knowledge that would be helpful to him. This is also one among other R&D outputs. It may be hidden. However, if we can train someone, he may be a capable researcher in the future. This output is also essential.

Agronomist also determined that strengthening researchers' abilities in doing research was considered to be the accomplishment of Project 1. From his perspective, to continue the development of the drug formula was another step that required the industrial investment.

In a like manner, Entrepreneur perceives the outcome of Project 1 as an ability to learn new things. From Entrepreneur's perspective, learning the plants' features was a consequence his firm earned from contributing in Project 1. However, he did not take any advantage from the plants. After completing Project-1, he did not either continue growing or have a business relating to the plants.

New knowledge and scientific work force developed from R&D projects were also foreseen in Professor I's opinion. Commercialization was a step that he did not consider. R&D activities were far from application if they lacked a scientific base knowledge. Professor I argued: "Commercialization is a word that has killed Thailand's science terribly." Professor I believed that R&D payoffs may not be merely measured by the profit of commercialization. From his opinion: "To create talented scientists is also an important outcome." He opposed the idea of commercialization because of his experience with a policy maker in the past decade. "I found it difficult because my own project was basic science research that was not designed to be commercialized."

The commitment on basic research caused Professor I to value the R&D outcome in terms of new knowledge discover and human resource development. It may be implied that the second type of outcome was obtained from Project 1, from his perspective. Since he argued "If you ask what was expected, it was less compared to the money provided for support. Anyway we could have had someone doing research."

The outcome of gaining research capability was also recognized by Director. He argued that this outcome should be separated from the commercialization opportunity. He had realized before launching Project 1 that continuing research efforts by the industry could not be foreseen. Director stated:

> The project was interesting in the sense of the development of medicinal plants; however, I need to explain that we knew from the beginning that the commercialization opportunity tended to be slight. In my sense, with a slight

> opportunity, the project had some degree of a competency. It should be tried out since the pharmaceutical industry in our country is very weak. . . . As a consequence, it is necessary to study in this field, which is the construction of the fundamental capability rather than the attempt to have the commercialization activity.

From Director's judgment, the project was completed without a potential to be commercialized. He indicated "The project competence was inadequate to push at that time." Therefore, there was no attempt from the funding agency to enforce the project to go forward.

On the contrary, Professor II expected the outcome of Project 1 in terms of developing the technology. Although he realized that the amount of the chemicals utilized in Thailand was very small, he supported this kind of project. His main concern was the success of Project 1 in the production stage. "There are two problems related to the project. First, how to improve the plants to produce the chemicals in our environment. Second, how to develop an extraction prototype."

Likewise, Supervisor's approach on R&D outcomes was emphasized on the creation of public goods. He asserted that the extraction processes of various chemicals were already known; moreover, the state enterprise could extract them in a small amount for the standardization purpose. The state enterprise did not attempt to extract purified chemicals to formulate the medicines because such a process needed a large amount of the chemicals and a large-scale production was costly. On the contrary, the state enterprise was interested in medicinal plants in order to produce medicines in a crude extract form. R&D projects relating to the crude extract production were conducted and sponsored by the state enterprise itself. Several projects were already transferred to the industry. Supervisor provided the example of his perceived outcome of R&D projects by comparing to the state enterprise R&D efforts. "Industry received our technologies. This is tangible technology transferring from laboratory to market."

From Manager's viewpoint, industrial sectors in Thailand were not ingenious enough for developing new technology. They needed to depend on public sectors for both expertise and budgets. Industrial sectors focused on technologies that had the potential for short-term implementation. In addition those technologies that have the potential for success. In this case, Manager believed that Project 1 was in this category. From his perspective, the drugs that would be developed from Project 1 could be substituted for import ones. Similarly, Businessman looked forward to effective utilization from research efforts.

Project 1's outcomes were perceived differently and similarly, which can be grouped into two categories. One category perceived Project 1's outcome on learning new knowledge. The participants understood that the project was in the very first stage of technology transfer. They accepted advantages of Project 1 in terms of testing, and practicing new techniques though there was no proof for the viability of commercialization. A second category, on the other hand, valued Project 1's outcome on its competitive advantage. By this belief, the participants envisioned that the technology can be verified by its viability to transfer to a commercialization stage. In other words, the technology must have clarity about the scientific principles, as well as economic proofs. However, the participants in this category perceived the Project 1's outcome in a different level of competitive advantage. While Supervisor did not realize the competitive advantage from Project 1, Professor II, Manager, and Businessman anticipated it. Table 6.7 summarizes these perspectives.

Outcome	*Stakeholder*
New knowledge	PI-1, Engineer, Entrepreneur, Agronomist, Professor I, and Director
Competitive advantage of technology	Supervisor, Professor II, Manager, and Businessman

Table 6. 7. Perspectives on R&D's outcomes of Project 1's stakeholders

Publication

Publication is perceived as a method of disseminating knowledge, which is an academic motive (Fairweather 1990). It is also identified as a facilitator of technology transfer (Dorf and Worthington 1989). Project 1's participants perceived publication in various aspects. Some participants appreciated the idea of having publications. However, some participants ignored and even objected to this aspect.

PI-1 was the one who appreciated the idea of publishing paper. He was proud that his paper was published in an international journal. The paper focused on the propagation of the plants, which was a part of Project 1. He recognized that the audience of the journal was too broad. However, he was not aware of transferring the technology by academic publication. "I don't know whether the industry would be interested in such a kind of journal."

From Professor I's opinion: "Publications are like a pile of bricks." He explained that a scientific discovery in the past might be obsolete; however, it was the basis of contemporary and future knowledge. Furthermore, publications allow for legitimate judgment of research. Professor I reasoned:

> People probably have bias for their own work. To publish research papers in journals is to ask other scientists to approve our research and to indicate its

strengths and weaknesses. Approving publications by a scientific community is a credit for the researcher. . . . Without published papers, we don't know whether his work is faithful."

From Professor I's attitude, to publish was mandated to the researcher. Also Professor's II agreed to this notion. He asserted "Otherwise, none knows research is already done. At least a preliminary result may be presented. It can be correct or incorrect." Professor II underlined that publishing was one of R&D's returns since conducting research required investment. His concern was:

> Several researchers do not have publications. They say they did research; however, they have only short reports indicating their R&D projects were done; nothing is distributed. At least they should publish something. It is not necessary to be a research result. It may be an article, or a survey that can show a basic result.

On the contrary, Engineer did not recognize publication as a priority for R&D. For Engineer, the utilization was the priority. He argued: "The idea of having publications is OK, but it should not be strict in that way. If I compare such an output to the utilization, I give a higher priority to the last one. Having no paper in international journals; however, someone can use the results, is more significant than having papers only."

From Engineer's perspective, the main value of publishing papers was to present data and to get inputs from audiences; nonetheless, to get promotion might be another consequence in others' opinion. He mentioned other stakeholders' perspectives, however, he insisted on his concept. Engineer explained:

> The funding agency's objective of having publications is to encourage researchers to have a contribution within a research community. This is the researchers' opportunity to present their insights, what they got from reviewers, and what improvements would be. Therefore, they would have feedback from audiences. The promotion is related to merit paid, such as a career cost and position cost, that may serve as an incentive for some researcher.... For me, currently there are other

> important tasks in line, so I make these tasks prior to publishing a paper. This stuff can wait. For example, if I am invited to be a speaker, I do it as my priority.... In our country, we have published papers in international journals. After that they are on shelves and that is it. Nothing is continued. OK some researchers may write a book contributing some new knowledge to academic colleagues. However, the utilization concept is problematic.

Like Engineer, Agronomist realized the value of publication as a professional incentive, though he did not make publishing his priority. "Academic faculty may have papers, do presentations and then get a promotion to be a professor. I have nothing. Anyway I am proud of it, and I have gained knowledge from my work."

In the same way, Supervisor accepted that publishing papers was one thing that reflected the researchers' ability. The state enterprise has a financial reward to encourage researchers to publish papers. However, he did not appreciate the value of publishing scientific papers. "Personally I am disinterested in writing scientific papers. I have my own published paper but I don't regard its meaning on my life. My life is to make products that are used by people. I am proud of this. This is what I have been working for." Since Supervisor was a former university faculty and was dissatisfied with a university system. The opposition to publication is noticeable. Supervisor stated: "I left a university because I couldn't proceed with my work. The remaining task was to write papers. I didn't know why I should do it."

From an industrial side, Entrepreneur valued publication. He had learned new technology from the publication and then initiated his existing business. "I went to a library, asked for research reports on... around the world. Then I learned about the plant and I knew its source. I imported it and hired a public researcher to test it."

Similar to Entrepreneur, Manager recognized the value of learning from academic journals; however, he did not take its advantage to his business. His willingness to invest in this subject was probably limited by other factors. Manager said:

> Publications are absolutely useful; however, it depends on whether we have a chance to grasp its value. First, we must have enough time to read it. Second, we have to allocate an abundant budget to subscribe it. Anyway in our country, the opportunity is insignificant. We used to subscribe one about the production, and then we canceled it. Especially, when the money value has changed, its price is double.

On the contrary, publication was out of Businessman's interest. Businessman believed:

> Industrial people do not understand and are not able to take advantages of R&D results from journals. Publications are one achievement rewarded to researchers who are interested in basic science. For them, pride, promotion and reputation are the consequences of publishing.

Director also believed that the industry did not take advantage of publications. Though he agreed that publication in international journals was an R&D quality control process, it was not a distribution channel to the industry. From his opinion, the industry could receive information about R&D by other channels, such as dialogues, seminars, round table meetings and factory visits. In addition, the success of an R&D project was not counted only by publishing, but also by delivering technology development. He explained the meaning of publication:

> Publication is necessary since it means the quality control of the R&D project. However, it is not all that. I think a mistake is to think that having publication is enough. It is not enough for a project that received a grant from the funding agency. For example, several researchers may think that to apply the grant is to conduct an R&D project and get a publication as an output. Then they have accomplished something. Such an R&D project may provide knowledge and perhaps human resources. However, it does not serve the purpose of technology development.

The participants perceived several aspects of publication. Though some perspectives did not add directly to Project 1's results, they reflected the value of scientific work in general. It may be concluded that all participants recognized the significance of publication. However, they valued publication in different aspects. Entrepreneur, Businessman, Engineer, Manager and Director related the value of publication to the utilization. On the other hand, Agronomist, Supervisor, PI-1, Professor I and Professor II did not. These various perspectives are summarized in table 6.8.

Value on Publication	***Stakeholder***
Related to utilization • No benefit to industry	Businessman, Engineer, Manager, and Director
• Benefit to industry	Entrepreneur
Not related to utilization • No value	Agronomist, and Supervisor
• Prestige	PI-1
• Quality control of research	Professor I, and Professor II

Table 6. 8. Perspectives on publication of Project 1's stakeholders

Participation Processes

Obviously, there were participation processes among PI-1, Engineer, Agronomist, Manager, and Entrepreneur, since they worked on different tasks during the research stage of Project 1. On the other hand, Businessman, Professor I and Professor II, Supervisor, and Director they did not perform any tasks. However, they had an opportunity to contribute ideas to the project. There were various patterns of participation processes between these stakeholders to PI-1.

Regarding Engineer and PI-1, their relations were informal--they were like colleagues. For instance, PI-1 explained about the relationship to Engineer "We always communicated by telephone, especially when we had a problem. Frequently we met and discussed the project." On the other hand, PI-1 did not have direct contact from the project's reviewers. He received the evaluation in written format, then discussed these issues and concerns of the project with Engineer and Agronomist. He argued that some issues raised by the reviewers did not make sense to Project 1, which maybe because "They were from other disciplines. They did not understand our concept very well." Nevertheless, PI-1 did not know the reviewers since they did not reveal themselves for the evaluation.

PI-1 believed that the participation among the co-investigators, namely Engineer, Agronomist, and Entrepreneur influenced the success of Project 1. From PI-1's opinion "Good relationships created trustworthiness among us. However, other problems, for instance, economics or other tasks caused us to discontinue our coordinating work."

Engineer also gained advantages from participation on Project 1and indicated:

> A great essence of coordination from different disciplines is to take vantage points from each one. I wish such an R&D activity would arise in our country. This will increase the weak mutual capacity in our country. Presently, there are rare R&D activities that a researcher from one discipline can work independently--without any other support.

To facilitate the participation, Engineer considered that the funding agency should enforce it as a mandate of the R&D project. Engineer argued:

> The policy should promote the coordination among various disciplines. In our country we always find out that whenever we work together, we couldn't go through. I think we must have to learn together in order to gain something we want. The participation in working should be a mechanism to get each side to be a co-learner. This generation has tendency to accept this approach more than the

> antecedent one. Maybe we need the enforcement—the funding agency may have to have a constraint for researchers, to have more than one professional to conduct an R&D project.

Since Engineer preferred flexibility in conducting the project rather than rigidity from the review process, he argued that the participation from peer-reviewers should not be established for the inspection. "Reviewers should guide rather than control us to conduct the project. They should tell us how far we are at the moment, where we are; they should suggest, but not inspect us." With respect to the review process to Project 1, he indicated "It was a format. The reviewers did not control us. As they suggested, we tried to follow. I didn't see any problem by this way."

According to his experience of coordinating to some firms, Engineer found some conflict that created his negative attitude to the private sector.

