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# Innovation intermediaries and triple helix networks in developing countries with particular reference to the case of Thailand

by

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the degree of Doctor of Philosophy
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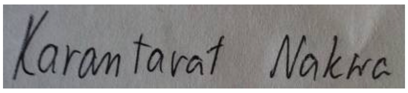
Signed: 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# Abstract

This study explores the evolution of the triple helix network and innovation system in relation to the role of innovation intermediaries based on the experience of knowledge network development in Thailand. The study attempts to show both conceptually and empirically the development of the triple helix innovation system as an evolutionary process starting from 'pre-existing inter-firm networks', which occur in the form of supply chain-based vertical links and industry or trade associations or cluster-based horizontal links, and progressing through triple helix networks that would be expected to culminate in the establishment of the triple helix innovation system underpinned by network dynamics. In the context of Thailand, as indeed elsewhere in developing countries, the challenge of knowledge network development is a major hurdle that has yet to be overcome in the long evolutionary process of getting to the triple helix innovation system. Triple helix networks are particularly significant for developing countries as they offer the opportunity for knowledge exchange and combination between diverse sources of knowledge that constitute the basis for network dynamics to arise. Given this, the study investigates the hypothesis that the active participation of Thai firms in triple helix networks depends on factors, including the availability of intermediaries and their effectiveness as a catalyst expediting knowledge network development among all triple helix actors; the technological capability of the firms; and their experience in pre-existing networks.

Generally speaking, networks are dysfunctional where intermediaries are absent or ineffective. Intermediaries function as sponsors at policy level; as brokers at strategic level; and as boundary spanners at operational level to stimulate the transformation of 'pre-existing networks' into triple helix networks and beyond this into the triple helix innovation system.

The data for investigation of the hypothesis were collected through interviews and a questionnaire-based survey in six manufacturing industries categorised into three industry groups – multinational corporation (MNC)-based, small and medium enterprise (SME)-based, and community enterprise (CE)-based. MNC-based industries include hard disk drive and automotive industries. SME-based industries include ceramic and

furniture industries. CE-based industries include local textile and rice cracker industries. The questionnaire survey was conducted to elicit data at the level of the firm. A total of 145 firms, which constitute 16 per cent of the total number of firms approached, responded to the questionnaire-based survey. A total of 20 key individuals extracted from universities, industry and government agencies were also interviewed to elicit data relating to network activities at the triple helix level.

The study finds financial supports from sponsors to be a crucial factor affecting success in the formation of triple helix networks, and the boundary-spanning role of intermediaries to be significant for the active engagement of universities and the emergence of network dynamics that is at the heart of the triple helix innovation system.

The study's contribution to knowledge consists in its conceptual and empirical analyses of the systemic roles played by innovation intermediaries; the evolution of the complex triple helix innovation system from simple inter-firm networks; the emergence of network dynamics from the interactions of heterogeneous players in the triple helix framework; and the effectiveness of intermediation across the three main industry groups in the Thai manufacturing economy.

# Publications

## Peer reviewed journals

Nakwa, K. & Zawdie, G. (2012). The role of innovation intermediaries in promoting the triple helix system in MNC-dominated industries in Thailand: the case of hard disk drive and automotive sectors. *International Journal of Technology Management and Sustainable Development, 11*(3), 265-283.

Nakwa, K., Zawdie, G. & Intarakumnerd, P. (2012). Role of Intermediaries in Accelerating the Transformation of Inter-Firm Networks into Triple Helix Networks: A Case Study of SME-based Industries in Thailand. *Procedia - Social and Behavioral Sciences, 52*(0), 52-61.

## Conference papers

Nakwa, K. & Zawdie, G. (2011). *The role of innovation intermediaries in promoting triple helix system: the case study of MNC-dominated industries in Thailand.* Paper presented at the Conference on 'Innovation Systems and the New Roles of Universities', 5-6 September 2011, Bristol, UK.

Nakwa, K., Zawdie, G. & Intarakumnerd, P. (2012). *Role of intermediaries in accelerating the transformation of inter-firm networks into Triple Helix networks: A case study of SME-based industries in Thailand.* Paper presented at the Triple Helix 10th International Conference 2012, 8-10 August 2012, Bandung, Indonesia.

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# List of Abbreviations

| | |
|---|---|
| AIT | The Asian Institute of Technology |
| ANOVA | Analysis of variance |
| APR | The Asia Policy Research Co., Ltd |
| ASEAN | The Association of Southeast Asian Nations |
| BOI | The Board of Investment of Thailand |
| BOT | The Bank of Thailand |
| CBE | Community-based enterprise |
| CE | Community enterprise |
| CDA | Cluster development agent |
| CIDC | The Ceramic Industries Development Centre |
| CMU | Chiang Mai University |
| CRC | Cooperative research centre |
| EDP | The Entrepreneurship Development Programme |
| EU | The European Union |
| FDI | Foreign direct investment |
| FTI | The Thai Furniture Industry Club under Federation of Thai Industries |
| GDP | Gross domestic product |
| HDD | Hard disk drive |
| HDDI | The Hard Disk Drive Institute |
| I/UCRC | Industry/university cooperation research centre |
| IDEMA | The International Disk Drive Equipment and Materials Association |
| IFCT | The Industrial Finance Corporation of Thailand |
| IPR | Intellectual property rights |
| ITAP | The Industrial Technical Assistance Program |
| KTC | The Knowledge and Technology Centre for Northern Textile |
| MNC | Multinational corporation |
| MOI | The Ministry of Industry |
| NECTEC | The National Electronics and Computer Technology Centre |
| NESDB | The National Economic and Social Development Board of Thailand |
| NIA | The National Innovation Agency |

| | |
|---|---|
| NIS | National innovation system |
| NSTDA | The National Science and Technology Development Agency |
| OECD | Organisation for Economic Co-operation and Development |
| OSMEP | The Office of Small and Medium Enterprises Promotion |
| OTOP | One Tambon (District) One Product |
| PIO | The Provincial Industry Office |
| PU | Payap University |
| R&D | Research and development |
| RDA | Regional development agency |
| RIS | Regional innovation system |
| RTO | Research and technology organisation |
| S&T | Science and technology |
| SACICT | The Support Arts and Craft International Centre of Thailand |
| SCEB | The Secretariat Office of the Community Enterprise Promotion Board |
| SI | Systems of innovation |
| SIS | Sectoral innovation system |
| SME | Small and medium enterprise |
| SPSS | Statistical Package for Social Science |
| TA | Technical assistance |
| TAI | The Thailand Automotive Institute |
| TAPMA | The Thai Autoparts Manufacturers Association |
| TFA | The Thai Furniture Industries Association |
| TLO | Technology licensing office |
| TPA | The Thai Parawood Association |
| TTO | Technology transfer office |
| TU | Thammasat University |
| UK | The United Kingdom |
| USA | The United States of America |
| USD | United States dollar |
| GMP | Good Manufacturing Practice |
| HACCP | Hazard Analysis and Critical Control Points |

# CHAPTER 1

# Introduction

This study explores the role of innovation intermediaries and their effectiveness in the innovation process in Thailand based on the triple helix model of interactions between university, industry and government as institutional actors. How do innovation intermediaries affect the transformation and effectiveness of networks, in general, and triple helix networks, in particular? This question will be empirically investigated with respect to experiences in six networks drawn from three categories of industrial activity in Thailand: multinational corporation (MNC)-dominated, small and medium enterprise (SME)-based and community enterprise (CE)-based industry groups. The study applies the triple helix model of interaction with the aim to show the significance of innovation intermediaries for stimulating technology capability development in the Thai industrial sector.

The remainder of this chapter is organised into six sections. The first section discusses the background of the study and the research questions, which form the basis of the study. The second section presents the research aims and objectives. This is followed by a discussion of the hypotheses of the study in the third section. The fourth section gives a brief overview of how the hypotheses are to be investigated. The fifth section explains the significance of the study. The last section outlines the structure of the thesis.

## 1.1 Background of the study and research questions

A major feature of the contemporary globalisation phenomenon is its impact on the market facing industrial enterprises, making it ever so more competitive, and too complex and rapidly changing to be predictable. The upshot of this is that firms can hardly expect to survive, let alone grow, without being innovative; and this would require them to be widely networked to be able to access resources external to them through partners who would complement their needs (Pananond, 2007). These partners could be other firms in a supply chain framework or at the same level of value chain as in industrial clusters; universities and research and development centres; and government agencies.

Governments in many countries, such as Canada (Madill et al., 2004), Ireland (Crone, 2003), Nicaragua, Mexico and Jamaica (Ceglie and Dini, 1999), have adopted the network approach to economic and industrial development. This trend appears to have been spurred in recent years by the unfolding of different approaches to networking, such as industrial clusters, innovation systems, social capital and triple helix systems that have gained attention among policy makers as viable strategies for industrial and economic development.

Since 2004, the Thai government has adopted the industrial clusters and the national innovation system (NIS) as the cornerstones of its industrial and science and technology (S&T) policies. To implement these policies, several government agencies have been charged to form, develop and strengthen new and existing networks. Consequently, new industrial clusters – firms in the same industry located in close proximity – were established. In the formation of clusters, government departments and specialised institutes have been assigned to work as intermediaries to establish and manage these clusters/networks by attracting firms, local universities and other government agencies to join the networks. Few clusters gradually developed into innovation networks, jointly creating product and process innovation (NSTDA, 2008). The majority of firms, however, do not have any joint activities (NESDB, 2006), and there are weak and fragmented linkages between universities, industry and government (Yokakul and Zawdie, 2010). For all this, there is growing pressure on firms to network and collaborate to cope with the challenges of globalisation and trade liberalisation (Pananond, 2007).

It is, however, one thing to create networks for collaboration, and another thing to make the network effectively functional. Some studies on industrial network development in Thailand agree that intermediaries are essential in the development of clusters/networks in Thailand (Intarakumnerd, 2005; Yokakul and Zawdie, 2010). Although it was accepted that intermediaries are significant for establishing and managing networks, it is not clear as to how – and how effectively – these intermediaries would play their roles as catalysts in facilitating knowledge creation, knowledge exchange and knowledge utilisation. This study attempts to respond to this knowledge gap as to how innovation intermediaries can effectively play their roles in establishing dynamic networks linking actors across the production sector, the knowledge sector and the policy and governance sector of the economy in Thailand.

The triple helix concept was developed in 1995 by Henry Etzkowitz and Loet Leydesdorff as a synergy that derived from a collaborative research effort addressing work on university-industry links and the third mission of universities, on the one hand, and knowledge network development, on the other (Etzkowitz and Leydesdorff, 1995). The concept was underpinned by experience deriving from the historical evolution of knowledge-based economic development in the USA and Europe. It explains use of the broad spectrum of knowledge and, in particular, the development of networks for facilitating the interaction of key institutional actors as well as the generation and circulation of knowledge among the actors, as the bases for innovation and economic development. Knowledge circulation within and between the institutional spheres generates economic value through commercialisation of knowledge and its diffusion across the economic spectrum.

The triple helix concept soon found strong appeal among policy and academic circles in both developed and developing countries, thanks to its association with the experiences of successful regions in the USA and Europe (see, for example, Kaukonen and Nieminen, 1999; Carayannis et al., 2000; Goktepe, 2003; Taylor, 2004; Marques et al., 2006; Saad and Zawdie, 2008). But still, its implementation as a strategy for innovation was found to be impaired by market failure occasioned by dysfunctional knowledge and information networks that effectively constrained interactions between institutional actors. It is against this background that the role of intermediaries has evolved as an interventionist mechanism to promote interaction between academic, industrial and government sectors to create knowledge networks and enable knowledge circulation across institutional spheres by providing the missing links (Dzisah and Etzkowitz, 2008).

According to Johnson (2009), intermediaries are necessary for supporting collaboration of trilateral networks by bridging gaps and mitigating risks. These gaps and risks arise for at least two reasons. First, cultural differences between the three institutional actors are a main obstacle, preventing collaboration and the formation of effective networks. Second, the triple helix institutional actors consider the risk in collaboration knowledge sharing to be a bone of contention in the absence of trust underpinning the network. This would make the collaboration across the network far from robust and the level of research and development (R&D) conducted in the network sub-optimal from the vantage point of society at large. Hence, the need to make up for the systemic deficiency in trust and for the sub-optimal level of knowledge circulation across the network. This can be achieved through the institution of intermediaries. Intermediaries occur in the form of organisations like university incubators, government programmes and industrial associations to bridge the cultural gaps in triple helix relations by actively promoting links between the three institutional actors; and to mitigate risks that militate against innovation opportunities and the maximisation of social benefits that could arise from a well functioning triple helix system.

Howells (2006) narrowly defined an ‘innovation intermediary’ as a broker who creates linkages, mediates collaboration and stimulates innovative activity in the innovation process. Etzkowitz and Zhou (2007) referred to this type of organisations as ‘interface organisation’, engaged in relaying feedback from outside an institutional sphere. Bendis et al. (2008) defined an ‘innovation intermediary’ in the context of regional economic development as “an organisation, situated at the centre of a region’s efforts to align local technologies, assets and resources to work together on innovation” (p. 4). Innovation intermediaries can be either organisations (e.g. research groups, liaison offices, technology transfer offices, incubators, research and technology organisations and government development agencies) or individuals who have the passion for network activities (Karlsson et al., 2010) (e.g. star scientists and firms’ leaders).

Innovation intermediaries are crucial not only for establishing networks, but also for bringing out creative forces that breed learning dynamics in established networks. Several studies have argued that networks with homogeneous actors and knowledge, like inter-firm networks within an industry, might find themselves locked into old technologies and could as a result miss opportunities for innovation and long-term technological progress. On the other hand, it is noted that the introduction to a network system of new institutional actors possessing additional resources and non-redundant knowledge can improve the conditions for network dynamics to come into play (DeBresson and Amesse, 1991; Bell and Albu, 1999; Breschi and Malerba, 2001; Knorringa and van Staveren, 2006; Capaldo, 2007; Giuliani, 2007; Lan and Zhangliu, 2011). In the context of triple helix networks, the intermediary organisations provide the catalyst to set the creative and innovative dynamics in motion and see the three main institutional actors evolve as 'hybrid actors' capable of role substitutability – i.e. one taking the role of others. Thus would emerge the entrepreneurial university, the knowledge-based industry and the supportive government as products of the evolutionary process.

The evolution of triple helix networks is not, however, straightforward, particularly in developing countries where institutional discontinuities and lack of trust prevail among actors across institutional spheres. In such countries, market failure would make it impossible to evolve fully through the transformation of the institutional actors. It can be postulated that the hybrid triple helix culture can be achieved through the provision of an institutional leverage in the form of innovation intermediaries. Studies on the role of innovation intermediaries in accelerating the process of transformation and unleashing network dynamics in developing countries are, however, few and far between. The present study is a response to this challenge.