> Once some equipment was required for a graduate student's thesis. We asked a supplier who sold the equipment. We hoped to track distributors since we would like to ask them for a donation of that equipment. The supplier did not tell us because he kept the distributors' names as a secret. So what I should do. This is why I have a bad attitude to the private sector. When a firm came to see me, they always wanted the public sector to help for free. In contrast, when I needed help from them, a secret, or another excuse was claimed. Occasionally, I sat down and debated with them. Sometimes it helped.

Engineer's idea that the industry needed the public sector for help was similar to Manager's perspective. Manager believed that it was unlikely for industrial sectors to initiate R&D without the cooperation form the government. Regarding Project 1, even though Manager's firm was indicated as a prospective user, Manager did not commit to invest in the technology unless it could be proven the technical success at the larger scale production. Also, he stated that the funding agency should grant the project enough budgets to get to this step.

The participation of Manager to Project 1 was created at the beginning of conducting the project since PI-1 needed the import data on chemicals to support the economic feasibility of Project 1. However, the participation was not continuous, the research effort was not integrated into a task of Manager's firm. There were no ideas; either technical or commercial exchanged between PI-1 and Manager while the project was going on. Manager recalled "We gave PI-1 the general data at the beginning. When the project started, we didn't know what to do."

On the other hand, the collaboration between Agronomist and PI-1 continued throughout the research activities. Agronomist met and called PI-1 periodically to discuss the project issue. In addition, the collaboration was continuous. When Agronomist was responsible to provide another kind of research grants, PI-1 was the one who received it and conducted research on another plant. This granting determined Agronomist's belief in PI-1's credibility. However, during contributing in Project 1, Agronomist was not informed about the evaluation. "The evaluation was taken care of by PI-1. The funding agency sent it directly to a principal investigator who received a grant. I only provided assistance in a particular part, and then I was not evaluated. I never saw any evaluation."

Similarly, there was the collaboration between Entrepreneur and PI-1 while Project 1 was in process. The collaboration was trustworthy from his opinion. However, his concern was about a scarce resource in the business sector. He perceived R&D as a way to help small businesses. Entrepreneur argued:

> Approximately 80% of R&D should be public activities, because large firms preferably buy know-how from abroad--they do business, not research. Small firms do not have enough money for doing the same thing. Without sufficient

> investment, small firms need to learn by themselves, then they require money that the government should support. R&D would be a possible way to help us. Unless the government recognized this significance, we have to buy foreign know-how. In addition, other countries may take an advantage from particular Thai medicinal plants.

For the evaluation process, peer-reviewers evaluated an R&D project by filling out the assessment form provided by the funding agency. The funding agency acknowledged peer-reviewers to perform the evaluation by reading a progress report, conducting site-visit and discussing with investigators. Mostly, peer-reviewers selected the first choice--the paper evaluation.

Businessman assessed Project 1 by providing the paper evaluation. With this respect, Businessman argued:

> Though I met PI-1, I've never revealed myself as a reviewer of Project 1. I didn't have a chance to discuss with PI-1 about the project's issues. The paper work was not enough for the evaluation. . . . PI-1 and I were sort of in a different room. My questions never had any feedback. Sometimes I got answers, but they did not address my questions. I had no idea whose questions were. The process did not have continuity. There was no chitchat. . . . I could sell my idea to PI-1, but without the real coordination, PI-1 did not realize what information was required to prepare the project to the application. . . . This project should have a business approach because there was some trend to application. There must be someone to match between the researcher and the investor.

Businessman recommended a form of participation processes in the evaluation.

> Basically, there should have been a setting, for example, a round table meeting where the reviewer is able to suggest the idea for the researcher. An economist is also important to be present at the meeting to give any economic perspective on the R&D project. However, such an economist must have sufficient scientific knowledge to grasp the technical idea. The setting and the R&D project must be launched concurrently. . . . A result of the R&D project must be reviewed to the reviewer at every step of the R&D process. The reviewer must know any secret causing the R&D project success. It is not a technical secret. For example, if the researcher has a new technique, he must present what the new technique is. The reviewer then can suggest how to improve the technique more efficiency. This is difficult for Thai researchers to accept; they are aware of someone taking advantages from their secret. I think researchers in developed countries take this

> concept easier than Thai researchers, they pay respect to a system. Reviewers would gain more knowledge to stretch their discipline, and disseminate to others. It is academic-related, not to serve a self-advantage.

Like Businessman, Professor I made the paper evaluation on the project. Site visit and direct discussion to the principle investigation were "a double-edged sword" in his opinion because reviewers were revealed themselves. Two shortcomings would have arisen. Professor I argued:

> First, Thai scientific community is restricted to a very small number of researchers. Investigators are likely to be superior in the area they conduct research. Having others' judges is not fair when others do not understand the research. Consequently, face-to-face evaluation is too sensitive to either investigators or reviewers. Second, the reviewer who does not think of the merit of the evaluation may use his influence to harm the investigator and get something he wants.

As a result, Professor I did not recognize a face-to-face evaluation as an appropriate way of the review process in the current Thai research system.

Likewise, Professor II did not reveal himself as a reviewer of the project to PI-1. In addition, Professor II did not know the other reviewers. He understood that the funding agency kept all reviewers' names confidently. He assessed the project by the paper evaluation. He sometimes conducted the site-visit himself; however, kept it as a secret.

Even though there was an option for reviewers to discuss the project's issues, Professor II was not informed clearly. "If we are allowed to meet, I would be pleased. We would have a chance to exchange an idea and summarize the idea to the funding agency. Consequently, the funding agency would be more comfortable to provide grants."

Though he proposed that cooperation among various disciplines was a way to add value to an R&D project, Professor II believed that the university culture was a barrier to implementing multidisciplinary teams to conduct an R&D project. "University faculty members have a nature that they don't want to provide information when required; however, they need their names to be honored when the research has a payoff. " Professor II also indicated that not only universities but also some governmental sectors concealed information. "Some ministries and departments work sometimes overlap and when they could support each other. But because each other's work is not disclosed, each is disused.

In Professor II's opinion, industrial users' collaboration was an important data source for an R&D project. Professor II stated:

> Two types of data may be obtainable from industrial users. The first type is product information. Industrialists are able to give quite exact demand of pharmaceutical products in the country while researchers sometimes cannot distinguish between legal and illegal chemicals. Industrial users would have more accurate value in a current use and a trend of pharmaceutical products since they take part in selling, importing, and utilizing the products. The second type is the production data. Most university researchers cannot figure the production cost, especially the hidden cost, which could be calculated by the industry.

Ideally, Supervisor had two roles in R&D projects supported by the funding agency. First, at an organizational level, several principal investigators of projects in the public health area expected the state enterprise as a prospective user. Second, at an individual level, Supervisor has been posted by the funding agency to be a reviewer of several projects. As a prospective user, Supervisor argued:

> Everyone would expect us. They could say that. Actually, they should ask our opinion, then they should send us something written. However, before conducting an R&D project there should have a feasibility study. Outsider must do a

> feasibility study on another project. Up to this time there has been no such thing in any R&D project.

The major aspect of Supervisor on R&D was to make public goods with economic benefits. His aspect was known, but argued by many policy makers. Though the funding agency did not emphasis primarily on economic payoffs, to make the decision to support some R&D projects, it needed input and contribution from the state enterprise. Then Supervisor had been posted as reviewer for some projects. Their contrasted idea was generally noticed. For example, Supervisor did not agree to produce chemicals that were usually imported because they would be more expensive than import chemicals. At the same time, an R&D objective of creating indigenous technology was attracted by the funding agency to support the project. Supervisor argued:

> I made comments on several projects; and none the less they were approved. I disagreed on several projects, which were finally passed. . . . I have had several discussions with policy makers but our ideas are different. Their idea is to encourage researchers to do R&D. Let them do it. However, if asking us whether we would utilize the technology, we would not. Unless the funding agency would build a plant itself, which required a huge expenditure.

Certainly, Director accepted that the user was important for contributing on a R&D project. However, the process of the contribution was not clear from his perspective. According to him, since the pharmaceutical industry was comparatively small in Thailand, the industry did not assume conducting R&D activities as its role. In addition, there were some organizations urged by international groups, which were established to be responsible for technology transferring from abroad. The direction of the funding agency to provide support to R&D activities, such as Project 1, may be problematic.

Director stated that the attempt to enforce Project 1 to commercialization was very optimistic. To support Project 1 was a lesson learned by the funding agency. "There has been a large gap between the understanding of the private sector and the potential of researchers. . . . To introduce users in the initial stage of the R&D project is a very necessary process in a case where there is a belief that the project is achievable." Therefore, such an introduction was not effective to Project 1. Director explained:

> At that time I think we pretended to ourselves. For Project 1, for instance, if obtaining a pharmaceutical-manufacturing firm was anticipated, granting that kind of project was insufficient. The development must be certain. PI-1 role's in Project 1 was only a part of R&D activities. Other groups would be required for additional important roles.

It can be seen the differences on the perspectives on participation processes among the stakeholders of PI-1. Some perspectives were direct to Project 1 while some were indirect, but had impacts on the patterns of participation processes. Furthermore, participants focus on diversified themes depended on their interest and their role in the project. The perspectives can be summarized and visualized in a matrix form (Table 6.9).

In order to answer the second research question, "*How do or might various stakeholders in the R&D process participate?*", the pattern of participation processes suggests there was proper coordination in R&D process among interorganizational stakeholders; i.e., PI-1, Engineer, Agronomist, and Entrepreneur. They perceived the goal and outcome of R&D from the same perspectives. PI-1, Engineer, and Agronomist agreed to conduct the R&D project to achieve the goal of acquiring of new knowledge. Also, they accepted the outcome of knowledge that they had anticipated. Though Entrepreneur expected that research efforts would result in product commercialization, he was satisfied with the outcome of gaining new knowledge.

Participant	*Perspectives on participation processes* Toward research process	Toward evaluation process	Toward industry/ user
1. PI-1	gaining trustworthiness	sometimes unacceptable because of different disciplines	non-existent
2. Engineer	creating mutual capacity	requiring guidance but not control	bad attitudes because of no mutual relationship from the industry.
3. Agronomist	gaining trustworthiness	passing the responsibility to PI-1	-
4. Entrepreneur	gaining trustworthiness	-	industry needs help from public sectors in R&D
5. Manager	no significance	-	industry needs help from public sectors in R&D
6. Businessman	-	requiring close evaluation	industry able to give idea to move to commercialization
7. Professor I	-	satisfying paper format evaluation	-
8. Professor II	supporting the idea of multidisciplinary but considering its challenge in coordinating	requiring close evaluation	R&D requires input from industry
9. Supervisor	-	giving the idea, but not being able to make decisions	requiring formal process for coordination
10. Director	-	-	uncertainty of industry's contribution in R&D

Table 6. 9. Perspectives on participation processes of Project 1' stakeholders

On the other hand, participation from prospective users was weak. Manager expected commercialization when he participated in the project, and also believed that the chemicals had a competitive advantage since they could be substituted for imports. He assumed his technology-receiving role and called for the assistance from public sectors.

Regarding another prospective user, Supervisor as the authority of the state enterprise, had very strong motives for focusing on marketability. From his perspective, the goal of R&D must be oriented toward the market, and the outcome must provide the firm a competitive advantage. Since Project 1's goal and outcome did not match those of his perspective, he did not acknowledge PI-1's research efforts. In addition, there was no attempt from PI-1 to coordinate with this user in the research stage. Supervisor's perspectives were not perceived by PI-1 and his team. The participation from the state enterprise never existed.

The evaluation may reflect and create some idea to the project. While Professor I appreciated the importance of basic research as a way of understanding the new knowledge, Professor II and Businessman thought about the project's goal and outcome in terms of technology and commercialization. These perspectives though different, they may be integrated. However, the coordination between the evaluation team never existed. In addition, their suggestions were of less concern since PI-1 considered that the reviewers were from different disciplines.

As an authority of the funding agency, Director accepted the knowledge-oriented goal regarding Project 1. He expected to strengthen the research capacity as an outcome of the project. In addition, with the uncertainty of the contribution of the pharmaceutical industry, he did not see a chance to push Project 1 to be commercialized. His belief in participation was based on a low degree of his expectation on the project.

Although publishing provides a means for knowledge disseminating, PI-1 did not take this advantage of his project. All participants, except Entrepreneur, did not recognize this advantage to the industry. Therefore, in this case, to disseminate knowledge by publication did not relate to technology transferring to the industry.

Case 2

PI-2 did not indicate a stakeholder in the development process, since the technology did not required an engineering process, such as building a prototype or a model. However, while conducting the project, the product was extended to a larger environment and tested by prospective customers. The initial customers included hospitals, with patients as end users. The funding agency had already applied the technology resulted from Project 2 to receive a patent. At the time of conducting this study, Project 2 was going to be commercialized.

Nine stakeholders including PI-2 himself were interviewed. They were from different organizations. Supervisor and Director were the same persons interviewed in the first case. Their anonymous names and roles are indicated in table 6.10. Similarly to the first case, the pronoun "he" or "him" regardless male or female of stakeholders is used to avoid a gender bias.

Interviewee	*Profession*	*Role*
1. PI-2	a university faculty	principal investigator
2. Doctor	a director of a unit hospital	co-investigator/ prospective user
3. Executive	a director of a unit of a public health organization	co-investigator/ prospective user
4. Professor	a university faculty	reviewer
5. Physician	a former university faculty	reviewer
6. Scientist	a head of a unit of a public health organization	extension facilitator
7. Lawyer	a lawyer of the funding agency	patent protection
8. Supervisor	a director of a division of the state enterprise	prospective user
9. Director	a director of the funding agency	fund provider

Table 6. 10. Professions and roles of Project 2's stakeholders

Goal of R&D

In conducting Project 2, PI-2 indicated his interest to use his knowledge to solve the country's public health problem. PI-2 indicated:

> I worked at . . . before I got a Ph.D. in . . . so I have thought that the diagnosis is a problematic issue. Tropical diseases are the problem of several countries in our region. The data about tropical diseases was not available in developed countries because of no incident of the diseases in those countries. . . . The development of the diagnosis would benefit the country in terms of public health, epidemiology, and technology dependence.

An objective of the project was to solve the public health problem. PI-2's knowledge and experience in the medical science was the foundation of the project. Though PI-2 indicated a plan for a commercialization in the proposal, it was to fulfill the funding agency's format. "I needed to specify users due to the limitation of the funding agency which required us to have users." When some company had contacted PI-2 after completing the project, PI-2 did not pay attention. "I haven't replied to a foreign company yet since I have been busy."

To collaborate with PI-2, Doctor also perceived the advantage of Project 2. The diagnostic kit would help doctors to select a suitable clinical treatment for patients. Doctor stated:

> The diagnostic kit would help ease and expedite the work of the hospital. If this is the case,. . . we will know more specifics. . . . It is about clinical treatments. . . . Ultimately, the result would serve the country. . . . We would like to collaborate on projects that will have benefit to the people of Thailand

Similarly, Executive perceived a goal of Project 2 toward utilization. Moreover, he also exercised commercializing the technology. Executive's organization, a public health organization, has a legitimate role to examine the disease, was involved in Project 2 in two main functions: (1) co-investigation, and (2) pre-utilization. For a first function, an organization employee, worked on a master thesis as a part of Project 2 under a supervisor of PI-2. While serving the first function, he conducted a field trial of the diagnostic kit. Samples were collected and tested compared to the conventional method. For a second function, the public health organization bought a semi-product from PI-2 to complete the production process, hired a firm to package, and then sold the product to hospitals and public health centers around the country.

Generally, the public health organization is responsible for several test developments, and provides technical recommendations to public hospitals and health care centers. According to Executive, as the organization receives the basic technology from co-conducting the project with PI-2, the organization then had an interest to develop the test kit to understand market acceptance.

> We always realize that PI-2 would take the product to the industry because he holds its right. We did the application to know the market acceptance, how to do product development, and what knowledge was gained from. . . We wanted to know whether the users would satisfy our developed formula. At least PI-2 has some solutions for the further development. Whoever turns the product into commercial would have such information.

Scientist also perceived a Project 2's goal of utilization. Scientist was responsible for establishing the training course to the users of the diagnostic kit. Since his unit was responsible to keep up with new concepts on public health, the concepts would be promoted to hospitals and public health centers around the country. While the project 2 was going on, his unit, by the collaboration of PI-2, arranged the training course on using the diagnostic kit. The participants of the training were medical staff from hospitals and public health centers. It should be noted that the unit was not controlled by Executive. Scientist and Executive were from different units of the public health organization.

Scientist expected the project's result to benefit people all over the country. Using the conventional method, public health units in remote areas must send samples to either provincial-level hospitals, or main public health centers, because they lacked sophisticated facilities. Using the diagnostic kit, on the other hand, the local staff can handle the kit without special equipment. Scientist stated:

> There would be a quick answer to whether there are such microorganisms. Therefore, the disease can be controlled on time. Since we can detect an early case, the early treatment would help exterminate the microorganisms before the epidemic occurs. . . . Large provincial-level hospitals are also benefited, instead of using the conventional method that is time consuming; using the diagnostic kit helps staff to save time for the screening.

Since the diagnostic kit demonstrates its competence, an actual utilization was expected from the training. To serve this expectation, a major role of the extension organization was to be a master trainer.

> We sell an idea, extend the result, provide the public health staff the knowledge of, where, who, and what the certain disease is about, we inform them of the academic basis. The test kit has been already proved with the sensitivity, which is normally accepted. If they are interested to use it in the disease control, they will proceed management, and prepare the available budget for purchasing the kit.

As a master trainer, the extension unit limited its authorization to encourage, but not to force other organizations though they are under the same umbrella of the administration. Scientist explained:

> Our purpose is to find something that is new and advantageous, then we propose it. If they think it is advantageous, and they are interested, they will take it. We can't force them to do. They will either do or not. However, we have this thing to propose so it would be a powerful choice that reduces the impact of the disease.

One of the reviewers of the project was a university professor. Professor was also a physician, who had researched a related field. Professor recalled that while evaluating Project 2, he was confident that when Project 2 was complete, there would be users to bring the idea to utilization. "The technology is not complicated, and is desired by the country. I already realized from the beginning that if the technology was successful, it would be applicable. I have believed in its success because of the potential of the team of investigators."

Thus, Professor's perception on the researcher's objective was to have target users. "It is a PI-2's role to have an objective. Investigators have to identify the users, and attempt to contact them to gain the most payoffs. I understand that PI-2 already contacted the...as the user."

Another reviewer was also a physician, who served as a faculty member in a university. He had a strong theoretical background and was keen in medical science research. His goal on Project 2 was scientific orientation. In addition, he expected the technical result that was worth the money invested. Physician argued: "The project's goal should be subjected to the money invested." Therefore, this project's result seemed to be insufficient in his opinion. The performance of R&D must be evaluated from the result whether it deserved the money the funding agency provided. Physician focused on the technical merit of the project. Since Project 2 received too much money in his opinion, there should have been more experiments and techniques to prove the specificity of the diagnostic kit for an effective utilization. "The report of the project provided rough data" was Physician's expression to the project's research design.

Physician was not convinced to accept the efficiency of the diagnostic kit because of a lack of detail that would provide the understanding of its action. His disapproval was stemmed from his underestimating the result of the project. Physician's expression was "You get the money in millions, you have to take back your work as you get it." He accepted that supporting of this kind of project was suitable because of its novel; however, the detail of the research was questioned. Physician argued:

> If you ask whether it is suitable to support this project, the answer would be *yes*. Because nobody would have ever done it before. However, when talking about the detail of the project, nothing was obvious. It was reported broadly and roughly, rather than specified in detail. Then I had some recommendation. Whether it would be taken to actions depends on the investigators, correct? Finally, the project was somewhat done, and they said they did it. Is this right? I don't know, it is like playing, or showing, something to complete any steps, and that's it.

From Director's viewpoint, he perceived the goal of Project 2 as the utilization, and commercialization. Relatively high expectation was counted on Project 2 because of three reasons; namely PI-2's distinguished competence, the technological merit, and the public need. Director explained:

> First, PI 2 is an established researcher whom we know has the potential. Second, the development of diagnostic tests is an elucidation process and the technology would be directly taken from laboratory to commercialization. From an R&D, we get the technology that needs the extended development from other technologies. As we obtain a kit, commercialization, distribution, and public utilization will follow. Therefore, we recognized that we should support the development of diagnostic kit that the researcher could conduct an R&D part on probe's discovery, for example. Third, there are organizations that have the need. PI-2 has been in a position to understand the need. Therefore, we may not need to evaluate the project. While we are in that kind of position, we apprehend it.

Though Supervisor expected the commercialization from the project, he seemed to disagree with Director that commercialization would follow if we obtain the product. From his point, marketability of the product must be truly considered.

> We must ask about the market size first--the market of the diagnosis. We must have the number of patients, the market value. I would consider at this point. If there is no answer, don't ask me. If it is possible, we must ask whether there is the production feasibility at the industrial scale. If producing it, what its price would be, comparing to the import kit, whether it will offset. . . . If there is no import kit, we must still ask for the price, and the purchasing power of users.

It can be seen that the perspectives of the stakeholders to the goal of Project 2 are classified into three groups, namely knowledge-oriented, utilization-oriented, and market-oriented. First, PI-2 and Physician are categorized of having knowledge-oriented goal on the project. The desire to pursue the knowledge motivated PI-2 to initiate Project 2. He neither perceived market value nor estimated a need of the diagnostic kit. Physician was included in the same category. Even though Physician was not satisfied with the research result; he focused on technical issues only.

On the other hand, some stakeholders; i.e., Doctor, Executive, Scientist, Professor, and Director focused on the utilization. The utilization was a direct advantage to the work of Doctor, Executive, and Scientist. Doctor's hospital was the center of the patients with that disease. Executive's as well as Scientist's organizations were responsible for the dissemination of technical knowledge about the disease. As a result, they could anticipate the usefulness on the utilization. In the same way, Professor's experience in the related field made him believed in the utilization of Project 2. Also, Director supported Project 2 because of his apprehension on the need of the diagnostic kit.

The market-oriented goal was also determined by Executive, Director, and Supervisor. In respect to Executive, this goal was apparent at the organizational level. Executive's organization effort to do market tests on diagnostic kits demonstrated the expectation on the commercialization. Also, as Director defined Project 2 "elucidation" process, he anticipated commercialization as a following step after obtaining the diagnostic kit. It can be seen that while Executive and Director also anticipated commercialization and utilization from Project 2, Supervisor focused on marketability only. R&D project must exhibit market feasibility from his perspective. Table 6.11 summarized the stakeholders' perspective toward goal of Project 2.

Goal	*Stakeholder*
Knowledge-oriented	PI-2, and Physician
Utilization-oriented	Doctor, Executive, Scientist, Professor, and Director
Market-oriented	Executive, Director, and Supervisor

Table 6. 11. Perspectives on R&D's goals of Project 2's stakeholders

<u>Outcome of R&D</u>

PI-2's research efforts were the discoveries of new processes for detecting various diseases. The outcomes he perceived included the academic study and the human resources development. PI-2 indicated his perspective on the return of his research efforts:

> A return is transferring of knowledge and experience. Comprehension of technology has an extraordinary value. Graduate students have learned the technology and then they could understand and apply it to their R&D projects. This involves human resource development. Three of my students are professors. My test can be produced and it is ten times cheaper than the conventional method.

Nevertheless, the project was introduced to a commercialized stage. One start-up company prepared to transfer the technology from PI-2. The negotiation of sharing a profit was set up among the funding agency, PI-2 and the company. At this stage, PI-2 emphasized another issue rather than a profit making. PI-2 stated:

> An entrepreneur has thought about the manufacturing of the diagnostic kit, however, he does not have scientists who understand the technology. I myself don't want to release the product without quality control. Therefore, he asked me to be a supervisor and conduct R&D to improve the diagnostic kit simpler and faster with a cheap cost. Then there would have been an R&D section in his firm.

PI-2 determined the technology outcome as the country's right. There are some foreign companies determined to invest in the technology. However, PI-2 felt reluctant to get it into commercialization with such companies. PI-2 mentioned the suggestion of the Ministry of Public Health's executive: "Whatever is invented from a Thai's brain, don't sell it to foreign countries. If they take and produce it, and sell it back to us with an expensive price, then we would be pain." As a result, PI-2 preferred the investment from a local company.

Doctor perceived the outcome of Project 2 from a user's aspect. Doctor was the co-investigator since his hospital provided samples used in the project. However, the diagnostic kit was not being used in the hospital. Doctor explained the reason for not using the diagnostic kit. "If the price is not so expensive and the kit provides a good result, we may use it. But now, we don't know."

Executive was similar to Doctor in that they would adopt the technology when they could perceive its competitive advantage. As already discussed, Executive's organization was involved in Project 2 in two positions. The first position was the co-investigator since the employee conducted the field trial of the diagnostic kit. The second position was the user since the organization was partially transferring technology and already commercializing the diagnostic kit. In addition, the organization's responsibility was to diagnose the disease and suggest an appropriate method for other organizations to follow. Therefore, Executive emphasized Project-2 on the benefit of the user, also the profit of the organization. From Executive's perspective, there were some constraints regarding using the diagnosis. The diagnostic kit's limitation was due to its specificity to a species of microorganism. Since several species of bacteria cause patients to have quite similar symptoms. Without a prior confirmation of the epidemic of a certain species, using the kit test would not be useful.

Another concern was a product friendly issue. From Executive's opinion, users who may be physicians, scientists, and technicians required training in order to use the diagnostic kit. At the trial stage of production, the diagnosis test was slightly complicated. Executive expressed "Speaking as an ordinary person, like me, a physician, I expect something simpler than that." It should be noted that PI-2 already developed the diagnosis test to be simpler than the one in the stage that was mentioned by Executive.

From Executive's perspective, the convenience of the process was another important issue for the user. The use of the diagnostic kit can make known a result within two hours, which was very rapid, compared to the use of the conventional method that consumed 48 hours. However, the user needed to be engaged with the process in the entire two hours period. Executive described the procedure:

> For using the diagnostic kit, it requires the staff to reserve in a continuous two hours. They need to continue the work, for 15 minutes, and for 10 minutes, for example, then the total is two hours. Wash it, and drop it, and so on. While doing the conventional method, the responsibility is ended step by step. The staff cultivate the bacteria, wait until the next day, then investigate them. While waiting, the staff can do something else. They seem to prefer this, they don't want to hang around for two hours. I think.

Executive anticipated several factors involved in estimating the cost of production. Executive explained:

> Commercializing this technology must add the training cost so the expected low prices may be comparatively higher. One solution is to get more benefit through increasing scale of production by amplifying of the market demand. The diagnostic kit would be imported to neighboring countries, for example, Vietnam, and Cambodia.

It should be noted that currently the organization utilized the conventional method in its routine work. The policy to use the diagnosis was ended because of the termination of its in-house production.