## 1.2 Research aims and objectives

This study aims to develop a conceptual framework for the evolution of triple helix system and to empirically investigate the roles of intermediaries in the evolutionary process based on firms and industry groups in six manufacturing industries (including hard disk drive (HDD), automotive, ceramic, furniture, local textile and rice cracker industries) in Thailand. The evolution of triple helix network and triple helix innovation system is underpinned by evolutionary and network theories that mainly argue that network dynamics emerging from interaction of heterogeneous actors are essential to sustain networks, thus evolving into system (DeBresson and Amesse, 1991; Bell and Albu, 1999; Breschi and Malerba, 2001; Knorringa and van

Staveren, 2006; Capaldo, 2007; Giuliani, 2007; Lan and Zhangliu, 2011). Triple helix model focusing on interaction of actors can be used to complement other network theories – such as social capital (Burt, 1976, 2000), industrial cluster (Porter, 2000) and innovation systems (Lundvall, 1992; Cooke et al., 1997; Edquist and Hommen, 1999; Malerba, 2002) – to explain the emergence of network dynamics through the concept of organisational learning (Argyris and Schön, 1978; Nonaka and Takeuchi, 1995). The conceptual framework for the analysis of the systemic roles of intermediaries is based on the principal-agent theory (Braun, 1993) and the concept of 'structural holes' that explain the significance of intermediaries in the formation of triple helix network and its transformation into the triple helix innovation system (Burt, 2001).

Empirically, the study is based on the premise that the efficiency of triple helix networks in developing countries, in general, depends largely on the role of governments, the effectiveness of innovation intermediaries and the participation of firms with absorptive capability (Kodama, 2008). However, the need for intermediaries varies across industries, depending on technological capabilities of the triple helix institutional actors (Hobday and Rush, 2007; Intarakumnerd and Schiller, 2009) and the path dependency of their development (Brimble and Urata, 2006).

Based on the research aims, the study aims to achieve the following objectives:

1 To show the evolution of innovation networks, especially triple helix networks;
2 To study innovation intermediaries in the context of the triple helix model;
3 To explore the roles of intermediaries in different industry groups, i.e. MNC-dominated, SME-based and CE-based industries;
4 To compare the effectiveness of intermediaries within and between industry groups in order to investigate factors affecting effectiveness of the formation and management of triple helix networks; and
5 To examine the methods and scopes of intervention to assist the development of triple helix networks.

## 1.3 Hypotheses of the study

The above set of objectives is to be achieved through the conceptual and empirical investigation of a set of propositions (hypotheses) discussed in the following part of this section. These hypotheses are derived from a synthesis of the relevant literature discussed in Chapters 2, 3 and 4.

It can be argued that innovation intermediaries are essential in the formation of networks and in the creation of network dynamics, because they provide resources and access to resources to attract firms to collaborate. Freeman (1991) and Kodama (2008) found that the motivation of firms for participating in the network is to overcome the problem of asymmetric distribution of information that causes high transaction costs limiting the scope for innovation, and to be able to exploit external resources for their technology development. Firms seek external resources through the medium of intermediaries (Cooke and Wills, 1999; Murdoch, 2000; Lyons, 2002) to make up for internal resource limitation and enhance opportunities for engaging in innovative activities (Freel, 2000; Kodama, 2008; Kim et al., 2010; White and Christopoulos, 2011)

It can also be argued that triple helix networks would be firmly established, where innovation intermediaries are effective, bringing into play their technological capability and their experiences of pre-existing networks. In the triple helix model, three institutional spheres overlap, leading to the circulation of knowledge, personnel and products within and among these spheres. The circulation of these elements creates network dynamics in the triple helix framework (Etzkowitz and Dzisah, 2008). In the absence of the triple helix interaction in developing countries, innovation intermediaries are necessary to promote the emergence of institutional networks (Dzisah and Etzkowitz, 2008). Kodama (2008) argued that the efficiency of triple helix networks in developing countries would depend largely on the effectiveness of innovation intermediaries and the absorptive capability of firms in the networks. Yang et al. (2008) argued that innovation intermediaries assist their customers to develop technological capability through spillovers from their core activities and industrial environment. Thus, firms having many linkages with other organisations are likely to have high innovative capability (Carayannis and Wang, 2008).

The efficiency of triple helix networks also depends on pre-existing networks. Triple helix networks evolve from inter-firm networks; and the heterogeneity of the actors and their experiences, resources and competence provide the basis for the emergence of network dynamics in the continued interactions between knowledge creation, knowledge exchange and knowledge use (Pyka, 2002; Menzel and Fornahl, 2007). In the development of new triple helix networks, the social capital of pre-existing networks would influence the strength of new networks (Lee et al., 2005). However, Wiesinger (2007) argued that the strength of pre-existing networks, such as trade associations, does not guarantee success of new networks, particularly when pre-existing networks are constrained by the lock-in effect of path dependency. This means that the intervention of innovation intermediaries is crucial for removing the constraints posed by pre-existing networks (Klerkx and Leeuwis, 2009).

These propositions can be summarised in terms of the following hypotheses.

1. Firms are responsive to triple helix intermediaries in order to exploit access to resources, including technological and financial resources, through increased relational capital.
2. Firms would be engaged in triple helix networks depending on:
   (i) the availability of incentives for participation, including the availability of intermediaries;
   (ii) the effectiveness of intermediaries providing resources and services;
   (iii) the degree of their technological capability development; and
   (iv) their experiences in pre-existing networks.

## 1.4 Research methodology

As noted earlier, this study is an attempt to address the knowledge gap in relation to the question as to how innovation intermediaries can effectively play their roles in establishing dynamic networks by looking into some aspects of the manufacturing sector in Thailand. This sector is recognised to be of strategic significance to the economy, contributing to about 35 per cent of gross domestic product (GDP) (NESDB, 2010).

Broadly, there are three industry groups, which can be identified as major players in the Thai manufacturing sector: MNC-dominated, SME-based and CE-based firms. Six industries in the three industry groups were selected for the purpose of this study, either because of their significance to economy at large, or because of their adoption of the cluster approach as a strategy for growth. For example, in the MNC-dominated industry group, the automotive and HDD industries were selected because they are respectively the largest and the second largest industries in terms of value added creation. In the SME-based industry group, the ceramic and furniture industries were selected for their adoption of the cluster approach. In the CE-based industry group, the local textile and rice cracker industries were selected both for their adoption of the cluster approach and for their significance in terms of their contribution to employment.

Both quantitative and qualitative methods are used to investigate the research questions and test the hypotheses. Data were collected through document reviews, questionnaire administration and interviews. First, documents, such as annual reports, websites and consultant reports, were reviewed to obtain initial information on the six industries. Second, key persons from university, industry, government and innovation intermediaries were identified and interviewed. Third, after interviews, questionnaires were sent to firms in the six selected industries by post and personal delivery. Data from interviews were qualitatively analysed through narrative analysis and case studies. Data from questionnaires were analysed using descriptive and statistical methods. The research methodology is discussed in full in Chapter 6.

## 1.5 Significance of the study

The findings of this study are expected to shed light on: the significance of innovation intermediaries in the development of the triple helix networks; the significance of innovation intermediaries for the formation and operation of dynamic triple helix networks; and policies and strategies that can be adopted to promote innovation and competitiveness in the Thai manufacturing sector.

There are many studies on innovation intermediaries operating in different countries, but there are only a few of the type for Thailand. Most of these studies have focused on a single intermediary organisation in some processes, such as technology transfer and commercialisation. There is knowledge gap about what 'innovation intermediaries' encompass and what roles they play. This study attempts to bridge this knowledge gap by exploring intermediaries operating at various levels across industries. Results of this exercise will inform policy, so that the Thai government will be able to effectively leverage triple helix network development as a strategy for industrial innovation and competitiveness.

## 1.6 Structure of the thesis

This thesis is organised in nine chapters. Following this chapter, Chapter 2 reviews approaches to innovation and economic growth and development. Chapter 3 discusses the classification of innovation networks into three forms: vertical value chain network; horizontal industrial network; and triple helix network. Chapter 4 categorises the roles of innovation intermediaries operating at three levels: sponsoring intermediaries operating at policy level by providing policy and resources; brokering intermediaries operating at strategic level by creating mechanisms for collaboration and allocating resources of sponsors; and boundary-spanning intermediaries functioning at operational level by facilitating learning and knowledge acquisition, and knowledge creation and circulation through the provision of operation services.

Chapter 5 reviews the state of economic, industrial and technology development in Thailand and the policies and plans thereof. In Chapter 6, the research methodology for data collection and data analysis is presented. Chapter 7 presents analysis of data obtained from documents, interviews and a questionnaire-based survey. The data are used to test the hypotheses of the study as discussed in Chapter 6. Chapter 8 uses the case study method for the analysis of the roles of intermediaries in the transformation of pre-existing networks into triple helix networks. Three case studies are used to test the hypotheses that the engagement of firms in triple helix relationships depends on (a) the availability of intermediaries; and (b) their experiences in pre-existing networks. Chapter 9 summarises the findings of the study and draws conclusions, highlighting the policy of the findings and suggestions for future research.

# CHAPTER 2

# Economic Development through Innovation and Knowledge Exchange

According to Joseph Schumpeter (1934), innovation and technological progress are central to long run economic development. But the question has remained as to how innovation and technological progress can be brought about. This chapter is an attempt to respond to this long-running question by focusing on concepts like social capital, industrial cluster, innovation systems and triple helix model, variously developed as approaches to network development and innovation. The aim of this chapter is to provide the basis and conceptual building blocks for the development of an integrated framework of the evolution of industrial clusters into triple helix networks and triple helix innovation system, discussed in Chapter 3.

In the knowledge-based economies, growth derives largely from technological change stemming from the generation and effective use of knowledge. In contemporary literature, technological change is considered as endogenous rather than exogenous as presumed in the neo-classical model. The neo-classical model explains economic growth in terms of increases in the quantum of material resources and labour resource or factor inputs in the production of goods and services. The role of knowledge or technology is treated in this model as a residual. But there is more to the role of technological progress in economic growth than what is simply accounted by the 'residual' factor in the neo-classical analysis of production functions. Technological progress produces growth by expanding the capacity of a given stock of resources available to an economy or by increasing the effective size of the economy's resource endowment. Thus, technological progress has the effect of removing or relaxing the resource constraint on production capacity and hence on growth, as would be expected to be the case in developed economies that are for the most part knowledge driven (Nelson and Winter, 1974).

In developing countries, on the other hand, technological progress is rare in its occurrence, which means that economic growth has hitherto been largely a 'factor-driven' phenomenon. However, there is no reason to believe that 'knowledge-driven' growth is the preserve of developed countries, as there is evidence to show that a growing number of countries even in the developing world – Thailand, among others – are observed taking on board science, technology and innovation policy as the basis for sustainable development in a rapidly changing global environment. The case for technological progress as the principal basis for economic development has, therefore, a global appeal.

Technological change arises from a systemic innovation process, which basically involves the creation, diffusion and utilisation of new products and processes (Lundvall, 1992, p. 25). As a system phenomenon, innovation also involves a complex set of network activities (Klerkx and Leeuwis, 2009); and so, several systemic and network approaches have been developed to date to analyse economic development (Etzkowitz and Leydesdorff, 1995).

The benefits firms derive from networking are variously conceptualised in the literature. In neo-classical economics, where firms, capabilities and inputs including technology are assumed to be homogeneous, networking does not arise as a problem, knowledge circulation is unrestricted and there is virtually no scope for transaction costs and for the prevalence of opportunistic behaviour in the market. Moreover, the homogeneity of firms and their capabilities makes innovation a *deus ex machina* originating from outside the economic system, thus making the need for regulating technological progress through science and technology policy redundant. In evolutionary economics, such assumptions are relaxed, and the heterogeneity of firms, capabilities and inputs is considered as a necessary condition for the creation of network dynamics, involving cross-fertilisation of knowledge culminating in innovation (Pyka, 2002).

In this chapter, network and systemic theories and concepts related to economic development and innovation are reviewed mainly from the vantage point of developing countries, where most firms are technology followers, chiefly engaged in 'innovative imitation' as a strategy for catching-up. Networking in these countries has largely been geared to promoting vertical linkages with global suppliers and buyers to tap into important sources of knowledge, rather than horizontal linkages aimed at the creation of local knowledge centres. However, networking of local firms is still required to close the capability gaps between the expectation of global buyers and what the existing capability of local firms can deliver (Knorringa and van Staveren, 2006).

The remainder of this chapter reviews network approaches to innovation and development with respect to social capital, industrial cluster and innovation systems, including the triple helix model.

## 2.1 Social capital and economic development

The concept of social capital is essentially inextricable from the knowledge and information network underlying the process of socio-economic development. Social capital can be used to explain the cooperative behaviour of actors at three levels: at micro level, involving inter-firm relationships; at meso level, involving networking across sectors, industries and geographical clusters; and at macro or national level (Woolcock, 1998). Thus, the concept relates to network theories, such as industrial clusters, business associations, value chain analysis and regional innovation systems (Knorringa and van Staveren, 2005; 2006). The concept has also been used in several fields of study, such as industrial development, rural development, democracy and public administration (Woolcock, 1998).

### 2.1.1 Definition of social capital: asset vs. process

In the literature, social capital has been considered as either asset or process. As a stock of asset, social capital represents the surplus value generated from investment in the development of a system of social network. Individuals engaging in networking gain benefits from interaction, and groups developing and maintaining social capital as a collective asset improve their members' benefits (Lin, 1999). Burt (2000) defined social capital as asset deriving from the inter-connection of people or groups exchanging knowledge and information on the basis of trust. Considered as a kind of asset, social capital is integrated as a variable into the production function of firms, networks and nations (Knorringa and van Staveren, 2006). It is, however, argued that even as an asset, social capital is too complex a concept to be reduced to a single quantifiable variable. For example, Landry et al (2002) measured social capital in terms of four types of assets: network assets (i.e. business, information and research networks); participation assets (i.e. degree of acquaintance); relational assets (i.e. frequency of participation); and trust assets (i.e. importance of trust). The first three forms of asset reflect structural social capital; and the fourth one, cognitive social capital. Krause et al. (2007) also explain that social capital can be accumulated as cognitive capital, measured in terms of shared values and goals of cooperation; structural capital, measured in terms of relational ties – whether direct or indirect; and relational capital, measured in terms of the strength of ties – whether strong or weak. Social capital as a type of asset is thus measured as a stock concept.

In contrast, Anderson and Jack (2002) viewed social capital as a social process that creates relationships and facilitates interaction within the relationships. In this context, game theory is applied to explain why social capital leads to reduction of risk and transaction costs. As process, the function of social capital is categorised into two: bonding and bridging. Bonding involves strong networks (where the actors have common identity); and bridging involves loose networks (where the actors are diverse) (Knorringa and van Staveren, 2006). In either case, social capital functions as a lubricant facilitating interaction between diverse and distinct types of actors possessing non-redundant resources and knowledge (Anderson and Jack, 2002).