Like Executive's, Scientist's perception on Project 2's outcome was utilization. However, while Executive did not attempt to help improve the product, Scientist did. According to Scientist, the concept of the diagnosis was accepted in general. In addition, the training helped improve the competency in use, of the diagnostic kit. Since participants of the training were the prospective users who would utilize the kit for their work. They demonstrated the user contribution to the kit development. For example, in the past, one kit was used for a particular number of samples. This was not cost effective since samples may be less than what is needed. As a result, the diagnosis was continuously improved to test any number of samples.

Another example of the user contribution was demonstrated by the users' requirement of an adapted process. There was a request from the users to adapt the diagnostic kit to another technique. Such a technique would lead to the utilization in the field. Scientist said:

> The current kit is convenient to us, the technicians. However, for academic persons who do not have a laboratory background, an adapted process is preferred. They had a request, then PI-2 has agreed to do it further. Whatever it goes to the public--it is able to detect the disease immediately, and to prevent the outbreak, it is very useful.

In a reviewer's opinion, Professor recognized the success of R&D in terms of the test development. The commercialization however was not a research focus. Professor argued:

> The role of researchers is ended at an R&D project--developing the test successfully and proving its specificity, sensitivity, and accuracy; as well as conforming academic principles. . . . The economic measurement is another step followed by the completion of R&D. Researchers don't understand. The funding agency needs to help. . . . Most researchers in university are not keen in commercialization.

From another reviewer's perspective, Physician believed that the outcome of the project was its technical success. With perfectionist type personality (described by himself), Physician expected to see the project with a transparent technical result. "I think they should do it and have more detail than that already have. It should have been more explicit. If they said they ended up with such a result. One thing that I need to tell them is that there is some delusion. You need to read the book. . . "

Physician thought the completeness of research depended on the depth of work. According to the project design and result, the project lacked for particular aspects, for example, specificity of the test, and comparison to other works. It was not persuasive to him to fully believe in the result of the diagnostic kit. For this reason, the confident level of the utilization would be up to people's perceptions that may be influenced by the creditability of the researcher. Physician argued: "If I am famous; I can make something a success, then I tell you I make this, and that. Are you going to believe me or not? You have to, right? This is because I am a professor. Then someday afterwards, I may say I did it wrong. Somehow I did it right if I was lucky."

From Supervisor's point of view, a major concern on the outcome of Project 2 was capital return. The customers of the diagnostic kit would be hospitals and public health centers, where their buying power was questionable. Thus, he supposed that if the state enterprise would be transferring technology from Project 2, it may need to provide such organizations the diagnostic kit for free. From Supervisor's standpoint, R&D projects required resources in order to maintain their activities. An organization must have an operation cost to conduct R&D projects. The state enterprise needed to make a profit to be a source of R&D support. Therefore, there was no strategy for R&D projects for charity except for policy R&D projects. Supervisor argued:

> We wouldn't conduct the kind of R&D projects that we don't know whether the users have money to buy our products because this does not yield benefits. I don't mean we are not humanitarian; however, we consider the possibility. If they don't have purchasing power, we never make it for donation.

In contrast, Director perceived that the feasibility of Project 2's from the beginning. "Diagnostic development has been my priority; I have seen its potential." In addition, the funding agency's support of the diagnostic development on R&D projects had been growing consequently. Director explained:

> As a result of the understanding grounded from Project 2, we have extended R&D on diagnosis. Then we have supported other researchers. Now the diagnosis is our priority. As we obtain the diagnostic kit, we saw a big picture. Though the technology is difficult as long as particular imported technology is required to complete the diagnostic kit, we push it.

Since PI-2 realized the possible of the implementing a technique resulting from Project 2, PI-2 needed a form of legal protection. Thus, by the authorization of the funding agency, Lawyer helped request a patent application for the technique resulted from Project 2. From a legal perspective, Lawyer believed that the research result of every project granted by the funding agency should receive legal protection. Even though research efforts may not be perceived to have the commercial benefit in a short term, they may have it in a long term. He thought that researchers could expect an outcome of a project in the form of financial benefits. A patent was a form of intellectual property protection that enabled researchers to hold the right of the technology they discovered. Therefore, researchers should be aware of legal issues in order to have financial benefits from their research efforts.

In summary, the perspectives on R&D's outcomes of Project 2's stakeholders were seen as two categories. First, PI-2, Professor, and Physician were interested in outcome of R&D in terms of new knowledge, though from different views. Second, Doctor, Executive, Scientist, Professor, Supervisor, Director, and Lawyer focused on the competitive advantage of technology that could lead to utilization, and commercialization.

Regarding the first group, PI-2 was concerned with the new technique he invented. He perceived the return of research efforts in terms of knowledge and human resource development, while commercialization seemed to be a spin-off of the project. Likewise, Professor believed in the success of Project 2 in terms of providing new technology. Doctor was interested in the technical outcome of research efforts also. However, he did not satisfy Project 2 since he anticipated more technical data to prove its validity of Project 2.

On the other side, the second group of stakeholders perceived the R&D's outcome in terms of the competitive advantage of technology. Doctor, Executive, and Scientist as the users, evaluated the diagnostic kit in terms of its utilization. Doctor preferred to be a late technological adopter since he did not have updated information on the diagnostic kit. Executive was concerned with the diagnostic kit's cost and benefit over the conventional method; moreover, he did not use it in the organization's routine. Scientist seemed to believe in the power of the diagnostic kit, and was willing to contribute to improve its capability. Also, from the funding agency's point of view, Director assumed the ability of the diagnostic kit in the utilization process since he believed in the need for the diagnostic kit. In addition, Director perceived the commercialization as a follow-up after completing Project 2. Lawyer believed that R&D's projects would be commercialized in the long term. As a result, he obtained legal protection as a strategy to protect the technology from other people. Furthermore, Supervisor, as the initial user, perceived that the technology would make profit and therefore, provided organizational benefit from the use of the technology. Table 6.12 summarizes all perspectives on outcome of Project 2's stakeholders.

Outcome	*Stakeholder*
New knowledge	PI-2, Professor, and Physician
Competitive advantage of technology	Doctor, Executive, Scientist, Director, and Supervisor

Table 6. 12. Perspectives on R&D's outcomes of Project 2's stakeholders

Publication

PI-2 published several papers in international journals. Such journals were well known in a scientific community. Publication, from the PI-2's perspective, aimed to provide audiences new knowledge. Academic groups were PI-2's target audiences. However, according to PI-2, private companies' researchers may be interested in his papers. "There have been individuals asking for a reprint, but I haven't known who they are." Another objective of publishing scientific paper is to get promotion. PI-2 had earned an academic faculty status; however, the attitude toward responsibility for the subordinates stimulated PI-2 to publish papers having a list of authors. "Other staff members also need output on R&D projects" was PI-2's notion on the publication.

Prestige of publishing papers was perceived by Doctor. Doctor and the hospital staff were co-authors of the paper published by PI-2 on research regarding Project 2. One part of the research was about a clinical study that was done by Doctor and his staff. Doctor appreciated naming persons collaborating on publications.

From Professor's perspective, he thought that publication in international journals was one channel to disseminate the knowledge in the scientific community. Professor believed: "Other scientists are able to take new techniques to apply in their research. . . . Nevertheless, publications do not provide a path for investors interested in commercializing the research findings. Investors are likely to have direct contacts to researchers when they recognize the researchers' reputation."

Similarly to Professor, Scientist realized the importance of publications in terms of disseminating of knowledge to people. He indicated: "This is usual, when accomplishing something, we must reveal to the others, especially anyone who can apply it and take it to implementation. Scientist himself has quite a few issues to be published; however, other burdens are the barriers. "I don't have time. . . . Actually, I want to publish but there is no available time, even though I work overtime, and during weekends."

On the contrary, Physician considered that researchers should publish papers to verify their success of R&D projects. To publish papers in international journals means that researchers present something new. Physician argued:

> When you have a grant to do an R&D project, you have to succeed. If publication is mandatory for researchers who obtain funding, it is fair, then that researchers need to work more throughout. . . . The funding agency may keep some of the money to compliment researchers when their paper is done. This method would be a perfect constraint, which I don't know whether researchers would accept.

However, Physician personally conducted research without publishing results in international journals. Physician gave the priority to academic teaching, conducting research, and writing textbooks. There were two barriers for him to publish. First, paper published must be based on a new scientific discovery. Second, to publish papers is time consuming. Physician indicated:

> I myself don't do publications. The reason is I have to spend at least three to four months to write a paper, because the data is not continuous. It would be an onset of work. When you do something from the start, you have to take time on it. If you have several works, how do you allocate time to them. . . . I have five to six subjects that can be published, but I haven't done them. . . . I had about 5 graduate students at the same time. Another important reason is I have been writing textbooks. I intended to write one book, but it is branched into three, and then six. They are overburden.

Director's and Supervisor's perspectives toward publishing were already discussed in the first case, whereas, Executive's and Lawyer's perspectives were not available. It is clear that the participants' perspectives may be categorized into two groups. First, as already discussed in the first case, Director related publishing to utilization, which he perceived added no value to industry. Second, PI-2, Doctor, Professor, Physician, Scientist, and Supervisor did not relate publication to utilization; however, the degree of value was varied. While Supervisor did not see any value on the publication, Doctor saw it as prestige, PI-2, Professor, and Scientist perceived it as a way of disseminating knowledge, and Physician suggested it as a way the funding agency put a constraint to R&D projects. These various perspectives are summarized in table 6.13.

Value on Publication	***Stakeholder***
Related to utilization • No benefit to industry	Director
Not related to utilization • No value	Supervisor
• Prestige	Doctor
• Dissemination of knowledge	PI-2, Professor, and Scientist
• Quality control of research	Physician

Table 6. 13. Perspectives on publication of Project 2's stakeholders

Participation Processes

Project 2 was accomplished by the collaboration among various organizations. It should be respected that the delegation of responsibilities among those organizations was not counted by the money. Though some tasks needed resources, they were regarded standard operations. In addition, some collaborators were PI-2's former students. Most collaborations were reciprocal. PI-2 also gave occasionally lectures and served as a consultant to several organizations without financial incentive. "There is no money issue in our synergy" was PI-2's notion.

The entrepreneur who intended to invest in the technology was PI-2's former medical student. An interest for commercializing the research was initiated because PI-2 had used a diagnostic kit as a teaching tool. Therefore, the entrepreneur had an idea, and convinced PI-2 to bring the diagnostic kit to be commercialized. PI-2 quoted Entrepreneur's expression by stating that: "My friends who are physicians would like it because it is practical--even they or their assistants can use it". Without such a connection to students by demonstrating the diagnostic kit in the class, this investment may not happen.

There was a drawback to the participation process from PI-2's experience. As already discussed, one of investigators was from an anticipated user, Executive's organization. This investigator was a PI-2's graduate student whose master thesis was one part of the Project-2. The technology was transferred through this channel. After learning the technology, this investigator produced the kit for sale; however, the production was made without the consent of PI-2. As a result, the production was already terminated. In PI-2's opinion: "This conflict was at a personal level, not an organizational one. We must separate them. We still have to maintain the academic relationship with that organization."

According for Executive, the involvement of the public health organization in the R&D project was originated from a mutual interest of the particular disease between PI-2 and the organization. Then, as already described, there was a conflict of profit interests because the commercialization was made without the consent of PI-2. However, collaborations at the organizational level were enduring. Most of collaborations were R&D efforts in which academic faculty in the PI-2's university assisted the public health organization through technical advice, and facilities, etc. In addition, the organization learned some techniques to diagnose other diseases from the university. Executive explained the relationship: "We are sort of junior staff. . . . Most tasks depend on that side which has done completed work. We need their advice, not to be co-R&D, but to acquire knowledge."

Scientist also stated that his organization depended on knowledge from PI-2 and other university faculty. As the extension organization, its role was to suggest appropriate tests for several diseases to other public health organizations and hospitals. This obligation included the development specific technology and the expansion of academic knowledge to such organizations. The extension organization needed to discuss academic issues with some experts, mostly from universities. The accommodating collaboration was due to the mutual interest to make goods available to the public. Scientist explained:

> We have a dialogue, and tune our opinions together--our desires and how we need expert assistance. At that point, an expert would help us, and let us to go on our

desired direction. That is a reason that there has been no conflict. Several experts offered us assistance in order to gain benefit for public.

Regarding the review process, Professor reviewed Project 2 by the paper format. This was due to the belief in the creditability of the researcher's team. Professor knew PI-2 personally. The evaluation was overall excellent since in his opinion the project could provide the efficient diagnostic kit, which was conformed to medical science principles and was value to the country. Though Professor understood that the funding agency supported other types of evaluation such as site-visit and meeting. Such types were not necessarily for the evaluation of Project 2. Professor argued:

> The evaluation of a strong R&D project does not need site-visit, and anonymous disclosure, which are required on a weak project. For the weak project, the evaluation has to be conducted periodically and examined closely, suggestions made and criticized. Therefore, a reviewer needs to reveal himself in order to have a conversation with a researcher in order to merge their idea. Otherwise, the researcher may be confused.

Also, the reviewer gained advantage from the evaluation, in Professor's opinion. The reviewer was able to learn new technique and knowledge from a project that was varied from his familiar field. "If the content of a project is not understandable, we have to read additional literature, and ask other experts, before we can use what we know to evaluate the project. Therefore, we gain more knowledge. Obviously, the evaluation benefits both sides, the researcher and the reviewer."

Similarly, Physician evaluated Project 2 by using the paper format. However, his evaluation was technically in-depth and mostly focused on particular subjects, for example, the specificity of the diagnostic kit. The comments did not have feedback, and Physician complained: "I never had any feedback. I don't know whether the funding agency's staff was afraid of letting the researcher know my evaluation because Thai people couldn't tolerate other comments. This is a problem."

Physician did not know PI-2 personally, though their research fields were related. Physician had never seen PI-2 even at the evaluation time. Also, this may be caused by Physician's personality. "Usually I am not acquainted with people". He did not attempt to make face-to-face discussion; nor establish an agreed upon time for site-visit. Physician did not believe that such formats would add value to the evaluation. "It does not matter to me to do that.... If I see researchers, I would have questions. Though I haven't seen them, I am not concerned." From his opinion, since meeting researchers may be sensitive, the paper evaluation would be more appropriate, if given in a suitable form. Physician said:

> Researchers would feel like you were examining them, i.e., you are spying on their secrets. This is the reason that the paper evaluation format would be easier. . . . Nonetheless, when I evaluated Project 2, there was nothing coming back. At least if you don't send an entire evaluation to the researcher, you should summarize the reviewer's opinion, then ask the researcher's idea of how to improve, or adjust the research plan. This way you should do the evaluation process by the paper format. The researcher would reply you.

From Physician's perspective, researchers would gain benefits from the evaluation if they open their mind. Furthermore, the funding agency should have high capability to analyze all data and reviewers' recommendations to determine its R&D support. The budget may be cut from the research plan if R&D performance did not reach the target within the time required. On the other hand, the budget may be expanded to support close-market R&D projects, if they showed high tendency for implementation.

Lawyer participated in the issue of legal protection when Project 2 was completed. However, he did administrative tasks while PI-2 demonstrated the technical procedures. PI-2 initiated the process to apply for the patent with his name as the patent holder. This violated the agreement of receiving a grant from the funding agency, in which the patent right would be belong to the funding agency. As a result, Lawyer engaged in the process of transferring the patent right to the funding agency. According to Lawyer "There was no problem to transfer the right. PI-2 had experience in applying for the patent; therefore, we could make it fast." According to PI-2, "The executive of the funding agency asked me to make it legally since the agreement was already endorsed by executives of the funding agency and the university. . . . I don't mind, but I need to describe how time consuming learning the procedure was."

Several perspectives and patterns of participation processes were expressed by the Project 2's stakeholders. Supervisor's and Director's perceptions were already described in the first case. Finally, these perspectives are summarized in table 6.14.

In order to answer the second research question, "*How do or might various stakeholders in the R&D process participate?*", the pattern of participation processes suggests that PI-2, Doctor, and Executive coordinated properly even though they perceived the goal and outcome of R&D from different perspectives. They participated voluntarily in R&D activities, and continued their collaboration on other R&D projects.

However, participation on Project 2 ended at the research stage. As prospective users, Doctor's and Executive's organizations participated less at the development stage. Though Doctor and Executive realized the benefit of the product, they did not exchange these perspectives with PI-2. Their organizations did not help improve the technology, nor did they adopt it to their operation. In contrast, Scientist contributed in improving the

Participant	Perspectives on participation processes: Toward research process	Toward evaluation process	Toward industry/ user
1. PI-2	• voluntary participation • personal conflict did not effect interorganizational participation	-	• participation is a way to engage commercialization
2. Doctor	• voluntary participation	-	-
3. Executive	• personal conflict did not effect interorganizational participation • gaining knowledge	-	-
4. Professor	-	• paper format was appropriate way of evaluation	-
5. Physician	-	• paper format was appropriate way of evaluation, but it needs an adjusted form	-
6. Scientist	• based on mutual interest • receiving knowledge and expertise	-	-
7. Lawyer	• depending on researcher	-	-
8. Supervisor	-	• giving the idea, but not being able to make decisions	• requiring formal process for coordination
9. Director	-	-	• uncertainty of industry's contribution in R&D

Table 6. 14. Perspectives on participation processes of Project 2's stakeholders

product at the end of the research stage. The input gained from the training was the feedback from users that was determined to enhance the efficiency of the product.

The participation from the reviewers was based on a paper format. Both reviewers preferred this format for different reasons. Professor believed that PI-2 was creditable. Project 2's attributes were accepted according to his goal and outcome, then he perceived that the paper format was suitable method for evaluation. On the contrary, Physician felt that the face-to-face format was sensitive to researchers. He needed an adjustable form of the paper format to get more technical feedback from researchers. He did not receive a satisfactory response, while PI-2 seemed to be unaware of his evaluation.

From the funding agency's standpoint, Director played a passive role in the participation process. Having market oriented goals and perceiving competitive advantage of technology, Director expected commercialization would be a following stage. Then the funding agency involved in commercialization at the end of Project 2 by assisting with the negotiation with a firm. In the same way, Lawyer involved passively in the legal process. He needed to depend on PI-2 to do technical and administrative tasks.

The participation from the state enterprise did not exist. PI-2 stated that the state enterprise as a prospective user, yet he did not contact Supervisor either formally or informally. There was no channel for Supervisor to communicate his idea toward commercialization of Project 2 to PI-2.

Publication was not an effective model for transferring technology. None of Project 2's stakeholders recognized publication as benefiting industry. Publication was perceived as a way of disseminating knowledge from some stakeholders to others.

However, their audiences were scientific communities that were independent from industry.

Cross-Case Analysis

The study has undertaken an exploration of participation processes of the stakeholders of two projects. Given their different accomplishment, it is surprising to discover that the pattern of participation does not differ considerably between the two projects. In each project, there were particular prospective users collaborating during the research stage. However, such users did not play an active role in helping to develop the technology. In the first case, the firm simply provided data of pharmaceuticals, and then the collaboration was discontinued. In the second case, though the prospective users and the principal investigator maintained their relationship, they are still involved in other activities, but not on this project. The prospective users did not contribute to the product development. Though one of them, Executive's organization, did the market test and made some profit, the data from the market test did not come to the principal investigator since there was conflict on this issue.

The co-investigators of both projects coordinated properly at a research stage though they had different perceptions on the goal and outcome of R&D. However, such coordination was not a means to move the project toward technology transfer. For example, in the first case, i.e., Engineer was responsible to a large-scale production; however, the commercialization of the research effort was not his objective. The condition was quite different in the second case that Executive's organization brought the product to the market. Such an action was made without consent of the principal investigator; therefore, it could not be accountable to the achievement of Project 2. It may be concluded that there was no attempt at a research stage to push the technology to be commercialized.

The reviewers of both projects actively participated by giving evaluations. Most evaluations were made toward the scientific value of the projects since they were scientific experts with special knowledge of the field in which the projects occupied. Unfortunately, when the researchers and the reviewers hold different beliefs, the evaluation system could not accommodate them effectively. In both projects, the reviewer complained that there was no feedback from the principal investigator. This could be for several reasons. For example, in the first case, the principal investigator seemed to disregard the evaluation since he understood that the reviewers did not have the same discipline as himself. In the second case, the funding agency's staff did not provide a full evaluation to the principal investigator since he was aware of the personal conflicts between the principal investigator and the reviewer. Furthermore, one claim by the industrial reviewer was that he could give an idea to push technology resulting from the first project to a development stage was dormant. It was unlikely that the researchers would fully realize such a suggestion unless real synchronization between the researchers and the reviewers would be encouraged.

A lack of participation of the potential user was similar in both cases. The principal investigators in both cases indicated the same organization, the state enterprise, as the prospective user who would produce and commercialize their product. Though the state enterprise had a strong commitment to implement only projects that are able to provide profitability. Both projects were questioned by this aspect. However, it was not a concern of the principal investigators of both projects. Both of them did not exhibit the market feasibility of the product or indeed contact the state enterprise.

Only one participation process made the difference between two cases. In the second case, there was extension organization that participated after a research stage. The training program was established so that the principal investigator could enhance the product's features according to the feedback he received. In contrast, there was no such an organization involved in the first case.

The funding agency seemed to be passive to participation processes in both cases. The perception toward new knowledge for the first case probably caused lack of commitment from the funding agency to implement the technology. This perception was different in the second case. Utilization was perceived toward the second project. The funding agency took a negotiator role to respond to technology transfer from the principal investigator to a firm. Also, it was involved in a legal procedure that was initiated by the principal investigator. However, in both cases it was not evident that the funding agency actively pushed technology to the marketplace, or was involved in technology development tasks.

In both cases, publishing was not a channel for technology transfer from R&D to the industry. Both principal investigators published parts of research results; however, the audience was not industry. Only one stakeholder of the first project realized the benefit of publishing for his business. The rest saw publishing in various ways, yet they did not relate publishing to commercialization.

It can be concluded that in both cases the stakeholders participated in the project by contributing the task that they were responsible for. However, they did not actively participate to apply the technology to commercialization. Since the patterns of participation processes in both cases did not differ considerably, it cannot be concluded that participation involved in the success or failure of the project in terms of technology implementation. The success of the second case was probably primarily influenced by other factors, for example, research capability, market need, and attemptiveness from industry to invest in the technology. Indeed, the case studies reveal that there were participation processes taking place in two projects. However, since the objective of the participation was not direct to commercialization, the participation could not move R&D toward eventual technology transfer. It may be a role of the funding agency to establish the technology policy that facilitates the participation of stakeholders toward technology transfer in the future.

Summary

This chapter presented the analysis of participation processes of two R&D projects. As already determined, one project was unsuccessful while another was successful. Both projects shared 3 common attributes, namely time frame, mission area, and location. This led to the project selection. The first R&D project was characterized unsuccessful since it could not illustrate any new scientific principle or technique. The second R&D project was characterized successful since it could provide a new technique that was commercialized. The results of the quantitative analysis indicated that the quantitative data is not appropriate to the pattern analysis planned in the research design. This is due to insufficient data gathered from the questionnaire. The results of the qualitative analysis offered in-depth explanation of participation processes of the two projects. We can see that participation processes took place in both projects; however, they were not directed to commercialization. Since the pattern of participation processes in both cases did not differ considerably, it cannot be concluded that they were involved in the success of the project in terms of technology implementation. The next chapter will discuss these results and suggest technology policy implications further.

CHAPTER 7

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

This chapter begins with a discussion of the results from the data analysis, followed by a discussion of the potential contributions to theory and research. Finally, it will determine the limitations of the research and provide some implications for future research and technology policy.

Discussion of the Results from the Data Analysis

This research explored participation processes for technology development in Thailand using technology transfer model, interorganizational network approach, and participative approaches. As argued in the prior case studies on Biotechnology R&D in Thailand, a lack of joint collaboration among stakeholders in R&D projects limited the capacity to convert R&D efforts into commercial successes. In addition, the literature remarks allude to conflicts of interest among different stakeholders at an individual and organizational level which may also act as barriers in their participation efforts. This research examined two R&D projects in order to distinguish the different patterns of participation processes between the successful and unsuccessful project. The following discussion is organized into two sub-sections: conflicts on R&D and participation processes. The discussion in this section uses quantitative data and qualitative data from documentation reviews, questionnaires, and interviews.

Conflicts on R&D

Conflicts on R&D were apparent in the research. R&D projects supported by the funding agency should be commercially applicable in the industrial sector. This is a significant criteria for government policy makers in evaluating the performance of government supported R&D projects (NSTDA 1992). However, such a criteria seemed to be unrecognized by some stakeholders of the projects that were studied. There is no surprised that most investigators conducted research with knowledge-oriented goal and perceived new knowledge as an output of the research effort. This is also evident in other countries. According to Jones-Evans et al. (1999) in Sweden and Ireland the lack of academic recognition for commercialization is a barrier for working with industry because universities are less likely to be sympathetic towards the potential clients. Also, they note that industries are generally unable to provide problems that are of direct interest to many academic departments. Similarly, Bird and Allen (1989) report that the academic mentality vastly differs from the entrepreneurial mentality. Van Dierdonck and Debackere (1988) also agree that these differences result in problems and conflicts such as mutual lack of comprehension and academic apathy to entrepreneurial behavior. Such a situation was therefore evident in this research. In the first case, the principal investigator pursued his research interest without the need to solve a specific problem in the industry. He has had a long term view of the R&D project, assuming that the practical applications of R&D's results would benefit society at some point in the future. Though there were firms that participated in the project, they did not have motives or interest to invest in the technology. The business people's perception on the R&D project was approaching the ideal of commercialization. Since the import of medicines appeared to earn more profit than domestically acquired technology, it was unlikely that the industry would take a risk and commercialize the pharmaceutical.

The invention of the diagnostic kit in the second case is dissimilar to the development of the medicines in the first case. The diagnostic kit is a substitute for the time-consuming conventional method. One characteristic of this potential substitute was to lower the usage rate of the resource required performing the function (Porter 1985). The diagnostic kit promises to reduce the amount of time to diagnose the disease. Though the principal investigator of the second project did not expect a profit from his research result, it was attractive to private companies because of its commercial potential.

Conflicts between investigators and reviewers were also found in this research. In the first project, though believing that the project may be successfully commercialized, the industrial reviewer did not exchange his idea with the principal investigator. One academic reviewer seemed to discredit the principal investigator since the principal investigator had adopted the template of his own dissertation without probing it to find out whether it was appropriate for Thailand's situation. On the other hand, the principal investigator seemed to lack confidence of the reviewers because he believed that their disciplines were different from his project's area. In the second project, the reviewer was more concerned with technical issues while the principal investigator was satisfied with the R&D results that would be utilized and ready to commercialize. These types of conflicts of interest were likely to provoke hostile reactions that were captured during the interviews. For example, "I don't want to know this kind of person" was an expression from one to another respondent. This was a pitfall in the scientific community that is presumed socially negotiated (Yearley 1988).