Social capital is the factor underlying the network of relationships involving diverse players in a system. As such, its key defining elements are trust, cooperation, networking and norms (Knorringa and van Staveren, 2005). Francois (2002) expressed the importance of trust and trustworthiness created from social ties in ethnic groups and expanded it into trading relationships, such as supply chain networks and industrial clusters. Knorringa and van Staveren (2006) referred to this process of change in relationships as the transformation of bonding social capital into bridging social capital with the common identity underlying ethnic groups being ratcheted up to common goals and shared values in horizontal or vertical networks involving heterogeneous actors. This means that for the strength of social capital to be fully realised, bonding social capital would need to be developed into bridging social capital, thereby broadening and deepening the network system.

### 2.1.2 Economic benefits and costs of social capital

In the economic literature, social capital, expressed in the form of trust, is known to yield three main economic benefits: reduction of transaction costs, reinforcement of collective action, and learning from spillovers. Trust, which is an outcome of social capital, reduces the opportunistic behaviour of firms, thus saving time and money that would be incurred due to the constant replacement of contracts and engagement in monitoring the activities of competitors. Trust also reduces the risk of engaging in cooperative enterprises and eventually creates collective actions thus minimising, if not eliminating, the scope for free-riding. Such cooperation generates economies of scale and enhances the negotiating or bargaining power of groups, thus increasing access to new markets, capital and technology. Working in groups or networks, members can learn from each other through the process of knowledge and information exchange made possible by the existence of a network system based on trust. This stimulates learning from knowledge spillovers and reduction in transaction costs (Knorringa and van Staveren, 2006).

Specifically, social capital is sought for its contribution to the enhancement of the competitive advantage of firms through innovation. Firms can take advantage of collaboration with other firms in technology development as they can engage in division of labour, thus reducing lead times and costs of technology development. In addition, technological cooperation based on trust can reduce transaction costs, including search and information costs, bargaining and decision costs and policing and enforcement costs, as a result of mitigation of the opportunistic behaviour of firms. Thus, networks with high level of trust are likely to be more innovative than those with low level of trust (Landry et al., 2002).

Social capital can create not only positive impacts but also negative impacts or economic costs that arise due to power asymmetries and social exclusion (Knorringa and van Staveren, 2006). Where power asymmetries and social inequalities prevail, resources would not be evenly distributed across networks. This has the effect of adding more to the costs than to the benefits of social capital (Woolcock, 1998). Murdoch (2000) found that the concentration of power in the hands of elites may weaken the position other social categories in networks, particularly in terms of influencing decisions regarding resource allocation. Underprivileged members with low credibility might not be able to access resources of their networks. In the presence of power asymmetries, social relations are established by power, not trust; so chances for sharing are hardly apparent. The negative effects of social capital are also apparent when networks are dense and closed, in which case, social capital benefits small groups, but generates costs for whole economy. For example, the social capital associated cooperation in mafias and cartels excludes the majority of people from sharing the accruing benefits (Knorringa and van Staveren, 2006). Another negative impact of strong social capital is that some members may have too much obligation for the networks, thus preventing them from participation in other broader networks (Woolcock, 1998).

Although social capital might not directly lead to economic development, it is, nonetheless, a prerequisite for economic development. Strong social capital in pre-existing networks influences the successful establishment of new development networks (Lee et al., 2005). However, some empirical studies show that the high level of social capital in poor communities does not guarantee economic improvement (Wiesinger, 2007). This is because the network associated with it is not broad and deep enough for incorporating diverse players. Walker et al (1997) have argued that social capital influences how networks evolve. Building closed network, related to strong networking between homogeneous actors in the same ethnic groups, involve aspects of social capital, such as direct and indirect ties (Ahuja, 2000), structural capital (Krause et al., 2007), strong ties (Capaldo, 2007), bonding social capital (Knorringa and van Staveren, 2005; 2006), vertical business network (Giuliani, 2007) and horizontal trade association.

### 2.1.3 Relational capital: bonding social capital vs. bridging social capital

As observed in much of the literature, a major weakness of strong ties is that firms can find themselves locked in narrow circles thus depriving themselves of the opportunities of access to new and diverse sources of knowledge (Capaldo, 2007). For example, Knorringa and van Staveren (2006) point out the weakness of ‘bonding social capital’ as barriers to change, preventing firms from learning from outside sources of knowledge as they lock into the existing less efficient technologies.

DeBresson and Amesse (1991) argue that weak ties are more dynamic than strong ties. Giuliani (2007) considered knowledge networks as weak ties. The main benefit of weak ties is knowledge spillovers. In theory, networks should contain both strong and weak ties. Harryson et al. (2008) showed that firms can use open networks with weak ties for seeking creativity in the exploration process and closed networks with strong ties in the exploitation process. Capaldo (2007) called networks with both weak and strong ties as dual networks.

Weak ties can be created by bridging ‘structural holes’ in open networks. Networks with disconnected actors are considered as ‘open networks’ with ‘structural holes’. ‘Structural holes’ are gaps in the information flow between actors representing different sources of information. ‘Structural holes’ thus involve disconnected actors having neither direct nor indirect link with actors in the network, partly because of the lack of trust and shared norms. These disconnected actors may exercise opportunistic behaviour of accessing and exploiting knowledge created in the network. On the other hand, they can be additional sources of distinct information greatly benefiting the network. In the former case of disconnected actors, the network becomes functional through the establishment of trust and norms that would strengthen ties and eliminate opportunistic behaviour. In the latter case, disconnected actors are not necessarily built into the network system as they would be useful if left as additional sources of knowledge. Actors in networks can benefit from ‘structural holes’ by forging weak ties with disconnected firms. Burt (2000) shows that firms or individuals who have connection with structural holes are more successful in many areas, such as sales, innovation performance and survival of firms. Forging links with disconnected actors is regarded as bridging ‘structural holes’ in order to obtain a wide range of knowledge. Bridging ‘structural holes’ often occurs in the form of business alliances, joint ventures and venture capital. However, learning from bridging ‘structural holes’ depends on the absorptive capacity of actors in the network.

In the long run, the evolving network closes all gaps thereby achieving an “equilibrium” position (Burt, 2000). And all actors in the network would benefit from network closure. ‘Structural holes’ are not, therefore, sustainable since those who benefit from their existence are not the disconnected firms but the brokers. It is therefore in the interest of the disconnected firms to bridge the holes. However, if social structure cannot change easily because of differences in institutional culture and absorptive capacity, brokers would still be needed to facilitate communication and co-operation.

In the context of developing countries, policy intervention is necessary in the formation of social capital and the development of network dynamics to promote the bonding process in a network system. This is particularly important for small and medium enterprises (SMEs), as this would enable them to benefit from the commercial critical mass deriving from evolving clusters. However, in some areas, actors may be scattered and may have too many differences. This would limit the formation of social capital and network development. In addition, in developing countries, policies aimed at promoting the development of social capital are far from effective (Woolcock, 1998). Intervention is nonetheless required to initially build adequate bonding social capital. This is of critical significance as the bridging process is invariably more difficult than the bonding process due to the high risk and harsh market environment associated with it. However, it is acknowledged that the bridging process is capable of creating the externalities and the dynamics required for the generation of sustainable economic benefits as shown in Figure 2.1 (Knorringa and van Staveren, 2006). Bonding social capital gives way to bridging social capital as policy intervention promotes learning within homogeneous networks as well as tapping into diverse sources of knowledge in heterogeneous networks and firms across 'structural holes'. This process would reduce the scope for 'lock- in' possibilities while at the same time broadening the choice environment for considering innovation trajectories (Knorringa and van Staveren, 2005).

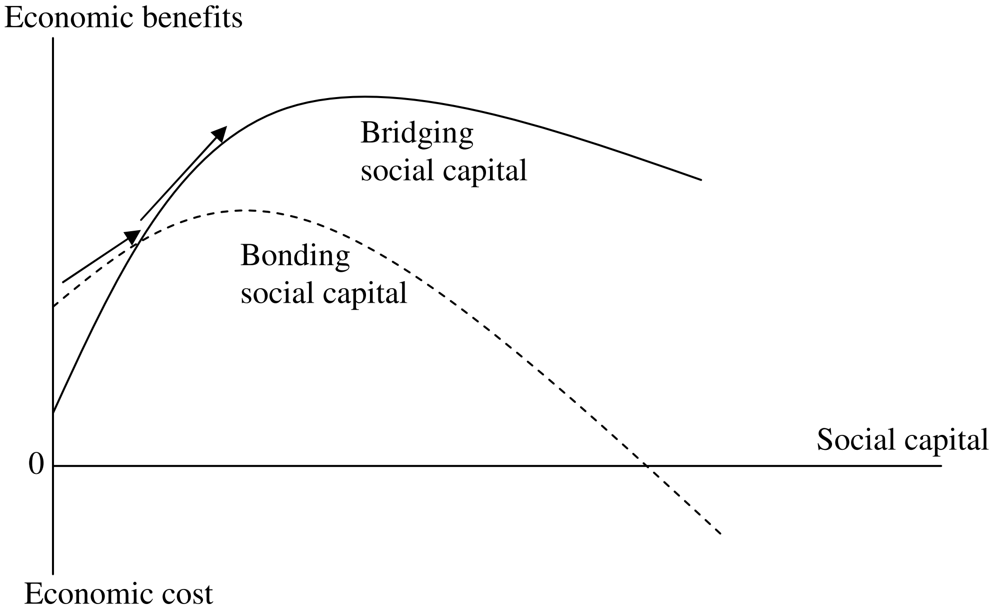



Figure 2.1 Relationship between variants of social capital and economic benefits

Source: Knorringa and van Staveren (2006, p. 23)

Note: Bonding social capital is networking or coordination of categories within the same ethnic or culture groups.
Bridging social capital is networking or coordination of categories between different ethnic or culther groups.

## 2.2 Industrial cluster

The concept of industrial clusters is not new. In fact, the notion of cluster has long been studied in economic geography in terms of industrial districts and localisation. And there has been a growing body of knowledge about industrial clusters particularly since the 1990s (Gordon and McCann, 2000). However, this growth in research interest has not been matched by growth in policy interest (Martin and Sunley, 2003; Tallman et al., 2004). In the late 1990s, Micheal Porter, a Harvard business economist, translated the concept of industrial cluster into business strategy and policy model for economic development in terms of productivity and competitiveness. Porter's concept of industrial cluster, which is associated with competitive advantage, caught the attention of policy makers around the world (Martin and Sunley, 2003), with the result that industrial cluster policy is now in use in several developed and developing countries, such as Japan (Nishimura and Okamuro, 2011), central American countries (Ceglie and Dini, 1999) and China (Guo and Guo, 2011).

Although Porter's concept has been widely adopted, his work neglects aspects of economic geography underlying the concept of cluster. In Porter's work, competitive advantage occurs due to the interaction of elements in the 'competitive diamond' – i.e. firm strategy and rivalry, factor input conditions, demand conditions, local context and related and supporting industries. Porter's work may be useful but is not comprehensive as a basis for policy. In fact, other theoretical models, such as social networks, collective learning (Martin and Sunley, 2003), industrial districts and innovative milieus (Bathelt et al., 2004), have been proposed to explain the cluster concept. More recent studies on industrial cluster (for example, Bathelt et al., 2004; Madill et al., 2004; Tallman et al., 2004; Giuliani, 2007) have sought to look at industrial clusters from the vantage point of knowledge network and innovation by integrating issues relating to economic geography and strategic management.

### 2.2.1 Definition of industrial cluster: shallow vs. deep

The definition of industrial cluster ranges from agglomeration to cooperation. Altenburg and Meyer-Stamer (1999) defined industrial clusters as agglomeration of firms in specific areas in which specialisation and trading are considerable. Based on this definition, Schmitz and Nadvi (1999) point out mobilisation and effective utilisation of local unused resources to be the key success factors behind industrial clusters. Other authors have incorporated cooperation and interconnection of local firms in their definitions. For example, Porter (2000) defined clusters as "geographic concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions (e.g. universities, standard agencies, trade associations) in a particular field that compete but also cooperate" (p. 15). These players are linked vertically and horizontally through commonalities and complementarities. Ceglie and Dini (1999) defined cluster as "a sectoral and geographical concentration of enterprises, which gives rise to external economies and favours the rise of specialised services in technical, administrative and financial matters. Such specialised services create a conducive ground for the development of a network of public and private local institutions which support local economic development promoting collective learning and innovation through implicit and explicit coordination" (p. 4).

A lack of clear definition of industrial cluster leads to diverse interpretation, measurement and empirical results. It was argued that Porter's definition is vague due to lack of clear industrial and geographical boundaries. However, this weakness makes the concept of industrial cluster amenable to be broadly applied to several boundary contexts, such as a group neighbouring countries, a country, a region, a city and a district. Gordon and McCann (2000) classified industrial clusters into three types according to the intensity of cooperation: pure agglomeration, industrial-complex, and social network. In line with Gordon and McCann, Swann (2009) classified clusters with respect to depth of cooperation from 'shallow co-location' to 'deep informal knowledge network'. In this regard, Martin and Sunley (2003) asserted that the varieties of clusters lead to problems in measurement and empirical studies, as can be seen Table 2.1.

Table 2.1 Varieties of cluster and the cluster measurement problem

| **Cluster concept** | **Conceptual/ definitional depth** | **Empirical methodology** | **Ease of measurement** | **Empirical support** |
|---|---|---|---|---|
| Co-location | Shallow | Top-down | Easy to measure (quantitative) | Indirect evidence |
| Co-location and technological proximity | | | | |
| Input-output table and complementarities | | | | |
| Co-location and superior performance | | | | |
| Mashallian externalities | | | | |
| Network firms | | | | |
| Explicit collaboration | | | | |
| Informal knowledge spillovers | Deep | Bottom-up | Hard to measure (qualitative) | Direct evidence |

Source: Martin and Sunley (2003, p. 20)

### 2.2.2 Economic benefits and costs of industrial cluster

According to the classification of industrial clusters by Gordon and McCann (2000), the pure agglomeration and industrial-complex models are underpinned by the neo-classical theory of economics, while the social network model is steeped in neo-institutional economics. Advantages of the pure agglomeration model can be explained through division of labour, pool of specialised labour, and provision of specialised inputs and infrastructure and the external economies generated thereof, including higher productivity of labour and inputs and reduction in job search costs due to geographical proximity. The benefits deriving from the pure agglomeration model are known as economies of agglomeration (Gordon and McCann, 2000).

In the industrial complex model, relationships between firms are in the form of vertical trading linkages. The benefits of this model derive from reduction in transaction costs, including transportation, communication and logistics costs. However, this model may lead to monopoly, and this may discourage individual firms from choosing to find themselves a location in clusters (Gordon and McCann, 2000). Firms falling into this model are closed networks like, for example, firms in oil refining, chemical, pharmaceutical and Japanese automotive industries (Gordon and McCann, 2000).

The social network model is related to the institutionalisation of organisations to overcome consequences due to the opportunistic behaviour of firms and transaction costs. In this model, trust is essential, replacing contracts and reducing the need for monitoring and the transaction costs thereof. Due to the presence of trust, firms in social networks are willing to take risks in cooperation without the fear of being exposed to the opportunistic behaviour of potential competitors. Networks in this model operate in the form of economic (business) clubs. The establishment of economic clubs can happen even without agglomeration economies because the social network model can internalise external benefits and transform these benefits into network values (Gordon and McCann, 2000).

Globalisation and liberalisation have the effect of raising the significance of industrial clusters. According to Porter (2000), the macroeconomic benefits of industrial clusters include increases in exports and foreign direct investments. Industrial clusters also serve as forums for mutual agendas. Clusters generate economic benefits through competitiveness, productivity growth and innovation. Without globalisation, cluster benefits arise from productivity growth due to economies of agglomeration in which proximity drives down transportation and communication costs. However, globalisation makes such benefits insignificant.

Under globalisation, clusters can still generate benefits in terms of productivity growth because of access to specialised inputs and human resources; access to information due to the occurrence of trust; complementarities in production, marketing activities among firms in clusters; and access to institutional and public goods (Porter, 2000). Under a regime of liberalisation of trade and globalisation, clusters make regional economies more significant through ‘localisation of the world economy’ (Martin and Sunley, 2003). According to Porter (2000), competitive advantage and the benefits thereof reside in clusters, not in individual firms, so that the strength of clusters is directly reflected on the strength of firms (Porter, 2000).

Bathelt et al. (2004) note that other aspects of the competitive advantage of firms neglected in Porter’s analysis can be explained through learning and innovation processes. In a knowledge-based economy, concentration and geographical proximity enable firms in a cluster to interact and exchange tacit knowledge, thus increasing the opportunity for knowledge creation and innovation. This knowledge accumulation process within clusters, considered as ‘localised learning’, increases the competitive advantage of firms (Lan and Zhangliu, 2011). In addition, pooling complementary resources to solve the common problems of firms within clusters leads to economies of specialisation and possibilities for radical innovation (Bathelt et al., 2004).

Clusters generate not only benefits but also costs that cascade down to both cluster and non-cluster firms. For example, cluster-based firms with high innovation may face the risk of technological imitation from within and outside the cluster. Areas with high productivity and growth clusters may suffer from inflation of labour and housing costs. Eventually, firms and labour with low productivity and growth may be forced to move out. In addition, areas with high profitability clusters may widen existing income gaps, leading to uneven economic development (Martin and Sunley, 2003).

### 2.2.3 Industrial cluster as medium of knowledge exchange

Recent discussions about industrial clusters, especially in the context of developing countries, have sought to bank on the social capital concept as a basis for knowledge exchange and the functionality of cluster or network dynamics (Bell and Albu, 1999; Breschi and Malerba, 2001; Bathelt et al., 2004; Eisingerich et al., 2010; Guo and Guo, 2011; Lan and Zhangliu, 2011). For example, Lan and Zhangliu (2011) have argued that clusters depending too much on proximity and being inward looking may face a lock-in situation, thus losing the potential for competitiveness and innovativeness. Bathelt et al. (2004) point out that successful clusters depend not only on local linkages within clusters, but also innovation and social networks across clusters. Other firms residing outside clusters can be pipelines of new global knowledge. As new knowledge is injected into clusters and spreads to other cluster firms, cluster or network dynamics are likely to occur because firms have now access to more appropriate technological and organisational options to deal with changes in the business environment. For instance, firms in the Boston biotechnology cluster connect with leading biotechnology firms around the world (Owen-Smith and Powell, 2004).

Interestingly, the concept of knowledge network has been applied to the industrial cluster concept to explain cluster or network dynamics. For example, Bell and Albu (1999) explained cluster dynamics in terms of knowledge systems embedded in the production system of clusters. A knowledge system consists of knowledge stock and knowledge flow or knowledge circulation. Circulation of knowledge between firms within clusters does not increase the knowledge stock of clusters, but shortfalls in knowledge stock would deprive firms within the cluster of the cluster or network dynamics for long-term growth. To increase knowledge stock, knowledge inflow from 'external links' through global buyers or research institutes is crucial. This would propel clusters into more complex and cutting-edge technology spheres. Lan and Zhangliu (2011) considered these 'external links' as medium for 'globalised learning' aimed to upgrade the dynamic capability of clusters. Clusters that have forged links with external actors possessing complementary resources and capabilities are considered as open networks. In open clusters, firms can absorb new market and technology trends from external links, thus reducing the risk of being locked into obsolete technologies (Eisingerich et al., 2010).

Clusters can promote knowledge exchange through the creation of what Tallman et al. (2004) refer to as component and architectural knowledge. Component knowledge is transferable through market and non-market mechanisms. It can occur either as stock or as flow. This form of knowledge can circulate between firms within clusters with similar stocks of knowledge and absorptive capacity. In contrast, architectural knowledge is related to whole structures and systems of organisations. It is private, complex, tacit, firm-specific and path-dependent. This form of knowledge cannot be transferred and separated from organisations, so it is used to identify and distinguish a firm from other firms in an industry. Due to the embeddedness and identity of architectural knowledge, Tallman et al. (2004) noted that clusters can create cluster-specific stock of architectural knowledge to distinguish cluster firms and non-cluster firms and enable cluster firms to absorb and make use of both component and cluster-specific architectural knowledge. This cluster-level architectural knowledge is said to be capable of dissemination through the interaction of clusters, thus creating identity of clusters and accelerating the absorption of component knowledge. Thus the processes of knowledge creation and exchange generate competitive advantage to clusters in the first place, and eventually to firms in clusters.

In the context of developing countries, intervention is necessary to create cluster or network dynamics (Bell and Albu, 1999). Tapping into global knowledge or establishing external networks is not a free and automatic process. It needs investment and resources in communication and interaction, which is costly. Moreover, firms have to understand differences in systems and regimes to be able to communicate. They also need to grow their absorptive capacities to be able to assimilate and integrate external knowledge. Intermediaries acting as knowledge spanners can help improve firms' absorptive capacity (Bathelt et al., 2004). In addition, intermediaries acting as gatekeepers are necessary to facilitate the screening and absorption of diverse external knowledge, and then to diffuse this knowledge across cluster firms, thus creating cluster or network dynamics. But knowledge about how gatekeepers would behave under varying circumstances is to date few and far between (Bell and Albu, 1999; Bathelt et al., 2004).

Guo and Guo (2011) have explored the knowledge transmission process within knowledge systems of clusters in developing countries in which they show leading firms playing the role of gatekeepers. Leading firms are large firms in clusters with high absorptive capacity. Knowledge acquired by leading firms is diffused to cluster members through interpersonal contacts and codified manuals. However, in their study, there is no significant empirical evidence to show the existence of formal knowledge transfer across clusters. Indirect knowledge spillovers occurring through common suppliers are the only way knowledge can be diffused across communities within and between clusters.

## 2.3 Innovation systems

'Systems of Innovation' (SI) involve a non-linear approach to innovation with feedback loops and emphasis on institutions and learning processes. Conceptually, SI evolved from various systemic models and theories, such as the chain-linked model, the distributed process model, interactive learning theory and network analysis (Edquist and Hommen, 1999). Unlike the concept of industrial cluster, the concept of innovation systems is broader in scope with geographical, sectoral and institutional boundaries as units of analysis. But the two can be complementarily used simultaneously to constitute a strategy for innovation and industrial development at regional or national levels. OECD (1997) used the industrial cluster approach as a framework to analyse national innovation systems (NISs). Industrial clusters can be considered as sectoral innovation systems (SISs). However, the industrial cluster concept focuses on geographical concentration in production, whereas the SIS concept focuses on S&T activities and the role of institutions in the innovation process (Hosein Rezazadeh Mehrizi and Pakneiat, 2008). NIS consists of sub-systems, including regional innovation systems (RISs) and SISs. However, Chung (2002) argued that NIS can evolve better through the effective promotion of RISs insofar as SISs can also be created in different RISs. For Chung (2002), regions are more significant and dynamic in the globalisation era as national boundaries are becoming less and less significant.

The concept of innovation systems has been widely adopted in science and technology policy making (Balzat and Hanusch, 2004). Although the concept of innovation systems has been developed largely in the context of developed countries with well-developed institutional and infrastructure systems, it can be duly applied usefully to fit into the context of developing countries as a framework for capacity building. However, in view of shortfalls in institutional, social and economic networks, it is not surprising that the state of NIS in developing countries is weak and fragmented. Weakness of the NIS is not, however, an argument against the recognition of its significance as a framework for the development of knowledge economy. For example, Chung (2002) in the case of Korea and Intarakumnerd et al. (2002) in the case of Thailand, have shown in their respective studies that S&T policies in such countries can be geared to foster the development of strong NISs.

### 2.3.1 National innovation system

National Innovation System (NIS) has evolved as a concept in the innovation literature since the late 1980s based on the works of Freeman (1987), Lundvall (1992) and Nelson and Rosenberg (1993), among others. The definition of NIS ranges from the narrow to the broad according to the scope of activities and the actors directly or indirectly related to these (Lundvall, 1992; Chung, 2002; Johnson et al., 2003). The narrow definition includes only organisations and institutions that are directly related to science-based R&D and innovation. For example, Chung (2002) defines NIS as "a complex of innovation actors and institutions that are directly related to the generation, diffusion and appropriation of technological innovation and also the interrelationship between innovation actors" (p. 486). In the narrow definition focusing on the act of searching and exploring processes, the main actors are government research institutes, universities, industry and government agencies as is the case with the three main institutional actors in the triple helix model (Chung, 2002; Johnson et al., 2003). The broad definition includes all related actors in the innovation process. For example, in Lundvall (1992) "a system of innovation is constituted by elements and relationships which interact in the production, diffusion and use of new and economically useful knowledge and … elements and relationships, either located within or rooted inside the borders of a nation state" (p. 2). Social, marketing and financial sub-systems are included (Lundvall, 1992). It is argued that the narrow definition is suitable for big developed countries, like the USA, and the broader definition, for either small or developing countries. This is because the economies of small and developing countries do not depend solely or at all on high technology sectors due to the low level of R&D activities and the lack of well-developed institutions (Johnson et al., 2003).

In interpreting the concept of NIS in a practical way, networking and interaction of key actors would feature prominently. For example, OECD (1997) focuses on four types of interactions in the NIS: joint activities among industry; interaction between the public sector, including public research institutes and universities, and the private sector; technology diffusion as a flow of new and useful knowledge from producers to users; and personnel mobility as a mechanism for the transfer of tacit knowledge. Kumaresan and Miyazaki (1999) attempted to apply network analysis, which constitutes the so-called Techno-Economic Network model, to the study of activities and actors in the NIS by focusing on three principal dimensions: science, technology and market.

It was argued that although the concept of NIS has evolved over for a period of more than two decades, it still remains fuzzy lacking in a robust theoretical underpinning (Johnson et al., 2003; Balzat and Hanusch, 2004; Chang and Chen, 2004). NIS is therefore variously applied across a wide range of countries with different institutional settings and path dependencies.

Unlike the case with the concepts of social capital and industrial cluster, the link between the NIS concept and economic growth has not been fully developed yet (Balzat and Hanusch, 2004). However, Johnson et al (2003) have suggested that emphasis on capabilities, knowledge and institutions, especially learning capability and tacit traditional knowledge in developing countries, should help set in perspective the link between NIS and economic growth. Fagerberg and Srholec (2008) used macro-level data from 115 countries to see if there is any evidence of association between economic development and NIS. They found that the level of NIS is associated with economic development expressed in terms of GDP per capita. To measure level of NIS, capabilities, including social and technological capabilities, were calculated through the application of factor analysis. Social capability includes: managerial and technical competence; stability and effectiveness of governments;

effectiveness in the operation of financial institutions and markets; and the extent to which transparency and trust underpin prevailing business culture. Technological capability includes production, investment and innovation capabilities. The basic argument is that economic development derives from interactions between these social and technological capabilities through the catching-up process. However, analyses at the micro (firm) level that would help shed more light on the theory and evidence of link between NIS and economic development are few and far between (Knorringa and van Staveren, 2006).

The concept of NIS may lose its significance in the face of globalisation and the advent of the post-industrial technological and information age as these have the effect of blurring the significance of geographical boundaries (Braczyk et al., 1998; Chung, 2002). Where geographical boundaries lose significance, other forms of innovation system would be more useful. For instance, RIS, which localises economic and innovation activities (Doloreux and Parto, 2005), and the triple helix system defined in terms of ‘choice environments’ (Leydesdorff and Zawdie, 2010) may in the circumstances have more appeal than NIS.

### 2.3.2 Regional innovation system

The concept of regional innovation system (RIS) was developed by Philip Cooke (Cooke et al., 1997) through the integration of theories of evolutionary economics and regional science with emphasis on ‘economies of association’ and ‘institutional learning’. RIS has evolved as a concept since with contributions from various sources. Braczyk et al. (1998) considered RIS as a “collective order based on a micro-constitutional regulation conditioned by trust, reliability, exchange and cooperative interaction” (p. 25). Cooperation between firms with trust leads to ‘economies of association’. Interaction of firms in the innovation process stimulates firms to accumulate knowledge through learning by doing (Braczyk et al., 1998). Chang and Chen (2004) assert that the concept of RIS focuses on ‘untraded interdependence’ between firms in the horizontal dimension in which tacit knowledge exchange is the object of cooperation.

Table 2.2 Clarification of a hierarchy of four region-related concepts

| Concepts | Definitions and differences |
|---|---|
| Regional cluster | A concentration of interdependent firms within the same of adjacent industrial sectors in a small geographic area |
| Regional innovation network | Increasingly organised co-operation (agreements) between firms, stimulated by trust, norms and conventions |
| Regional innovation system | Co-operation between firms and different organisations for knowledge development and diffusion |
| Learning regions | Increasingly organised co-operation with a broader set of civil organisations and public authorities that are embedded in social and regional structure |

Source: Isaksen (2001, p. 104)

Doloreux and Parto (2005) point out the difficulties in understanding and interpreting RIS as a concept and particularly as to what uniquely constitutes RIS. As seen in Table 2.2, Isaksen (2001) clarified four hierarchically related concepts (i.e. regional cluster; regional innovation network; regional innovation system; and learning regions) to avoid confusion about RIS. Regional cluster is considered to be a prerequisite for the creation of RIS. Also, to develop RIS, it is considered essential that an innovation network is set in place in a regional cluster. RIS occurs when interactions happen between firms and knowledge-related actors in the processes of knowledge production and diffusion. Thus, RIS can be considered as a strategic policy framework for identifying bottlenecks and missing links in the transformation of regional clusters into regional innovation systems. For Knorringa and van Staveren (2006), activities in RIS involve interactions and intermediations between firms and research and technology centres. Thus, in the RIS context, gaps between the demands and inventories of local knowledge are identified through brokering activities. These gaps can be filled through networking and the forging of partnerships between firms and knowledge producers.

As in the case of industrial clusters, scales of regions are not specific. Originally, regions were considered "in terms of shared normative interests (culture areas), economic specificity (mono-industrial economies) and administrative homogeneity (governance areas)" (Braczyk et al., 1998, p. 16). Doloreux and Parto (2005), however, asserted that different units of analysis can be used in RIS studies, such as districts, cities, metropolitan areas and provinces. The non-specificity of size would make RIS attractive to local governments as a useful and flexible approach to regional development.