Conflict between investigators was created when there was a profit from the R&D project. This was a case in the second project when an organization that co-investigated

R&D in the research stage bought semi-products from the principal investigator, and then packaged and commercialized the products without the consent of the principal investigator. Though both organizations still collaborated in other activities, they discontinued co-development of the products resulting from the R&D project. In addition, the co-investigating organization as a prospective user did not maintain the interest in utilizing the product. This finding is not surprising since the study of technological innovation also reports that the success of user-producer collaboration can often depend on the avoidance of commercializing conflict by maintaining stable boundaries, or vertical demarcation, between the activities of the producer and the user (Buisseret 1993). At the early phase of R&D, two parties shared mutual interest in developing the product; however, the conflict caused by a misunderstanding and this prospective user crossed the line by producing the product by itself. Unfortunately, there was no mechanism to resolve of the conflict, and to encourage understanding between them.

Participation Processes on R&D Development

The patterns of participation processes on R&D development explored in the two cases were not considerably dissimilar. Participation processes took place in both of them; however, they did not directly facilitate commercialization. The members of investigators in each project coordinated properly at the research stage. They were simply responsible for accomplishing their task; however, there was no evidence that they had attempted to move the project toward the commercialization. This was quite surprising since each research team was composed of key persons who were supposed to carry the project over the research stage. For instance, in the first project, the engineer who was responsible for extending the production scale had experience in contacting the industry; however, he did not relate his intentions and objective of the project to that of commercialization. Also, two members who were industrialists did not have a large stake in the project. In the second project, team members were also prospective users of the products; however, their main goals and objectives were focused on utilization. They did not have outputs that would lead to commercialization. The exception was one organization that commercialized the research results without the consent of the principal investigator.

Nonetheless, participation in both projects provided a sense of trustworthiness and the value of interorganizational collaboration of various team members. The multi-disciplinary teams in the both cases were examples of good R&D partnerships. There were no impediments in collaboration between different organizations. Therefore, the participation in this sense was effective. The investigators were responsible for their tasks. In addition, the fact that the money was not an issue to encourage researchers to work together was investigated in the second project. In both cases, the principle investigator had a project management role in order to allocate resources and control schedules for conducting the project. Most investigators expressed their satisfaction to work together on a team basis. This satisfaction was confirmed since some of them still continued their relationships in other academic and research activities.

The reviewers of both project also actively participated by giving scientific evaluations. However, it was noticed that when the investigators and the reviewers hold different attitudes, the evaluation system could not be synchronized effectively. From these findings, it may seem like a lack of communication or participation was evident.

Since anonymity of reviewers were presumed in the evaluation system, it was ineffective for participation. Participation, like the site-visit is not a new process of the evaluation of government funding R&D. Gibson (1979) reports that it worked very well for research program funded by the Department of Defense in the United States. In addition, the site visit also functioned in the evaluation of some R&D projects funded by the funding agency in Thailand.

The lack of participation from the potential user of both projects was interesting especially when the potential user and each investigator perceived R&D from different perspectives. Participation may have opened a channel to communicate their ideas. Without participation they could not understand each other. The potential user had the ability for large-scale production. Furthermore, its focus on marketable R&D may provide commercial insights to the project. As a result, the contribution of such a user should diminish distance of R&D projects from the market.

How will all participation processes among stakeholders in R&D processes be improved and directed to commercialize R&D results? Different stakeholders hold different ideas while all of them are anticipated to contribute their idea to make social benefit. Though the funding agency expected technology transfer to be utilized, it did not have mechanisms that encouraged stakeholders to share their idea effectively. Lessons learned from granting more than a hundred R&D projects including these two projects has stimulated the funding agency to become more active in encouraging technology transfer. Currently, the funding agency has established particular activities to support technology transfer to the industry. They include Product Development Push program, Biotech-Business Development program, few consortiums, regular round table meetings, and trainings. Such activities are expected to offer an encounter between producers and users. Then R&D projects will get advantages from there.

However, the funding agency needs to ensure that participation among stakeholders in R&D processes exist in order to lessen a gap between them. Given the explanation of participation in the two individual cases, there were gaps of understanding them on the technical and commercial basis. It was also noticed that the funding agency did not play an active role of encouraging stakeholders to participate in R&D development. A technology policy proposed here is participation and its implementation. The funding agency should play a liaison role in R&D process to promote participation between interorganizational connections, namely investigators, investigators-users, investigators-reviewers, as well as investigators-other facilitator organizations. Though participation among investigators already existed, it should be guided to accommodate R&D's results. Real commitment from prospective users should be sought to ensure commercialization. Site visit should facilitate the mutual understanding between researchers and reviewers and provide more effective evaluations.

Contributions

This research made several contributions to research approach, participation processes approach, and organizational network theory. These contributions are described below.

Research Approach

This research demonstrates the value of research on management of R&D by using research tools and philosophy in the social sciences. This research provides a new way of thinking about R&D development because it integrated the organizational network analysis and participation framework to explore participation processes in the R&D process. The organizational network analysis offers a way to look at the collaboration from different perspective. The qualitative approach of research extends the way of understanding the collaboration between R&D stakeholders by offering in-depth data of participants role in the R&D process.

Participation Processes

The research contributes to the academic literature on participation processes by adding the value of participation in R&D development. This is accomplished by two directions. First, the research findings stress the importance of participation processes directed to the cases. Secondly, the researcher's role added the value of participation by providing a leadership role and for encouraging stakeholders' participation.

To the Cases

Three elements of participation processes, including shared-meaning, partnership, and ownership were deficient in the two cases studied because of their weak participation. The first element is shared-meaning. In both cases, the primary focuses of their roles limited their learning and development of shared meaning, as well as their perceptions of the value of someone's contribution (Ellinor and Gerard 1998). The stakeholders saw the R&D from different perspective. This was a chance to increase creativity if they could participate and shared in their islands of knowledge. Because of the lack of multi-stakeholders participation investigated in both cases, there were boundaries around knowledge and information. Not surprisingly, each stakeholder could not develop the sense of shared meaning that includes diverse perspectives on the R&D process.

The second element is partnership. In both cases, the stakeholders maintained individuality and sometimes hostility in their relationship with others. Creating multi-disciplinary teams by interorganizational linkage requires establishing relationships to outsiders, from the focal organization's perspective. Partnership in technology development is created by tight coupling of complementary skill sets which refers to the organizational link of knowledge (Leonard-Barton 1998). This means having "trustworthiness" among organizations. Also Ellinor and Gerard argue, "working with shadow material and with undiscussibles is necessary for building trust and creating alignment" (Ellinor and Gerard 1998, 242-243). According to them, appreciation of interconnection and interdependence is vital to the creation of successful collaborative partnerships. Unfortunately, lack of trustworthiness was demonstrated in some levels of the relationships in both cases. Inspiring all stakeholders to participate needs to build a deep respect for knowledge bases other than one's own because it creates an atmosphere for sustaining technological capability (Leonard-Barton 1998).

The third element is ownership. In both cases, most stakeholders engaged in the R&D process without a sense of ownership for the whole process. The technology life cycle and the technology transfer approaches also provided a way for each stakeholder to contribute to the technology on his/her own task. Ownership in knowledge processes described here refers to the "emotional investment" (Wheatley 1992, 66) that stakeholders should have in the entire process of work. Wheatley describes the strategy to create a sense of ownership to organizational employees as "the participation process that generates the reality to which they then make their commitment" (Wheatley 1992, 67). This process is also imperative to interorganizational linkages. For the successful project (the second case), its principal investigator demonstrated a sense of ownership when he decided to take part in commercialization stage. "The product is alive and if not managed, it will die. Then nobody can take their advantage. I think I want to assure them by myself." This might be a good starting point to R&D projects to distribute the sense of ownership to other stakeholders by participation.

To the Stakeholders

Wheatley (1992) argues that leadership should be encouraged to include all stakeholders to evoke followship and to empower others. To highlight the importance of participation to leadership she explains "Leadership is *always* dependent on the context, but the context is established by the *relationships* we value." The researcher's role was taking place here. The researcher is the "vehicle" for the participation, when the information is conveyed from one level of organization to the next (Young 1996). Fortunately, the perspectives of particular stakeholders were made available to the others by the researcher also. In this research context, the researcher held the leadership responsibility by being the vehicle for the participation. The researcher "open gates and active environmental scanner" (Leonard-Barton 1998) to the import of knowledge. As soon as the stakeholders participated with the interview, the knowledge was conveyed to them. When they listen to this vehicle, they were knowledgeable about the R&D development. The significance of participation by the interview was to stimulate the stakeholders to realize the value of R&D process and its implementation. At this point, leadership was shared between the researcher and the stakeholders.

Organizational Network Analysis

The literature proposes organizational network analysis as a way of thinking about the relationship of several organizations. Unfortunately, there was no sufficient data collected from the two cases to support the significance of the organizational network in this research. However, the contribution of international organization may suggest that some level of knowledge imported might be linked to the success of the project. This is a trend that demonstrates the significance of organizational networking to the R&D project. The improvement of the questionnaire in future research is suggested to make contributions to the organizational network analysis to research.

Implications and Suggestions

Results of this research raised several issues for future research as well as practical implications for technology policy.

Implications for Future Research

Future research could explore participation processes using the model of interorganizational network approach to other forms of R&D development. Such forms, for example, a consortium could establish a clear boundary of linkages. This could increase the validity of research since the linkages from a local organization to others can obviously be identified. Therefore, the internal validity can be increased because of its ability to show pattern matching of the quantitative data. In addition, future research should be conducted in parallel with R&D development activities. With this approach, the field observation can generate more qualitative data. Researchers can gather stakeholders' perspectives, and conflicts in real settings, for example, scientific forum, seminars, and meetings. Not only current linkages can be observed, but also, coexisting participation could be motivated by concurrent research.

Future research might replicate this research to other R&D projects in other settings as well to extend the generalizability of the findings. However, the central idea of generalization is to apply the findings of a current research to a large frame (Potter 1996). This research was designed for generalization though only two projects were studied. According to Kennedy (1979), few cases were efficient to the case studies if there were general common attributes for their generalization. Three common criteria of the cases in this research were specific domain, specific location and time consistency. Furthermore, this research context was limited to the public-funded R&D projects in Thailand, which is described in chapter 2. These constraints have to be considered if someone tries to generalize from these findings.

Future research might apply other organizational management theories, such as cybernetics, socio-technical systems, and organizational learning to build the explanation of qualitative data of the participation processes in R&D projects. This will enhance validity of this research if the conclusion from theories triangulation can be converged. Also future research can apply other network tools, for example, centrality, range multiplex, and stars (Auster 1990) to identify more relevant linkages during R&D conducting. With such approaches, the statistical methods will be appropriate to find the relationship of the linkages of the network and the success of R&D project in quantitative sense, while the qualitative data might be gather to help facilitate the understanding of their correlation.

Future research might focus the linkage between any R&D setting to international organizations. This is due to the trend of the importance of such kinds of linkage in this research. Since the studies (Mansfield et al. 1982, Barrera and Williams 1990, Bozzo and Gibson 1990, Chatterji 1990, and Madu 1992) identify gains and losses from international technology transfer, future research may challenge such studies. Finally, future research might replicate this research in different countries to explore the impact of cross cultural effects on participation processes of R&D development.

Suggestions for Technology Policy

At present, weak participation among stakeholders in R&D processes is found. Although its linkage to the success of R&D process is not obvious, it is not a good sign of interorganizational relationship. Participation should take a part through all linkages contributing to R&D development. One mechanism "dialogue" is suggested here to enhance participation. Dialogue is a form of conversation that has the power to build partnership, ownership, and leadership among participants. As long as they listen and learn others' perspectives, they are able to develop shared meanings together. Then the success can be anticipated when participants move in the same direction.

Implications for R&D Management in Developing Countries for Policy Makers

Developing countries can gain substantial benefits from supporting R&D by recognizing the importance of R&D management. R&D cannot be successful only because of its technical excellence. Management should be integrated in the R&D

processes. From the case studies, when several stakeholders in the projects had different perspectives about R&D, they did not share their meanings. It is the managerial role to facilitate the participation processes. Some management implications related to participation processes are explained as followings.

1. Funding agencies should take a facilitating role for the participation processes among R&D stakeholders. From the case studies, though the funding agency's objective was to promote collaboration and cooperation between the stakeholders, it can be seen that the funding agency did not play an active role to participate in the R&D projects. There were no mechanisms to promote linkages between researchers, the users, and the reviewers.
2. In order to facilitate the participation processes, funding agencies should define explicit mechanisms that will be understandable by relevant stakeholders. For example, in the R&D project's review, funding agencies should clarify all available review processes to all reviewers. As discussed earlier, a site visit is an appropriate evaluation process that promotes participation; therefore, researchers as well as relevant stakeholders should be encouraged to accept this process.
3. A lesson learned from the case studies shows that users did not have motivations to invest the technology from research results. There should be mechanisms or incentives to stimulate users to have the sense of ownership of the R&D process. The mechanisms, for example, exchanging researchers between universities and industry, and training industry's researchers for the R&D project's purpose are considered participation processes that may

increase the sense of ownership to the industrial user. Such mechanisms are interactive learning-processes among all participating parties. A dialogue may result in the creation of a common terminology that may often be lacking in academic-industry collaboration. Also, funding agencies might play a role here by providing incentives such as offering the low royalty cost of the developed technology to the participated industry.