Like in the case of other network approaches, RIS dynamics, which is the basis for the development of competitive advantage, can be generated by tapping into other innovation systems. Searching external knowledge would globally expand RIS boundaries (Doloreux and Parto, 2005). Moreover, assimilating new technologies and creating new sectors within regions can save regions from the potential risk of lock-in situations. Based on this, Isaken (2001) argues that policy should, therefore, support infrastructure development to generate externalities that would stimulate the emergence of new firms.

### 2.3.3 Sectoral innovation system

Sectoral innovation (and production) system (SIS) was developed by Malerba (2002) as "a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products" (p. 248). The concept of SIS stands as a synthesis of evolutionary theory, focusing on learning and knowledge and the innovation system, focusing on relationships and networking. Boundaries of SISs are limited to specific products of their related industries and services. The SIS focuses more on vertical linkages between heterogeneous firms with complementarities and other types of organisations (Malerba, 2002).

The emphasis in SIS is often on the dynamics of technology development as this has direct bearing on the market position of industry through competitiveness. Interconnection between related industries leads to increasing returns to scale, knowledge creation, knowledge exchange and accumulation. The innovation of an industry, like equipment suppliers, can, for example, be used as input by other industries. There is a high opportunity for interrelated industries to cooperate in technology development, thus increasing the scope for technology flow within and between sectors (Chang and Chen, 2004).

The concept of SIS follows the broad definition of innovation systems that encompasses all related institutions in the innovation process, especially non-firm organisations. These institutions play an important role in the innovation process in developing countries, where the technological and entrepreneurial capabilities underlying activities in the private sector are generally weak. The SIS thus bears on the development of capabilities and learning processes, which are essential for developing countries in the catching-up process. In this respect, SIS can be useful in identifying areas of institutional failures in developing countries and prompting action against such failures (Hosein Rezazadeh Mehrizi and Pakneiat, 2008).

### 2.3.4 Critique of innovation systems

Although the various SI approaches may have the theoretical appeal to explain innovation as a systemic process, their practical policy appeal leaves much to be desired as there is little or nothing in these systems based approaches by way of heuristics to help with their operationalisation. The concepts underlying innovation systems fail to explain how elements interconnect and interact (Hosein Rezazadeh Mehrizi and Pakneiat, 2008) as the models do not provide guidelines or heuristics for creating and controlling interactions between actors (Chang and Chen, 2004). It has also been argued that geographical boundaries associated with NIS and RIS may limit the network dynamics associated with knowledge-based economies (Leydesdorff and Zawdie, 2010). This weakness can be redressed by incorporating the triple helix model as a feature of the innovation system.

## 2.4 The triple helix model

The triple helix model, developed by Etzkowitz and Leydesdorff (1995), is based on evolutionary theory to explore the dynamics in knowledge creation and use arising from the relationship between three institutional spheres: university, industry and government. This relationship is conceptualised to have evolved from the statist model to the *laissez faire* model and then to the trilateral hybrid triple helix model in which the three institutional spheres or actors expand their boundaries by working together in a way that would ultimately blur the boundaries between them. The evolutionary process culminates in a spiral pattern of knowledge creation and circulation, which is at the heart of value creation and entrepreneurial development in knowledge-based economies.

Interaction between institutional actors is central to the triple helix system, as indeed it is to other forms of innovation system. What distinguishes the triple helix system from other forms of innovation system is the evolutionary process underlying the relationship between the three institutional actors. Moreover, in the triple helix system, the university is considered to be the main driver of the innovation process. This is because as an evolutionary system, the triple helix model is essentially geared to addressing issues arising in the evolution of knowledge-based economies from the backwaters of agrarian and industrial culture.

Etzkowitz (2008) applied the magnetic field theory to explain the transformation from the *laissez faire* to the triple helix system of interaction. He argued that the roles of the three institutional actors have to be balanced to maintain independence and continuity of interaction. Where government is strongly dominant, the statist model prevails. If the interactions are not strong enough to create the interface for collaboration, the relationship conforms to the laissez-faire model. Etzkowitz and Zhou (2007) point out three variants of triple helix model: university-pushed model, government-pulled model and corporate-led model. The roles of entrepreneurial universities in these three models considered to be different.

Interactions among the three helices develop networks and communication through personnel, information and output circulation. The circulations can be considered at two levels: macro and micro levels. Macro circulation, occurring horizontally between the three helices, creates hybridisation, leading to the creation of new types of organisation with new sets of culture such as trilateral networks, collaborative projects and hybrid organisations. Micro circulation involves vertical circulation within an institutional sphere such as personnel turnover in industry through recruitment. Although macro circulation can cause conflicts of interest, it is argued that cross-institutional understanding would lead to new organisational culture which is more influential than the effects of micro circulation (Etzkowitz, 2008).

### 2.4.1 Interaction as basis for triple helix dynamics

The triple helix model was proposed as a heuristic for solving the analytical weaknesses in the innovation system approach based on the application of geographical boundaries. The model thrives on the functionality of an evolutionary institutional system within which the demand for and supply of knowledge are managed through the interaction of key actors representing the production sector or the economy (industry), the knowledge sector (universities and research centres); and policy/governance sector (government). Evolution of the knowledge actor (university) creates technological opportunities, whereas evolution of political actor (government) creates the mechanism for technology trajectory selection. Each actor has its evolutionary mechanism: industry through selection; government through stabilisation; and university through knowledge creation and knowledge exchange (Leydesdorff and Zawdie, 2010).

The continual interaction between the triple helix actors sets out the 'choice environment' as the basis for determining the trajectory along which the spiral pattern of knowledge creation and knowledge use should evolve, bringing forth technological progress and social and economic development. In a dynamic triple helix model, choice has to be made from a wide range of options deriving from research and development activities in the knowledge sector. Social, economic and political forces bear on the policymaking process in a complex manner to provide incentives and regulatory mechanisms, thus defining the shape of the trajectory for progress in knowledge creation and its use. Paradigm shifts in this context involve the coming into being of new 'choice environments' and new forms of cooperation between the triple helix actors – such as science parks and incubators – that produce business spinoffs, multi-disciplinary and strategic research initiatives and institutional and organisational cultures that are conducive to innovation and entrepreneurial development. Kim et al. (2012) considered triple helix interactions and roles of actors as being supportive of environment enhancing entrepreneurial activities. This would make triple helix interactions crucial for the transformation of scientific and technological outcomes into economic outcomes.

### 2.4.2 Triple helix and economic development

The economic benefits deriving from triple helix interactions are reflected by growth in the population of firms prompted by economies of knowledge and information and reduction in transaction costs. Etzkowitz and Leydesdorff (1995) proposed the triple helix model in an effort to conceptualise and contextualise the significance of science and technology – and hence of the knowledge sector – for economic development by invoking historical antecedents. In the 19$^{th}$ century, the revolution in education saw expansion of the roles of universities encompassing research as the second mission, in addition to teaching. In the 20$^{th}$ century, after accumulation of research capability, many universities commercialised outputs of their R&D contributing to economic development through firm formation. Moreover, universities assisted industry to solve industrial problems through contract research and joint research. These activities undertaken by entrepreneurial universities constitute the third mission of universities. Kim et al. (2012) measure the economic benefits of triple helix interactions in terms of entrepreneurial activities by using the birth and death rates of firms as proxy variables.

The economic impact of the triple helix system can also be expressed in terms of the extent of collaboration between the actors within the system and activities relating to the boundary-spanning role of each actor. Boundary spanning, which is essentially geared to enhance mutual competence of actors in the system, can be the starting point of triple helix collaboration with actors going beyond their traditional roles driven by the higher objective that serves mutual purposes, such as regeneration of regions through economic growth. These actors can play their additional roles by taking the role of the others to be entrepreneurial universities, knowledge-based firms and supportive government agencies. The functionality of the system is enhanced by the development of social capital, which warrants the continuity of the evolutionary process. In such a system, the government of a region or a country would act as a triple helix player, for instance, and establish or support regional R&D programmes for universities to participate in the task of improving the technological capabilities of local industry. Normally, collaboration may start with bilateral interactions that provide the basis for co-evolution within the system. The third actor will then be pulled into the triple helix relationship as the need arises for more resources or for conflict arbitration (Etzkowitz, 2008) and for providing a favourable environment for the triple helix dynamics to emerge and help shape the trajectory of regional growth and development (Leydesdorff and Zawdie, 2010).

## 2.5 Conclusion

This chapter has reviewed the literature on systems based approaches to knowledge creation, knowledge circulation and knowledge use – i.e. social capital, industrial cluster, innovation systems and triple helix model. Although these approaches were developed from different theoretical or conceptual vantage points, they share a common aim of placing emphasis on the policy implications of cooperation and networking between firms and other related institutional actors to create economic development. However, the focal centres of interest of these approaches are different. For example, social capital places emphasis on shared value of cooperation; industrial cluster on cooperation between firms; national/regional innovation systems on production sector and supporting agencies; and triple helix model on role of the knowledge sector, in general, and universities and research centres, in particular.

The following are the major points arising from literature review on systems based approaches.

- Firms engage in network activities in order to exploit access to external human resources and additional information and knowledge.
- Firms can use these external resources to complement their internal resources in technology development process. However, firms need to have absorptive capability to exploit such resources.
- In the context of developing countries with rigidity of institutional changes, intervention of intermediaries is a kind of supporting infrastructure created to bridge structural holes in order for firms to benefit from such external resources.

Based on these points, the following hypotheses are proposed for empirical investigation (see Chapter 7 and 8).

- Firms are responsive to intermediaries to exploit access to resources and additional sources of knowledge.
- Firms engage in network activities depending on the technological capability.

These systems based approaches to knowledge creation and knowledge use were developed based on the experiences of developed countries. Their application to developing countries poses a challenge, as the systems would become dysfunctional where capacity deficits make bottlenecks and missing links prevalent. This does not, however, make the systems approaches discussed in this chapter irrelevant to developing countries, as missing links and bottlenecks can be identified and solved through policy intervention for institutional capacity and network building. This point will be discussed in the next chapter.

# CHAPTER 3

## Evolution of Knowledge Networks: from Cluster Networks to the Triple Helix Mode

This chapter discusses knowledge networks and learning processes and dynamics occurring in such networks. The aim is to develop a conceptual framework of the evolution of the triple helix system through classification of innovation or knowledge networks and analysis of the emergence of network dynamics. The development of conceptual framework in this chapter is underpinned by transaction cost (Pyka, 2002) and evolutionary theories (Nelson and Winter, 1974).

Knowledge networks can evolve within growing industrial clusters (Menzel and Fornahl, 2007). They can be classified into three types: vertical networks (supply chain); horizontal networks (industrial associations); and triple helix networks (a combination of the two dynamically activated by actors in the networks responsible for knowledge creation and diffusion). While the first two inter-firm networks are linear in character, triple helix networks are non-linear insofar as they involve networks more complex than those of the ‘supply chain’ and ‘industrial association’ type. Triple helix networks involve interactions of actors across production, knowledge and policy/governance sectors (Etzkowitz and Leydesdorff, 1995). Interactions in triple helix networks produce learning and network dynamics that transform the network into a triple helix innovation system. Central to this transformation process are the synergistic activities of institutional players with diverse knowledge and complementary resources.

This chapter is organised into four sections. In the first section, the significance and classification of innovation networks are reviewed. In the second section, the transformation of inter-firm networks into triple helix networks is discussed. In the third section, the conceptual basis for the emergence of network dynamics is explored through a discussion of organisational knowledge creation and technological learning in triple helix networks. The fourth section presents the conclusions to the chapter.

## 3.1 Significance and classification of knowledge networks

The evolution of knowledge networks is underpinned by a mix of neo-classical economic theory, transaction cost theory, and evolutionary economics. In neo-classical economics, firms would engage in knowledge acquisition from external sources when in-house knowledge and resources are inadequate; and insofar as the functioning of the market mechanism is unrestrained, knowledge exchange or knowledge circulation among competitive firms is assumed to be the factor that enables the system to progress indefinitely. In other words, competition drives innovation and innovation provides the basis for economic growth and the continuity of the system. All firms are equally placed to be competitive and innovative. In the neo-classical paradigm, the 'invisible hand' of the market functions in lieu of knowledge networks.

But to the extent that the market is not perfect and knowledge and information are not evenly distributed across firms, market relations between firms would involve transaction costs, which pose a constraint on the process of knowledge exchange or knowledge circulation. The market is far from a level playing field and left to its own devices, would prompt firms to be free-riders driven by opportunistic behaviour. With firms given to opportunistic behaviour, transaction costs prevail reducing the production of goods and services to sub-optimal levels. Collaborative networks are set up as a response to minimise transaction costs in either market or hierarchical relations and restore optimality in the production of goods and services.

In evolutionary economics, knowledge is the main point of focus – knowledge evolves through innovation and so do the institutional and organisational systems within which knowledge is produced. Novelties are created mainly because of the heterogeneity of actors that constitute a network of cooperation. In such networks, the competencies of the various actors are assumed to be complementary enough to produce novelties through a synergy of ideas. As firms develop their absorptive capacities to be able to understand and exploit the knowledge and know-how transferred through networks, they also contribute to the emergence of network dynamics that define the pace and trajectory of innovation and technological progress. Thus, firms within networks can benefit from broader technological opportunities due to exposure to a wide range of technological paths (Pyka, 2002).

In the literature, knowledge or innovation networks are classified in different ways. For example, Freeman (1991) points out that successful innovations involve three types of linkages: user-producer linkages to respond to the needs of users; intra-organisation linkages to integrate development, production and marketing activities; and inter-organisational linkages to get access to external resources. Networking between firms and universities and among firms is mainly aimed to access complementary sources of information in order to bolster in-house R&D for the syntheses of new products and processes.

Robertson and Langlois (1995) classified innovation networks among firms into six types according to vertical integration and coordination: the Marshallian District with low vertical integration and coordination; the Third Italian District with high coordination but low vertical integration; the Holding Company with high vertical integration but low coordination; the Venture Capital Network evolving from Marshallian District with short-term coordination and vertical integration through development projects of venture capitalist; the Japanese Kaisha Network between firms in supply chains; and the Chanderlerian Firm with high degree of vertical integration and coordination. These networks are known to have their appeal to different industries depending on economies of scale, scope of innovation and product life cycles (Robertson and Langlois, 1995).

According to Pöyhönen and Smedlund (2004), inter-organisation networks in regional clusters are classified into three types: vertical production, horizontal development and diagonal innovation networks. A vertical production network involves knowledge implementation by using knowledge to create economic value. Relationships in this type of network occur as formal agreements between raw materials suppliers and end product manufacturers. Collaboration within firms in this type of network is mechanical, and has the potential of reducing transaction costs and enabling firms to achieve higher level of efficiency. A horizontal development network consists of firms in the same industry. Development networks are significant for their role in the dissemination of knowledge and for enhancing the negotiating power of firms against third parties. Members in this type of network can share knowledge, experiences and best practices that would enable them to be competitive and innovative. A diagonal innovation network consists of actors operating in same and different production and development networks. Collaboration between actors in the innovation network stimulates innovation through access to knowledge, products and resources. Regional clusters generally contain all of these three types of networks, albeit in different forms (Pöyhönen and Smedlund, 2004).

A firm can be a member of several networks related to trade, profession, and location. Networks deriving from trading relationships are reflected in the form of supply chains. Spatial networks can be seen in form of either supply chain or trade association networks. Profession-based networks can be research-related (Johannissson, 1998). Gemünden et al. (1996) enumerate innovation network partners as follows: suppliers, buyers, distributors, co-suppliers, competitors, government administration, research and training institutes and consultants. Each firm has different types of external partner, depending on the sources of the knowledge the firm needs and the types of relationship that are deemed valuable. The extent of relationships depends on the experience and networking capability of firms.

In this study, innovation networks are considered in three forms: vertical supply chain networks; horizontal industrial networks; and diagonal triple helix networks. Cooke and Wills (1999) found that the first two inter-firm networks between large and small firms are used to assist the commercialisation process of innovation.

### 3.1.1 Vertical supply chain network

Vertical supply chain networks involve contractual inter-firm relationships at two levels: between producers/assemblers and users; and between producers/assemblers and suppliers (Teubal et al., 1991; Wathne and Heide, 2004). The former involves market relations, and the latter, production relations. Edquist and Hommen (1999) called vertical networks as ‘trade networks’ in which product innovations are developed from buying power and demand articulation.

As users, customers can contribute to product innovation processes through the identification of their requirements and through their feedback to prototype testing practices (Gemünden et al., 1996). In the non-linear innovation process, user-producer relationships stimulate innovation through interactive learning. In well-established user-producer relationships, general users can provide feedback on quality of products to producers via user associations, which are focal organisations with adequate competency to recognise user demand (Edquist and Hommen, 1999). Participation of customers in the innovation process can also increase their motivation to use and disseminate new products, which can be helpful for producers in reducing market risk in the diffusion process (Gemünden et al., 1996). Freel (2000) identified the following as benefits deriving from producers' linkages with customers: access to the skills of customers; optimisation of price and specification of products; acceleration in the rate of adoption; and increase in product life span due to improvements following customer feedback.

In the case of the producer-supplier relationship, the concept of supply chain network, or sub-contracting, was widely used to explain inter-firm relationships in Japanese industries. This type of network evolved from a hierarchy of networks based on ownership and control used before the Second World War (Freeman, 1991). Supply chain networks that are based on information exchange involve relationships between firms either within or outwith the same business groups. The technological development of firms, especially assemblers at the centre of the supply chain network, affects other firms in the network. The Japanese experience instructs that firms would need to upgrade the technological capabilities of their suppliers and also help build the networks of their suppliers so that they can assimilate new technologies and become efficient suppliers (Freeman, 1991).

The benefits of well-established and well-functioning supply chain networks involve efficiency in the allocation of production and investment resources (Ceglie and Dini, 1999). Freel (2000) identified the benefits of vertical collaboration with suppliers to include: reduction of transaction costs; access to resources that are insufficiently provided internally; access to tacit knowledge; and reduction of investment expenditure on R&D equipment for innovation.

According to Lazzarini et al. (2001), a supply chain network, which functions on the basis of planned coordination, involves sequential interdependence between actors.

The coordination and flow of products and information are planned and scheduled with discretionary actions of actors. Outputs of upstream actors are inputs of downstream actors. The value-added sequentially along supply chain networks are enhanced through the optimisation of production and operations; and the reduction of transaction costs (Lazzarini et al., 2001).

With repetitive transactions based on contractual relationships, supply chain networks become dense networks, thus reflecting the existence of strong ties (Giuliani, 2007). Strength of ties between players on the supply chain is expected to bear the following characteristics: reduction of uncertainty associated with the introduction of new technologies; reduction of the incidence of opportunistic behaviours that arise from the asymmetry of knowledge/information distribution along the supply chain; and increase in investment in human capital to enhance the efficiency and effectiveness of information and material flow along the supply chain (Capaldo, 2007). To maintain their position in supply chain networks, firms would need to keep up with and adopt technological developments and innovative ideas originating from their suppliers and customers. Thus, with technology transfer and transparency of activities along the supply chain, the occurrence of opportunistic behaviour would be expected to be minimised, while opportunities arise for higher level of human resource development. Firms can spend savings from reduction of investment in R&D equipment and transaction costs on investment in other innovative assets, such as human capital and relational capital (Rothwell and Dodgson, 1991; Freel, 2000).

Gemünden et al. (1996) argued that supply chain relationships might be insufficient to create radical innovation. While supply chain relationships are necessary for incremental product and process innovation, relationships with universities and research institutions can influence possibilities for radical product and process innovation, and consultants can assist in the innovation process. However, the problem with strong ties along the supply chain is that could pose obstacles to the growth of vertical networks as discussed in section 2.1.3. Firms in dense networks with strong ties may be locked-into small areas of collaboration and old technology trajectories due to lack of new and diverse sources of knowledge (Balthasar et al., 2000; Capaldo, 2007). This would preclude prospects for radical innovation. Other institutions should, therefore, be included in supply chain networks to provide heterogeneous sources of knowledge and complementary resources. This would enhance prospects for the emergence of network dynamics.

### 3.1.2 Horizontal industrial network

A horizontal network involves relationships between firms within the same industry. This form of network, in which the results of cooperation could be clearly seen in the form of trade associations, cartels and consortia of sorts, was widely used in the establishment of networks before the 1960s (DeBresson and Amesse, 1991). Economies of scale, resulting from collaboration among firms, would offer more benefits to firms in the network than what could be derived from outside the network. Economies of buying with respect to raw materials, for example, would drive down unit costs of firms in the network. Moreover, larger amounts of supply of products open opportunity for firms in the network to access more potential markets (Ceglie and Dini, 1999). However, these benefits were limited by the anti-trust laws in some countries, like the USA and the EU (Ghosal et al., 2007).

Nowadays, activities of most horizontal industrial networks are limited to information sharing (Kirby, 1988). For example, trade associations are aimed to be a forum for information sharing among members. Firms in oligopolistic industries can opt to collude in order to increase their profits through, *inter alia*, information exchange. When private information of firms is equally shared and gathered as aggregate signal by trade associations, firms can use this aggregate signal to make more accurate decisions in production (Kirby, 1988).

Firms in associations may benefit from knowledge spillovers created by other firms in the network, thus increasing opportunities for innovation (Ahuja, 2000). Moreover, networking between firms within the same industry facing common problems and technological opportunities can generate positive externalities. Externalities also occur when the number of firms adopting new technologies increases driving down the costs of technology procurement and leading to increasing returns to technology adoption. Externalities also occur as firms are saved from being locked-in obsolete and inferior technologies (Balthasar et al., 2000). According to Freel (2000), the benefits of horizontal networks include: complementarity of internal product development; cost and risk sharing; transfer of embedded technology and tacit knowledge; and access to new markets.

Information exchange underpinned by pooled and reciprocal interdependencies of actors in the horizontal network creates knowledge diversity, trust, norms and standardisation in the development of innovation. In horizontal networks, the relationship of actors may be in the form of weak or strong ties. Strong ties within a network can stimulate the emergence of trust, rules and social norms, leading to process standardisation as a coordination mode. Dense networks with strong ties may increase the negotiating or bargaining power of their industries against the industries of other networks. However, weak ties connecting with structural holes allow firms to access new distinct knowledge outside networks (Lazzarini et al., 2001). Giuliani (2007) called this type of network 'knowledge network'. Harryson et al. (2008) point out that open networks with weak ties are suitable for the exploration process of innovation, and closed network, for the exploitation process.

Horizontal networking reduces technological development costs and lead times of technology introduction. Typically, R&D is expensive and risky. But rather than compete, firms within the same industry can opt to engage in the development of common technologies through collaboration in R&D projects. In R&D collaboration, complementary resources of firms are pooled together. As a result, the R&D costs of a firm would decrease (Robertson and Langlois, 1995), and lead times of innovation introduction can be reduced, thus improving market opportunities against outside competitors (Hagedoorn and Schakenraad, 1990). Firms may cooperate with their competitors in areas they have comparative advantage (Lee et al., 2010).

Spatial proximity is a crucial factor to create horizontally dense networks. But if firms in such networks face the problem of lack of new distinct information, they would be constrained from learning and innovating (Lazzarini et al., 2001). Spatial and thematic proximity can stimulate the learning process of firms in networks (Menzel and Fornahl, 2007). Johannissson (1998) found that existing firms in conventional industries have more dense spatial networks for learning and knowledge creation than emerging firms in knowledge-based industries. In closed and homogeneous networks, like in the case of mature clusters in conventional industries, Menzel and Fornahl (2007) argue that firms within the clusters may perform worse than firms outside the clusters because those within tend to get locked into old technology trajectories that made them successful in the past. Innovation or network dynamics would be expected to decrease within clusters in the mature stage of technologies due to stabilisation and standardisation that lead to lack of heterogeneity of knowledge inputs. If firms cannot have access to a diverse set of new knowledge, they will not be capable of adjusting and innovating. Therefore, new heterogeneous actors can be attracted to join networks in order to expand thematic boundaries by combining new knowledge with existing knowledge, thus reducing technological distance and creating more collaboration (Menzel and Fornahl, 2007). In line with this view, Knorringa and van Staveren (2006) point out that members of trade associations may choose to have access to other networks and alliances to learn from others and to innovate rather than remain locked in the trajectories they are already on.

In emerging industries, a major obstacle impeding cooperation of horizontal networks is lack of trust. In open networks, the main advantage of locating in spatial proximity with competitors is knowledge spillovers (Giuliani, 2007). However, firms might be reluctant to share knowledge with other firms, lest they give in to free-riding practices arising from the opportunistic behaviour of firms (Ahuja, 2000). Firms also rarely collaborate with their competitors because of their concern about the ownership of outcomes of mutual projects (Freel, 2000).

### 3.1.3 Diagonal clusters and triple helix networks

Industrial clusters are defined by Porter (2000) as "geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g., universities, standards agencies, trade associations) in a particular field that compete but also cooperate" (p. 15). In other words, clusters consist of firms in vertical value chain; horizontally positioned firms in the same industries; and other key institutions (Eisingerich et al., 2010). The triple helix model of interaction between universities, industry and government, developed by Etzkowitz and Leydesdorff (1995), can be used as a framework to implement the industrial cluster concept proposed by Porter. The triple helix model, however, places emphasis on the interface between the three institutional actors, thus facilitating knowledge circulation within and between the three institutional actors and the creation of network dynamics.

Within a cluster, there could be different networks and institutional actors. Ceglie and Dini (1999) identify three types of network associated with cluster development: vertical integration mainly driven by large firms and multinational corporations; horizontal networks between firms at the same level of value chain; and networks among network brokers and service providers. Innovation success is contingent on the multi-dimensional cooperation of firms with several actors. Firms would therefore be at an advantage if they chose to integrate all types of relationships as strategic networks rather than be satisfied with isolated relationships (Capaldo, 2007).

Clusters vary with respect to formation and characteristics. St. John and Pouder (2006) differentiated the evolutionary paths of the formation of industrial clusters and technology clusters. Industrial clusters are concentrated in some areas, where opportunities for proximity to key resources, markets and anchor firms can be maximised. For example, furniture and wine clusters are located in areas with abundant resources. Initially, clusters are formed with vertical relationships between suppliers, producers, and customers. Later, more suppliers would relocate in cluster areas, thus creating the basis for competition or else for the development of horizontal relationships between potential competitors. However, growth of industrial clusters tends to decline when industries constituting the cluster reach the mature phase and demand for goods and services become income-inelastic, thus pre-empting opportunities for growth and innovation.

Technology clusters are, on the other hand, always located near universities or government laboratories, as in the cases of the electronic technology cluster in the Silicon Valley and the biotechnology cluster in Boston. The development of technology clusters may be prompted initially by spin-off companies set up to commercialise new technologies deriving from the R&D ventures of universities and government laboratories. These technologies can be so generic as to be able to serve a wide range of industries. Technology clusters invariably cover several industries. Horizontal and vertical knowledge exchange between suppliers and producers across industries may create radical innovation and new industrial sectors. This is considered as a diagonal dimension, which St. John and Pouder (2006) referred to the 'lateral dimension' in network development. Innovations occurring along the diagonal network have the effect of marginalising existing industries based on mature technologies, and replacing them with new growth industries.

In the diagonal triple helix network, vertical supply chain and horizontal industrial networks are integrated. Clusters require both horizontal and vertical complementarities (Menzel and Fornahl, 2007). Because learning is path-dependent, firms in the same industry are likely to converge in their technological paths. On the other hand, coordination between firms from different paths can open new technological opportunities, culminating in the so-called 'cross-fertilisation effect' (Pyka, 2002). The cross fertilisation applying to a diverse range of actors can potentially lead to radical innovation (White and Christopoulos, 2011).

Giuliani (2007) also believes that clusters consist of both vertical business and horizontal knowledge networks. Her study compared business and knowledge networks in clusters through network mapping. Business networks include market-based transactions, and knowledge networks involve knowledge transfer activities. She found business networks in clusters to be dense and localised, and knowledge networks to be weak. The weakness of knowledge networks in clusters derives from the fact that firms tend to depend on knowledge generated outside the clusters. This is in line with Capaldo's (2007) argument that firms in clusters should contain both strong and weak ties to compensate the weaknesses of strong ties with the strengths of weak ties.

Similarly, Lazzarini et al. (2001) introduced 'Netchain analysis' integrating supply chain and network analyses to explain diagonal inter-firm collaboration. A 'Netchain' consists of sequentially vertical supply chain relationships between firms on different layers of a supply chain and reciprocally horizontal relationships among firms/suppliers on the same layer of a supply chain (see Figure 3.1). The 'Netchain' includes interdependencies; sources of value; and coordination mechanisms of both vertical supply chain and horizontal network (discussed in Section 3.1.1 and 3.1.2). There are three types of interdependence (i.e. sequential, pooled and reciprocal) related to different sources of value and coordination mechanisms as shown in Figure 3.2.

In line with Lazzarini (2001), Lan and Zhangliu (2011) categorised the learning mechanism of industrial clusters into three dimensions: horizontal, vertical and multi-angle learning. The learning process in the horizontal dimension involves observation, comparison and imitation of innovation activities of clustering firms at the same level of value chain. In the vertical dimension, the learning process involves complementarity, specialisation and backward and forward information flows between firms at different levels of value chain. These characteristics of vertical networks stimulate knowledge creation and innovation. Multi-angle learning involves learning from other institutional actors providing knowledge and technology infrastructure, such as universities, local government, public research institutes and intermediary organisations. By linking with these institutions, firms can acquire knowledge and benefit from collaborative technological development projects.