4. Since support of basic or applied research is another dilemmatic issue in the case studies. It is demonstrated in both cases that applied R&D needs strong basic scientific knowledge. Thus, in support of R&D projects, there must be a short-term goal for achieving scientific knowledge, and a long-term goal for implementation of project's results. These goals should be developed and evaluated in a bottom-up manner, which also needs a dialogue among policy makers, academic, industry, etc.
5. The case studies show the firm's perception of high investment of R&D and innovations. The policy maker should facilitate construct users' perception to recognize the importance of developing their own technologies. By doing this, such technologies must have their economical feasibility in the long run. Dialogue can take part here between all relevant actors such as economists, technologists, and managers, to evaluate technologies' feasibility in the first place.
6. In some cases, technology transfer from industrialized countries might be considered more feasible. Also, a dialogue should play a role to make a decision between make-and buy- strategy. Deciding to make a technology

requires the country's capacities, and facilities. Deciding to buy a technology requires the readiness to learn or absorb foreign technologies that will enhance the countries' capacities to develop their own technologies in the long term.

7. "Demand pull" is an important strategy of selecting projects. In appraising the users' demand, the policy maker needs to create a dialogue that will carry the information of true needs of business community.

These management implications toward participation processes require initiating and facilitating "dialogue" in technology development processes. Such participation processes should not end when the initial policies have been formulated and implemented. Rather, a continuous dialogue is needed to refresh knowledge, and enable the share meaning between relevant participants throughcut the technology development process. Thus, the policy maker should be make sure that participation processes will be endogenous activities within R&D processes.

Conclusions

This research has proposed the integration of interorganizational network analysis and participation approaches to explore participation processes in R&D development in Thailand. The interest of the research was inspired by the prior case studies that indicated weak collaboration of the stakeholders of R&D development, and related this incident to unsuccessful commercialization of products from R&D projects. The research effort is to influence participation among these stakeholders to stimulate the R&D projects' commercialization. The technology transfer and technology life cycle were used as a model to define stakeholders and their contribution to R&D processes. The quantitative and qualitative approaches were also used in this research.

The findings show that participation processes in the successful and the unsuccessful projects were not considerably different. The stakeholders participated at some level; however, participation was not a means for commercialization. Though the interorganizational network analysis could not show the link between participation and the success of the R&D projects quantitatively, the involvement of international organizations was a trend in the success project.

The findings also illustrate some conflicts among the stakeholders. Such conflicts are a pitfall in the scientific community and may serve as a barrier to commercialization. This research proposes dialogue as a participative strategy to diminish conflicts. Technology policy could include dialogue as an R&D management strategy to stimulate participation among R&D stakeholders in order to build their relationships. Also, desirable results such as the commercialization of R&D are anticipated from the dialogue implementation.

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APPENDIX 1: The Survey Questionnaire

Part I: General Information

1. Name..
2. Name of the organization...
3. Name of the performing Biotechnology R&D project funded by the National Agency for Science and Technology Development (NSTDA) during 1994-1996

   ....
   ....

Part II: Technology Development

4. Did you expect the result of your R&D project to be implemented in industry or agricultural sector?

Yes (go to 5)

No (go to 9)

5. Did your project need engineering process to upscale the results of the research?

Yes (go to 6)

No (go to 7)

6. Did you indicate the names of the organization or the persons that would do upscale process in your project proposal?

Yes

What are the names of the persons/ organizations that would do upscale process? Please give all names.

No (go to 7)

7. Did your project need any process to extend the results of the research?

Yes (go to 8)

No (go to 9)

8. Did you indicate the name of the organization or the person that would do the extension process in your project proposal?

Yes

What are the names of the persons/ organizations?

Please give all names...

No (go to 9)

9. How did you intend to implement the results from your R&D project?..................

....

Part III: Utilization

10. Did you indicate the name of prospective users who would implement the technology developed from the project in your project proposal?

- Yes

What are the names of the persons/ organizations?

Please give all names.

- No (go to 11)

11. What is the benefit from your R&D project?...

Appendix 1 (Con't)

12. Can you identify who will consume/utilize the product from your technology, i.e. the farmers, the patients, the consumers, the plant breeders, etc.)?

- Yes, who?

Please indicate..

Part IV: Other Organizations' Participation

13. Please indicate the names of other research organizations *within the country* that you had ever contacted regarding your project during 1994-1996.
14. Please indicate the names of other research organizations in *other countries* that you had ever contacted regarding your project during 1994-1996.
15. Did you ever contact the following organizations about your project's issue?

Professional Organization	Yes	No
a) Project's technical committee assigned by NSTDA		
b) The Board of Investment (BOI)		
c) The Federation of Thai Industry (FTI)		
d) Thailand Food and Drug Agency (FDA)		
e) Intellectual Property Right Center (IPC)		
f) Thailand Industrial Standards Institutes (TISI)		
g) Department of Medical Science		
h) Thai Biotechnology Association		
i) Thailand Research Fund		
j) Others		

16. What are any organizations that you wanted to contact for the benefit of your project, but you did not have a chance?...

Part V: Linkage Type and Frequency

17. Please approximate how many times you and the stated organizations have these contacts.

    A. To be informed of technical evaluation concerning the project by that organization/ person
    B. To be informed of related technical information concerning the project by that organization/ person
    C. To be informed of other information by that organization/ person (i.e. business, regulation, etc.)
    D. To discuss about the technical project's issue
    E. To discuss about any project issue (i.e. business, regulation, etc.)
    F. To hold joint the seminar/ conference/ training
    G. To send staff to the seminar/ conference/ training that was held by that organization/ person

Appendix 1 (Con't)

H. To admit that person/ staff from that organization to the seminar/ conference/ training that was held by your organization

I. Others (please indicate)

Organization	How many times that you had relations (1994 -1996)							
Name	A	C	D	E	F	G	H	I

18. How did you feel about the contact between your organization and the mentioned organizations?
Please indicate the names of the organizations, and provide the reasons.

Organization					
Name	Most satisfy	Sometimes Satisfy	Dissatisf y	Don't know	Reason

19. Do you think the relation between your organization and the mentioned organizations influence the utilization of your project's result?
Why? ....
....
....
....
....

Appendix 1 (Con't)

20. What organizations do you think have influence to the utilization of your project's result? Please rank from the most influence organization.
    A. ....
    B. ....
    C. ....
    D. ....
    E. ....

Thank you for your assistance in completing this questionnaire.

APPENDIX 2: Questions for Interview

(Structured Interview: Asking all stakeholders)

1. Name
2. Education
3. Name of organization
4. What role does your organization have in contributing to the "*name of the project*"

Financing agency

Research performing

Product/process Up-scaling

Research Extension

Initial-user

End-user

Facilitator

Others

Unstructured Interview

1. What do you think the goal of "a name of a project" was?
2. Was the goal achieved?
3. How formal are you when/if you communicated to other stake holders(*indicate the names*)?
4. Did you always agree with the other stakeholders (*indicate the names*)? Why or why not? Please give example.
5. What was the driving force to resolve the conflict between you (your group) and other stakeholders (*indicate the names*)?, if you answer is "no" in the previous question?
6. How did you approach "a name of a project" to the industry (or to the extension) in your opinion?
7. What is an appropriate way to approach "name of a project" to the initial users in your opinion?
8. What barriers of the process of technology transfer for "name of a project" to the initial users are in your opinion?
9. How did you disseminate the information about the "name of a project" to the initial and end-users?
10. What are barriers of the information dissemination to the initial and end-users?
11. Have you received the information about the technology (from "name of a project")? If yes, what have you been aware of that technology?

Appendix 2 (Con't)

12. What do you think about the adoption of the technology (from "name of a project") to be the alternative in your organization? Why or why not?
13. What do you think about the utilization of the product from technology (from "name of a project")? Why or why not?
14. Did you give any technical opinions to the scientist who perform "name of a project"? Why or why not?
15. If the answer from question 14 is "yes", was you opinion taken to practice?
16. If the answer from question 15 is "yes", how?
17. If the answer from question 15 is "no" , why?
18. Did you give any opinion (except technical) to the scientist who perform "name of a project"? Why or why not?
19. If the answer from question 18 is "yes", was you opinion taken to practice?
20. If the answer from question 19 is "yes", how?
21. If the answer from question 20 is "no" , why?
22. What actions do you think your organization provided to the development of the "name of a project"? How?
23. Do you think the actions (from Question 22) facilitated the technology transferring of that project? Why or why not?
24. Have you had an informal communication with "name of a stakeholder"? How?
25. Have you published the paper about "name of project"? If yes, who are your audiences? what do you think about other groups of people?
26. Do you think whether scientists and engineers are salesmen? Why?
27. Have you ever thought about cost-benefit ratio of "name of a project"? Why or why not?
28. What do you think about the role of "liaison" of research and industry or utilization agency?
29. Have you ever be informed the information of the technology? If yes, how?
30. Have you ever attended or sent your staff to the conference/ meeting/ training to the organization "name"? What is the advantage for "name of a project"?

Appendix 2 (Con't)

The interview will be performed using the plan in this table (questions for "others" will be considered as appropriate for their identification).

	Stakeholder							
Question Number	*Financing agency*	*Research performing*	*Product/ process up-scaling*	*Research Extension*	*Initial-user*	*End-user*	*Facilitator*	*Others**
1	*	*	*	*	*		*	
2	*	*	*	*	*		*	
3	*	*	*	*	*	*	*	
4	*	*	*	*	*	*	*	
5	*	*	*	*	*	*	*	
6	*	*	*	*	*		*	
7	*	*	*	*	*		*	
8	*	*	*	*				
9	*	*	*	*				
10	*	*	*	*				
11					*	*		
12					*	*		
13					*	*		
14	*		*	*				
15	*		*	*				
16	*		*	*				
17	*		*	*				
18	*		*	*			*	
19	*		*	*			*	
20	*		*	*			*	
21	*		*	*			*	
22							*	
23							*	
24	*	*	*	*	*	*	*	
25		*	*	*				
26	*	*	*	*	*	*	*	
27	*	*	*	*				
28	*	*	*	*	*	*	*	
29					*	*		
30	*	*	*	*	*	*	*	

APPENDIX 3: The Survey Questionnaire (in Thai)

แบบสอบถาม

เรื่อง

ความร่วมมือในการพัฒนางานวิจัย

ตอนที่ 1 : ข้อมูลทั่วไป

1. ชื่อผู้กรอกแบบสอบถาม...
2. ชื่อหน่วยงาน...
3. ชื่อโครงการวิจัยที่รับทุนอุดหนุนจากศูนย์พันธุวิศวกรรมและเทคโนโลยีชีวภาพแห่งชาติ สำนักงานพัฒนาวิทยาศาสตร์และเทคโนโลยีแห่งชาติ ระหว่าง พ.ศ. 2536 - 2538...

ตอนที่ 2 : การพัฒนาเทคโนโลยี

4. ท่านคาดหวังว่าผลจากโครงการวิจัยและพัฒนาจะได้นำมาใช้ในภาคอุตสาหกรรมหรือภาคเกษตรกรรมหรือไม่

   ใช่.........(ตอบข้อ 5)

   ไม่ใช่.........(ตอบข้อ 9)
5. โครงการวิจัยและพัฒนาของท่านต้องการกระบวนการทางวิศวกรรมเพื่อพัฒนาสู่ระดับที่ใหญ่ขึ้น (Upscale process) หรือไม่

   ใช่..........(ตอบข้อ 6)

   ไม่ใช่.........(ตอบข้อ 7)
6. ท่านได้ระบุชื่อบุคคลหรือหน่วยงานที่จะดำเนินการพัฒนากระบวนการทางวิศวกรรมในข้อเสนอโครงการวิจัย และพัฒนาหรือไม่

   ได้ระบุ......โปรดระบุชื่อบุคคลและ/หรือหน่วยงานดังกล่าว...

   ....

   ไม่ได้ระบุ (ตอบข้อ 9)
7. โครงการวิจัยและพัฒนาของท่านต้องการกระบวนการอื่น ๆ ในการขยายผลงานวิจัยสู่ระดับที่ใหญ่ขึ้น(Extension process) หรือไม่

   ใช่........(ตอบข้อ 8)

   ไม่ใช่........(ตอบข้อ 9)
8. ท่านได้ระบุชื่อบุคคลหรือหน่วยงานที่จะดำเนินการขยายผลงานวิจัยในข้อเสนอโครงการวิจัยและพัฒนาหรือไม่

   ได้ระบุ ..โปรดระบุชื่อบุคคลและ/หรือหน่วยงานดังกล่าว ....

   ไม่ได้ระบุ..(ตอบข้อ 9)
9. ท่านได้คาดหมายการนำผลงานของโครงการวิจัยและพัฒนาไปใช้อย่างไร...

   ....

Appendix 3 (Cont')

ตอนที่ 3 : การนำผลงานวิจัยและพัฒนาไปใช้

10. ท่านได้ระบุกลุ่มบุคคล/องค์การ/อุตสาหกรรมที่จะนำเทคโนโลยีที่ได้จากโครงการวิจัยและพัฒนาไว้ใน ข้อเสนอ โครงการหรือไม่

ได้ระบุดังรายชื่อต่อไปนี้...

....

ไม่ได้ระบุ (ตอบข้อ 12)

11. ผลประโยชน์ที่ได้จากโครงการวิจัยและพัฒนาของท่านคือ...

....

12. ท่านสามารถระบุบุคคล/กลุ่มบุคคล/องค์การที่สามารถใช้ผลผลิตจากเทคโนโลยีที่ได้จากเทคโนโลยีจาก โครงการวิจัยและพัฒนา (ตัวอย่างเช่น เกษตรกร คนไข้ ผู้บริโภค นักผสมพันธุ์พืช เป็นต้น)

ได้ ....โปรดระบุ..

ไม่ได้..............

ตอนที่ 4 : การร่วมมือจากหน่วยงานอื่น

13. โปรดระบุรายชื่อขององค์กรวิจัยอื่นๆ ภายในประเทศที่ท่านได้ติดต่อในระหว่างที่ท่านดำเนินโครงการวิจัยฯ

....

14. โปรดระบุรายชื่อขององค์กรวิจัยต่างประเทศที่ท่านได้ติดต่อในระหว่างที่ท่านดำเนินการโครงการวิจัยฯ

....

15. ท่านเคยมีการติดต่อกับหน่วยงาน/สมาคมต่อไปนี้ในระหว่างที่ทำงานวิจัยโครงการฯ หรือไม่

หน่วยงาน/สมาคม	เคย	ไม่เคย
15.1 คณะอนุกรรมการติดตามประเมินผลโครงการฯ ที่ได้รับการแต่งตั้งโดยศูนย์พันธุวิศวกรรมและเทคโนโลยีชีวภาพแห่งชาติ		
15.2 สำนักงานคณะกรรมการส่งเสริมการลงทุน (BOI)		
15.3 สภาอุตสาหกรรมแห่งประเทศไทย		
15.4 สำนักงานคณะกรรมการอาหารและยา		
15.5 กรมทรัพย์สินทางปัญญา		
15.6 สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม		
15.7 กรมวิทยาศาสตร์การแพทย์		
15.8 สมาคมเทคโนโลยีชีวภาพแห่งประเทศไทย		
15.9 สำนักงานกองทุนสนับสนุนการวิจัย		
15.10 หน่วยงานอื่น ๆ (โปรดระบุ)		

16. มีหน่วยงานอื่นๆ ที่ท่านต้องการติดต่อเพื่อประโยชน์ต่อโครงการของท่านแต่ท่านไม่มีโอกาสจะติดต่อ หรือไม่ ถ้ามี โปรดระบุชื่อของหน่วยงานดังกล่าว..

Appendix 3 (Cont')

ตอนที่ 5 : ประเภทและจำนวนครั้งของการติดต่อกับหน่วยงานต่าง ๆ

17. โปรดประมาณจำนวนครั้งที่ท่านและหน่วยงานต่าง ๆ มีการติดต่อกัน ในประเภทต่อไปนี้

17.1 ได้รับการประเมินทางวิชาการเกี่ยวกับโครงการฯ

17.2 ได้รับข้อมูลทางวิชาการที่เกี่ยวข้องกับโครงการฯ

17.3 ได้รับข้อมูลอื่น ๆ ที่จะเป็นประโยชน์ต่อโครงการฯ (ตัวอย่างเช่น ข้อมูลทางธุรกิจ ข้อมูลทางกฎหมาย ระเบียบ ข้อบังคับ เศรษฐศาสตร์ เป็นต้น)

17.4 มีการอภิปรายเชิงวิชาการเกี่ยวกับโครงการฯ

17.5 มีการอภิปรายในหัวข้ออื่น ๆ ที่เกี่ยวกับโครงการฯ (ตัวอย่างเชน การอภิปรายในแง่ธุรกิจ กฎหมาย ระเบียบ ข้อบังคับ เศรษฐศาสตร์ เป็นต้น)

17.6 มีการจัดสัมมนา การประชุมเชิงวิชาการ หรือการฝึกอบรม ร่วมกัน

17.7 เข้าร่วมหรือส่งบุคลากรที่ทำวิจัยในหน่วยงานของท่านเข้าร่วมการสัมมนา การประชุมเชิงวิชาการ หรือการฝึกอบรมในหน่วยงานที่ระบุ

17.8 ได้รับบุคลากรในหน่วยงานที่ระบุเข้าร่วมการสัมมนา การประชุมเชิงวิชาการ หรือการฝึกอบรมในหน่วยงานของท่าน

17.9 การติดต่ออื่น ๆ (โปรดระบุ)

ชื่อหน่วยงาน	*จำนวนครั้งของการติดต่อ*								
	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9

Appendix 3 (Cont')

18. ท่านมีทัศนคติอย่างไรต่อหน่วยงานที่ระบุ

ชื่อหน่วยงาน	ทัศนคติ				
	พอใจมาก	พอใจ	ไม่พอใจ	ไม่ทราบ	เหตุผล

19. ท่านคิดว่าความสัมพันธ์ระหว่างท่านหรือหน่วยงานของท่านกับหน่วยงานอื่น ๆ ที่ระบุมีอิทธิพลต่อความสำเร็จในการนำเทคโนโลยี/ผลิตภัณฑ์ที่ได้จากโครงการวิจัยฯ ของท่านไปใช้หรือไม่ ทำไม และอย่างไร ....

20. หน่วยงานใดที่มีอิทธิพลต่อความสำเร็จในการนำเทคโนโลยี/ผลิตภัณฑ์ที่ได้จากโครงการวิจัยฯ ของท่านไปใช้ โปรดเรียงลำดับจากมากไปหาน้อย

20.1 ....

20.2 ....

20.3 ....

20.4 ....

20.5 ....

ขอขอบพระคุณในความร่วมมือของท่านที่กรุณาตอบแบบสอบถามนี้

APPENDIX 4: Questions for Interview (in Thai)

ร่างคำถามสำหรับการสัมภาษณ์

คำถามแบบที่มีคำตอบเฉพาะเจาะจง (ถามผู้เกี่ยวข้องกับโครงการทุกท่าน)

1. ชื่อผู้ให้สัมภาษณ์
2. การศึกษา
3. ชื่อหน่วยงาน
4. หน่วยงานของท่านมีหน้าที่/บทบาทใดในการร่วมพัฒนาโครงการวิจัย
   - หน่วยงานที่ให้ทุน
   - หน่วยงานที่ทำงานวิจัย
   - หน่วยงานที่ทำการพัฒนางานวิจัย/การขยายขนาด
   - หน่วยงานที่ทำหน้าที่การส่งเสริมงานวิจัย
   - ผู้ใช้เบื้องต้น เช่น ผู้ผลิตผลิตภัณฑ์ที่ใช้เทคโนโลยีจากโครงการ
   - ผู้ใช้ผลิตภัณฑ์ที่ใช้เทคโนโลยีจากโครงการ (เช่น ผู้บริโภค)
   - ผู้ให้การสนับสนุนในด้านอื่น ๆ
   - อื่น ๆ (โปรดระบุ)

คำถามที่ไม่มีคำตอบเฉพาะเจาะจง

1. ท่านคิดว่าเป้าหมายของโครงการคืออะไร
2. เป้าหมายดังกล่าวบรรลุตามที่ตั้งไว้หรือไม่ อย่างไร ทำไม
3. ท่านมีการติดต่ออย่างเป็นทางการในระดับใดกับหน่วยงาน
4. ท่านมักจะมีความเห็นที่สอดคล้องกับหน่วยงาน หรือไม่ ทำไม โปรดให้ตัวอย่างและเหตุผลประกอบ
5. ท่านทำอย่างไรเพื่อลดความขัดแย้งที่เกิดเมื่อท่านหรือหน่วยงานของท่านกับหน่วยงานมีความเห็นที่ไม่สอดคล้องกัน
6. ท่านทำอย่างไรในการเสนอโครงการต่ออุตสาหกรรม หรือหน่วยงานส่งเสริม
7. ตามความเห็นของท่าน วิธีการอย่างไรที่เหมาะสมในการเสนอโครงการต่ออุตสาหกรรม หรือหน่วยงานส่งเสริม
8. ตามความเห็นของท่าน อะไรคืออุปสรรคของการถ่ายทอดเทคโนโลยีของโครงการฯ ไปสู่หน่วยงานผู้ใช้เบื้องต้นเช่น อุตสาหกรรมหรือหน่วยงานส่งเสริม
9. ท่านเผยแพร่ข้อมูลของโครงการฯ ไปสู่หน่วยงานผู้ใช้เบื้องต้น เช่น อุตสาหกรรมหรือหน่วยงานส่งเสริม โดยวิธีใด
10. ตามความเห็นของท่าน อะไรคืออุปสรรคของการเผยแพร่ข้อมูลของโครงการดังกล่าว
11. ท่านเคยได้รับข้อมูลเกี่ยวกับเทคโนโลยีจากโครงการ หรือไม่ ถ้าเคย ท่านได้ตระหนักถึงสิ่งใดจากเทคโนโลยีหรือไม่/อย่างไร

Appendix 4 (Cont')

12. ท่านคิดจะรับเทคโนโลยีจากโครงการฯ มาใช้ในหน่วยงานของท่านหรือไม่
    ถ้าคิดเพราะเหตุใด
    ถ้าไม่คิดเพราะเหตุใด
13. ท่านคิดจะใช้ผลิตภัณฑ์ที่ได้รับจากโครงการฯ หรือไม่
    ถ้าคิด เพราะเหตุใด
    ถ้าไม่คิด เพราะเหตุใด
14. ท่านได้ให้ความเห็นเชิงวิชาการต่อนักวิทยาศาสตร์ที่ดำเนินงานวิจัยในโครงการนี้หรือไม่
    ได้ให้ เพราะเหตุใด
    ถ้าไม่คิด เพราะเหตุใด
15. ถ้าท่านได้ให้ความเห็นในข้อ 14 ความเห็นของท่านได้นำไปสู่การปฏิบัติจริงหรือไม่
16. ความเห็นของท่านได้นำไปสู่การปฏิบัติจริงได้อย่างไร/วิธีใด
17. ทำไมความเห็นของท่านไม่ได้นำไปสู่การปฏิบัติจริง
18. ท่านได้ให้ความเห็นอื่น ๆ ที่ไม่ใช่เชิงวิชาการต่อนักวิทยาศาสตร์ที่ดำเนินงานวิจัยในโครงการนี้หรือไม่
    ได้ให้ เพราะเหตุใด
    ถ้าไม่ได้ให้เพราะเหตุใด
19. ถ้าท่านได้ให้ความเห็นในข้อ 18 ความเห็นของท่านได้นำไปสู่การปฏิบัติจริงหรือไม่
20. ความเห็นของท่านได้นำไปสู่การปฏิบัติจริงได้อย่างไร/วิธีใด
21. ทำไมความเห็นของท่านไม่ได้นำไปสู่การปฏิบัติจริง
22. กิจกรรมใดที่หน่วยงานของท่านช่วยในการพัฒนาโครงการอย่างไร
23. ท่านคิดว่ากิจกรรมดังกล่าว (ข้อ 22) มีส่วนช่วยในการถ่ายทอดเทคโนโลยีจากโครงการหรือไม่ อย่างไร
24. ท่านเคยมีการติดต่อแบบไม่เป็นทางการกับหรือไม่ อย่างไร
25. ท่านเคยมีเอกสารตีพิมพ์เกี่ยวกับโครงการหรือไม่ ถ้ามี ใครคือผู้อ่าน
    ท่านคิดอย่างไรเกี่ยวกับบุคลากรกลุ่มอื่น
26. ท่านเคยคิดว่านักวิทยาศาสตร์และวิศวกรควรเป็นคนขายของหรือไม่ ทำไม
27. ท่านเคยคิดถึงการประมาณการคุ้มทุนของโครงการหรือไม่ เพราะเหตุใด
28. ท่านคิดอย่างไรเกี่ยวกับบทบาทของผู้ติดต่อ (Liaison) ระหว่างหน่วยงานวิจัยและหน่วยงานที่นำไปใช้
29. ท่านเคยได้รับทราบข้อมูลของโครงการบ้างหรือไม่ ถ้าเคย ได้รับอย่างไร
30. ท่านเคยเข้าร่วมหรือส่งบุคลากรในองค์กรของท่านเข้าร่วมการประชุมเชิงวิชาการ
    การประชุมหรือการฝึกอบรมซึ่งจัดโดยหน่วยงานหรือไม่ โครงการวิจัยได้รับผลประโยชน์อย่างไร

Appendix 4 (Cont')

การสัมภาษณ์ดำเนินตามแผนดังตารางนี้

	ผู้เกี่ยวข้องกับโครงการ							
คำถามหมายเลข	หน่วยงานให้ทุน	นักวิจัย	ผู้ขยายขนาดงานวิจัย (product process up scaling)	ผู้ขยายขนาดงานวิจัย (research extension)	อุตสาหกรรมผู้ใช้	ผู้ใช้ผลิตภัณฑ์	ผู้ให้การสนับสนุน	อื่น ๆ
1	•	•	•	•	•		•	
2	•	•	•	•	•		•	
3	•	•	•	•	•	•	•	
4	•	•	•	•	•	•	•	
5	•	•	•	•	•	•	•	
6	•	•	•	•	•		•	
7	•	•	•	•	•		•	
8	•	•	•	•				
9	•	•	•	•				
10	•	•	•	•				
11					•	•		
12					•	•		
13					•	•		
14	•		•	•				
15	•		•	•				
16	•		•	•				
17	•		•	•				
18	•		•	•			•	
19	•		•	•			•	
20	•		•	•			•	
21	•		•	•			•	
22							•	
23							•	
24	•	•	•	•	•	•	•	
25		•	•	•				
26	•	•	•	•	•	•	•	
27	•	•	•	•			•	
28	•	•	•	•	•	•	•	
29					•	•	•	
30	•	•	•	•	•	•	•	

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