As institutional actors like universities and government are attracted to join industrial clusters, inter-firm networks evolve into triple helix networks. Within a cluster, knowledge developed by the resources of universities can be circulated around firms. The triple helix network would thus help alleviate the deficiency of firms, in terms of the supply of qualified human resources and financial supports. Where the network is dysfunctional, the government plays an essential role bridging gaps in the network among firms and between firms and universities through the creation of intermediaries and other policy mechanisms (Freel, 2000). The diagonal triple helix network can be represented as in Figure 3.3.

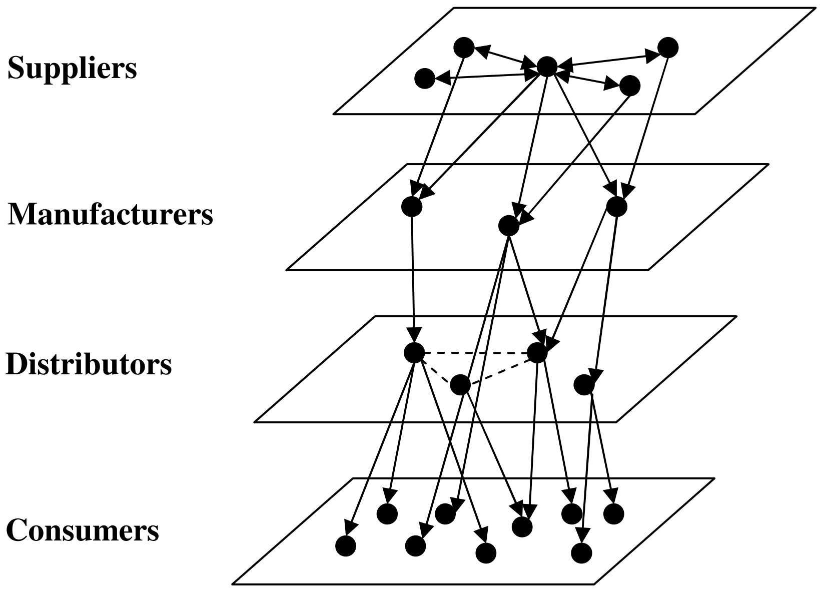



Figure 3.1 A generic Netchain integrating supply chains and horizontal networks

Source: Lazzarini et al. (2001, p. 8)

Note: Netchain explains the relationship of firms within and between levels of supply chains

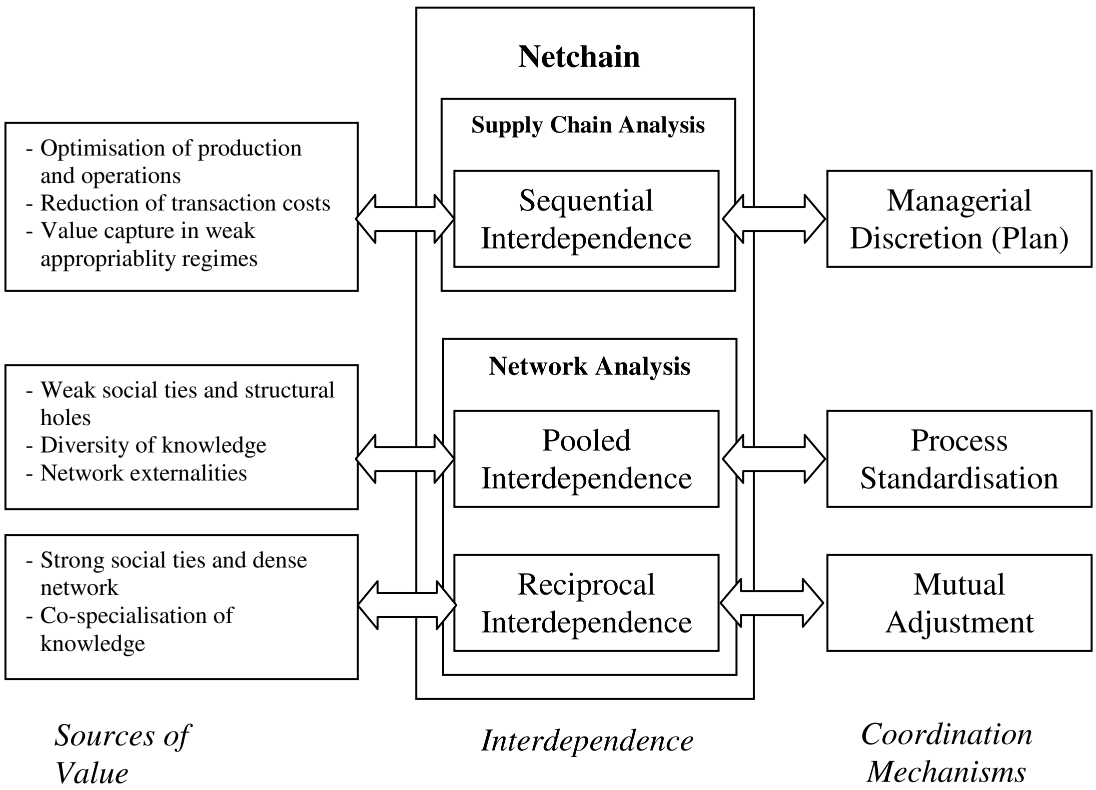



Figure 3.2 An overview of Netchain Analysis

Source: Lazzarini et al. (2001, p. 14)

Note: Netchain analysis integrates supply chain and network analyses

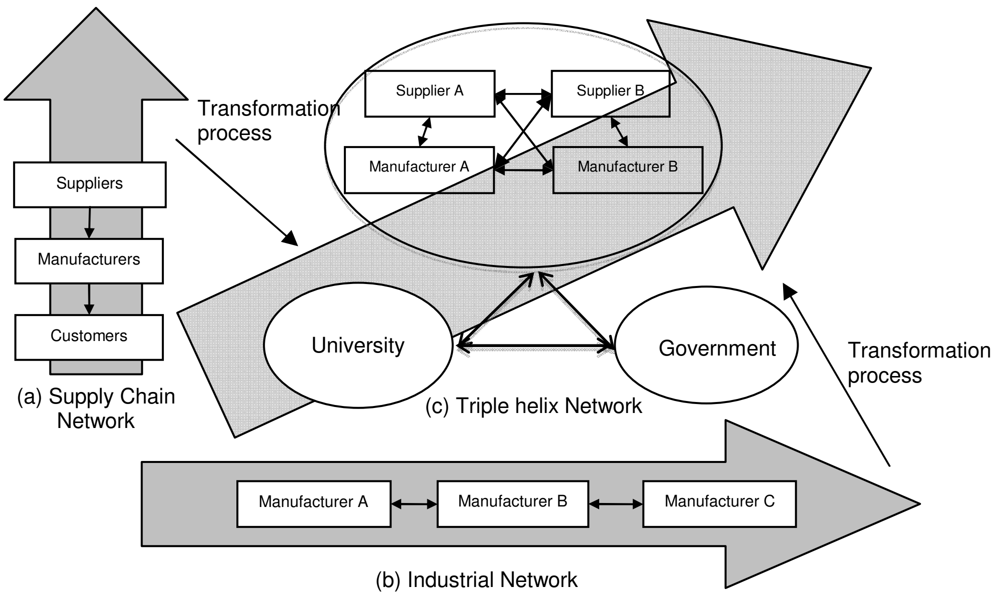



Figure 3.3 Three types of innovation networks: a) Supply chain network; b) Industrial network; and c) Triple helix network

The triple helix network can evolve into an innovation system as it gives rise to network dynamics through the complementarity of heterogeneous actors, complex learning procedures and cross-fertilisation processes. A triple helix network consists of various kinds of actors, possessing different resources and competencies. Due to the heterogeneity of the actors, coordination in the network creates pooling of complementary resources and competencies. This is crucial for resolving the resource deficiency problem, and for enhancing opportunities for innovation (Madill et al., 2004).

As discussed earlier, diagonal inter-firm networks, by virtue of maximizing the scope for heterogeneity of knowledge and competencies, can create radical innovation. New heterogeneous actors are attracted to join networks in order to combine new knowledge with existing knowledge, thus reducing technological distance and creating the conditions for collaboration (Menzel and Fornahl, 2007). Apart from inter-firm cooperation, other institutions, such as universities and government agencies, can be essential actors of triple helix networks as knowledge producers, resource providers and providers of policy and institutional mechanisms to stimulate the cross-fertilisation effect of the diagonal inter-firm networks (Gemünden et al., 1996). These extra-firm network players can be considered as ‘weak ties’, albeit benefiting inter-firm networks due to the diverse information they bring to the network (DeBresson and Amesse, 1991; Madill et al., 2004).

## 3.2 Transformation from inter-firm networks to triple helix network

It can be argued that triple helix relationships provide a sustainable basis for network development and hence for the development of the innovative capability of firms. Dense inter-firm networks (both vertical and horizontal types) are in principle considered to be beneficial for firms in networks as they increase the scope for collaboration and knowledge exchange. But dense networks also lack new sources of knowledge, which limits the innovativeness of firms. Institutions such as research institutes and universities can be new sources of knowledge that can help restore the dynamics of networks (Balthasar et al., 2000). Inter-organisation linkages tend to be loose due to differences in culture and areas of interests. Firms can use open inter-organisation networks with weak ties in the exploration process (Harryson et al., 2008).

Conceptually, development of the diagonal triple helix network presumes the pre-existence of both vertical and horizontal networks. As these grow in depth and breadth, they feed into the growth of the triple helix network on the diagonal path. To expand vertical value chain network, firms engage in internationalisation by increasing their exports and accessing global value chain. Entering the global value chain increases the pressure on firms to improve their performances to meet international standards. This improvement can be achieved through cooperation with the existing vertical and horizontal networks. Cooperation with suppliers and subcontractors improves product quality and delivery; and bilateral and multilateral horizontal (trade association) cooperation enables the sharing of knowledge and experiences, thus creating multilateral upgrading initiatives for new markets (Schmitz and Nadvi, 1999) and for solving mutual institutional problems (Knorringa, 1999). Knorringa (1999) showed that direct exporters in the Agra footware cluster in India created initiatives through trade associations to solve low speed export procedures with the assistance of government. In this case, government officials also played an important role as a catalyst inviting firms who benefited from cooperation to participate.

There can be several pre-existing networks within an industry or a cluster. Vertical integration is often seen in mature and low technology industries where economies of scale and standardisation are points of concern. Horizontal networks are observed in new and high technology industries (Madill et al., 2004). To transform existing networks into triple helix network along the diagonal path, more institutional actors, including universities and government agencies, can be brought into the network to assist in the technology development and innovation process of players in the production sphere.

Sometimes, particularly at the early phase in the evolution of the triple helix relationships, intermediaries are necessary to transform inter-firm networks into triple helix networks. Ceglie and Dini (1999) showed that government policies in some central American countries – i.e. Honduras, Nicaragua and Jamaica – had attempted to transform pre-existing inter-firm networks into triple helix networks. It was found that the occurrence of network promoting agencies as brokers and consulting institutes as service providers constituted part and parcel of the evolutionary process of network development (Ceglie and Dini, 1999). The roles of these network promoting agencies or intermediaries are discussed in Chapter 4.

## 3.3 Network dynamics as organisational knowledge creation and technological learning in triple helix relations

The emergence of network dynamics is, as already discussed, crucial for the transformation of triple helix networks into triple helix innovation system. According to Nonaka and Takeuchi (1995), network dynamics arises from a complex set of interactions involving individuals and groups at intra- and inter-organisational levels. As can be seen Figure 3.4, network dynamics produce innovation through iterative processes of knowledge conversion. Knowledge can occur either in tacit or explicit form; and the conversion of one type of knowledge into the other involves four processes – socialisation, externalisation, combination and internalisation. These processes form a loop and evolve in a spiral mode generating new knowledge and experience which constitute the basis for innovation.

In the first loop, the socialisation process enables the sharing of individual experiences and access to tacit knowledge through observation, imitation and practice. Through socialisation, individual knowledge can spread widely within groups in organisations. The externalisation process involves the transformation of individual tacit knowledge into explicit organisational knowledge through the creation of concepts, models and hypotheses. The combination of different existing explicit knowledge within an organisation can then create a new explicit knowledge system, such as new prototypes and new products/processes. This new knowledge system can be implemented at the operational level through the process of internalisation thus creating economic value for an organisation. These four modes or processes constitute a loop of organisational knowledge creation. These can be shared, thereby creating new larger loops of inter-organisational knowledge as shown in Figures 3.4 and 3.5.

The Nonaka and Takeuchi (1995) scheme of organisational learning however begs the question as to how the act of learning is pursued within and between organisations. Beeby and Booth (2000) classify levels of learning into five: individual learning; team learning; inter-department leaning; organisational learning; and inter-organisational learning. Learning at each level occurs through cyclical processes: experiencing; processing; interpreting; and taking action. These learning processes are iterative, and there are feedback loop within and between the levels of learning. Inter-organisational learning is the highest level of learning and involves integration of the lower levels of learning. This is consistent with Nonaka and Takeuchi (1995) that the next loop integrating organisational knowledge is the creation of inter-organisational knowledge, as seen in Figure 3.5. The Nonaka-Takeuchi model suggests that learning within a network system would culminate in the development of innovation and technological capability when the four modes of knowledge conversion, including socialisation, externalisation, combination and internalisation are allowed to run their full course, as can be seen Figure 3.6.

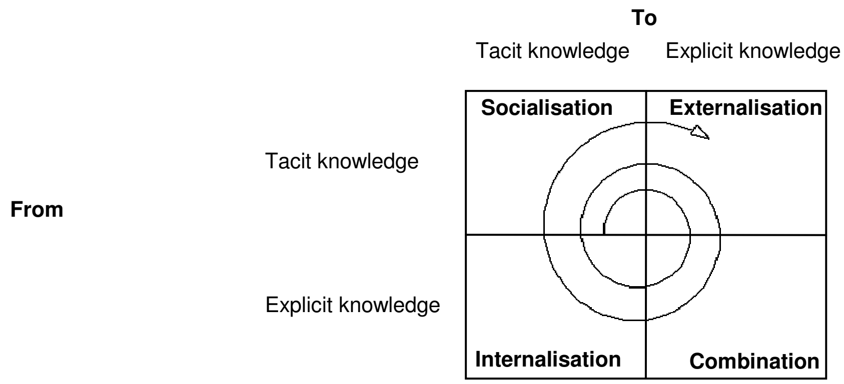



Figure 3.4 Four modes of knowledge conversion and knowledge spiral

Source: Nonaka and Takeuchi (1995, p. 71)

Note: Knowledge can be created through four modes, starting from socialisation to exchange tacit knowledge. After socialisation, tacit knowledge can be codified through externalisation, becoming explicit knowledge. In combination, explicit knowledge of actors can be combined to create new knowledge. And new explicit knowledge can be utilised in internalisation process.

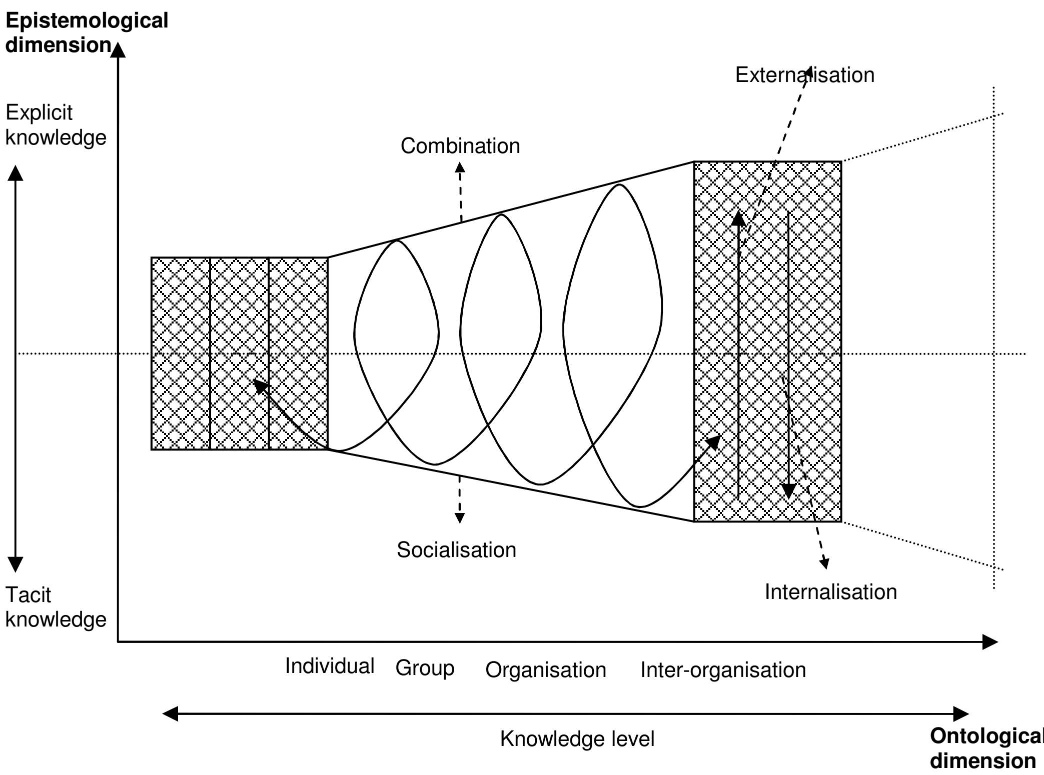



Figure 3.5 Spiral of organisational knowledge creation

Source: Nonaka and Takeuchi (1995, p. 73)

Note: In the first cycle of knowledge conversion, individual knowledge becomes group knowledge. In the next cycle, group knowledge becomes organisational knowledge, and inter-organisational knowledge.

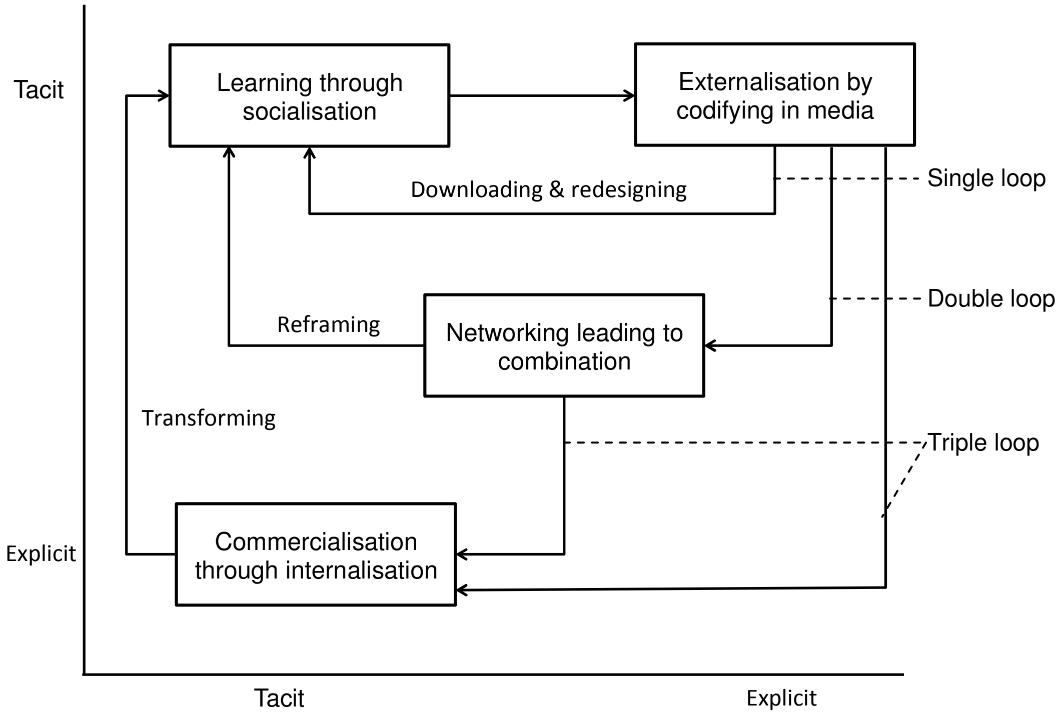



Figure 3.6 Four modes of knowledge conversion

Source: Based on the systhesis of the works by Nonaka and Takeuchi (1995) and Argyris and Schön (1978)

Note: In the process of conversion of implicit knowledge into explicit knowledge, single loop leaning occurs if firms choose to download and redesign their processes to solve *ad hoc* problems by using media from externalisation. Double loop learning occurs if firms choose to reframe their policies and activities by networking with other actors. Triple loop learning occurs if firms transform their goals and structures to interact with other heterogeneous actors, i.e. feedback from markets after commercialisation (see Figure 3.7).

The Nonaka and Takeuchi model can be used to explain the emergence of network dynamics in triple helix relations by also integrating into it the modes of organisational learning, which can range from the simple to the complex and occur in loops, as discussed below.

Peschl (2008) and Pahl-Wostl (2009) identified the learning process in loops according to the intensity and level of change realised in the process of learning. The first level of the learning process is aimed at solving problems through the application of existing knowledge. Redesigning and adaptation of some activities in order to optimise operations and create incremental improvements is the second level of learning. At the third level, knowledge is sought to reframe activities, which involves the establishment of new dimensions and alternative frames by reconsidering the underlying assumptions that define relationships within systems. This amounts to transforming the context of learning, which is the highest level of learning. Learning at this level involves the creation of profound changes through radical innovation.

As seen Figure 3.7, the first level relates to 'single loop' learning in which errors can be detected and corrected without changes in policies and objectives (Argyris and Schön, 1978, 1996). This mode of learning is referred to as 'adaptive learning' (Senge, 1990) or 'non-strategic learning' (Mason, 1993). The second level corresponds to 'double loop' learning in which organisational norms, procedures, policies and goals are changed to detect and correct errors (Argyris, 1990, 1992, 1994, 1996). In this learning mode, the learning organisation is asking not merely if it is doing things the right way (as in the case of single loop learning), but more importantly, whether it is doing the right things. Double loop learning is considered to be strategic as it enables the learning organisation "to make sense of its environment in ways that broaden the range of objectives it can pursue or the range of resources and actions available to it for pursuing the objectives" (Huber, 1991 cited in Mason, 1993, p. 843). The highest level of learning, according to Peschl (2008) and Pahl-Wostl (2009), corresponds to 'triple loop' learning or what is alternatively known as 'deutero-learning' (Flood and Romm, 1996; Snell and Chak, 1998). Triple loop learning is about 'learning how to learn' and involves complexity thinking relating to the "diversity of issues and the dilemmas faced by linking together all local units of learning in one overall learning infrastructure, as well as developing competencies and skills to use this infrastructure" (Romme and Wittleoostuijn, 1999, p. 440). Learning at this level leads to radical innovation (Romme and Wittleoostuijn, 1999). It is this mode of learning, alternatively referred to as multi-loop learning (Pahl-Wostl, 2009), which drives the network dynamics in triple helix relations. It also corresponds to the organisational learning process as conceptualised by Nonaka and Takeuchi (1995)

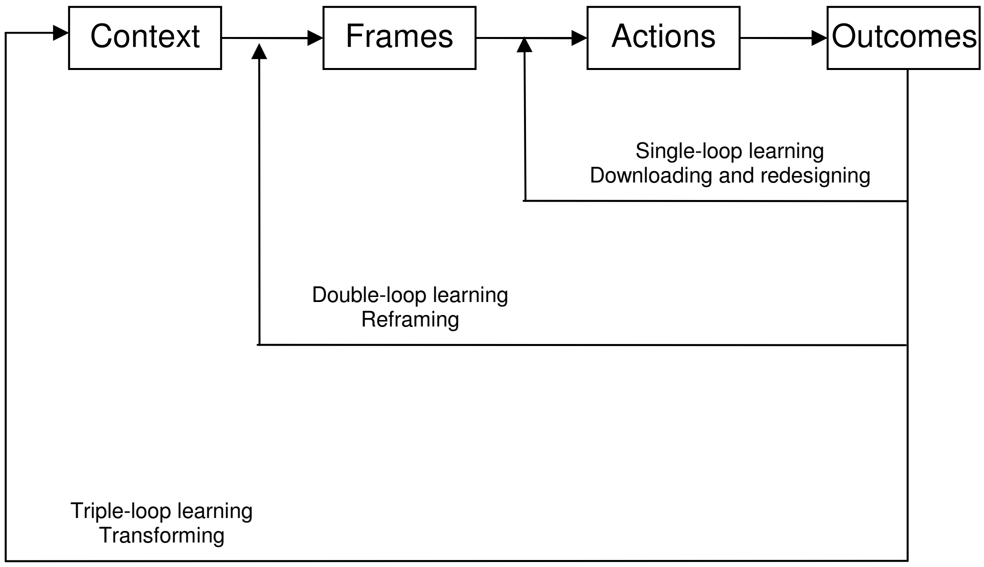



Figure 3.7 Levels of learning process and sequence of learning loops

Source: Pahl-Wostl (2009, p. 359)

Note: Feedbacks from outcomes create loops of learning. Learning process can be classified according to the intensity of change as follows. In single loop learning, downloading and redesigning can be done through existing solutions and adaptation of some actions for optimisation, enhancing efficiency of performance. In double loop learning, reframing involves the reestablishment of new dimensions and alternative frame by considering relationship within systems, thus providing the basis for incremental innovation. Triple loop learning involves transformation of structural context or change of paradigms, purposes, belief systems, relationships and cultures. This provides the basis for radical innovation.

The learning process has implications for the ways in which resources are organised and managed to impact production activities and the context or environment within which production takes place. Savory (2006) differentiated abilities to use resources at three levels. The first level is competence related to the ability to use resources to perform tasks. The second level is related to the ability to combine and configure a set of resources. The third and the highest level is dynamic capability, related to the ability to reconfigure and recombine resources to change the organisation's environment and direction. The first level corresponds to single-loop learning, the second level to double-loop learning, and the third level to triple-loop learning.

Triple-loop learning can occur in a triple helix network as organisational and institutional actors reconsider their values and beliefs to recognise needs for changes. It creates different levels of changes in actor networks and interactions as Pahl-Wostl, (2009) classified in Table 3.1.

Table 3.1 Characteristics of changes in governance regimes for multi-loop learning

| | Single loop | Double loop | Triple loop |
|---|---|---|---|
| **Actor network** | Actors remain mainly within their networks<br><br>Established roles and identities are not called in question | Explicit search for advise/opinion from actors outside of established network<br><br>New roles emerge e.g. facilitators in participatory processes<br><br>Boundary spanners of increasing importance that start to connect different networks | Changes in network boundaries and connections<br><br>New actors, groups, roles have become established<br><br>Changes in power structure<br><br>Roles get blurred or less important, rather joint approaches than isolated performance according to one's role |
| **Multi-level interactions** | Vertical coordination in established patterns | Increased informal knowledge exchange between levels of informal coordination groups to improve exchange in planning processes established | Formalised participation of actors at different levels<br><br>Established practices of knowledge exchange across levels<br><br>More polycentric structures and balance between bottom-up and top-down approaches |

Source: Pahl-Wostl (2009, p. 360)

Bringing all strands together, it is now possible to explain how network dynamics evolve in triple helix relations. In triple helix networks, the learning process proceeds cumulatively in a multi-loop mode through the phases of socialisation, externalisation, combination and internalisation; and learning culminates in innovation based on opportunities afforded by triple helix networks for combining diverse knowledge and competencies of heterogeneous network actors (Beckman and Haunschild, 2002).

In the knowledge exploration process, firms within the triple helix network can search for and combine knowledge from ‘strong ties’ with cognitive closeness, thus creating, at best, incremental innovation. They can also select and combine knowledge from ‘weak ties’ with cognitive distance, which would be expected to provide significantly new knowledge categories that are capable of opening opportunities for radical innovation.

However, learning through the circulation of knowledge among network players presumes the existence of trust and mutual understanding between the actors. Where the trust factor is absent, intermediaries would come into play as network builders. Trust strengthens networks and enhances the circulation and generation of new knowledge within the networks. But lack of diversity in knowledge, experience and competency within a ‘strongly connected network’ limits the scope for dynamic learning and the generation of new knowledge in spite of the trust factor that closely binds the network. Thus, ‘strongly connected networks’ would engage in knowledge exploration by opening their boundaries for knowledge from other networks with whom they are ‘loosely connected’; and so the process of learning by networking evolves (Gilsing, 2005). For this to happen, the role of intermediaries is crucial.

Where potential network players are disconnected, intermediaries play a major role transforming structural holes into strong and weak ties through two network mechanisms: closure and brokerage (Burt, 2000). Generally, structural holes or disconnected actors exist within and between groups in networks. Networking with disconnected actors or structural holes within institutional actors can benefit firms in terms of information access. Because of homogeneity, these internal structural holes should be closed to facilitate communication, micro knowledge circulation and coordination (Etzkowitz and Dzisah, 2008) and avoid opportunism (Burt, 2001), while creating strong ties. This mechanism (i.e. closure) is known as ‘bonding social capital’. Networking with structural holes in different institutional actors benefits firms in terms of access to diverse and non-redundant knowledge. Because of heterogeneity reflected in terms of differences in culture and technology, these external structural holes are bridged through brokerage. Brokerage allows access to new diverse sources of knowledge and creates macro knowledge circulation (Etzkowitz and Dzisah, 2008), while creating weak ties (Burt, 2000). This mechanism is known as 'bridging social capital' (i.e. brokerage). Intermediaries can increase the level of social capital or trust among network players by working on the bonding process (creating strong links) and then switching to the bridging process (creating weak links), as discussed in section 2.1.3 (Knorringa and van Staveren, 2006). As seen in Figure 3.8, these two network building mechanisms, which are central to the essence of network dynamics, can stimulate the triple helix system to evolve into spiral model by blurring boundaries of institutional actors. Networking of actors within the same institutional categories are characterised by strong ties. And networking between actors across different institutional categories produces weak ties.

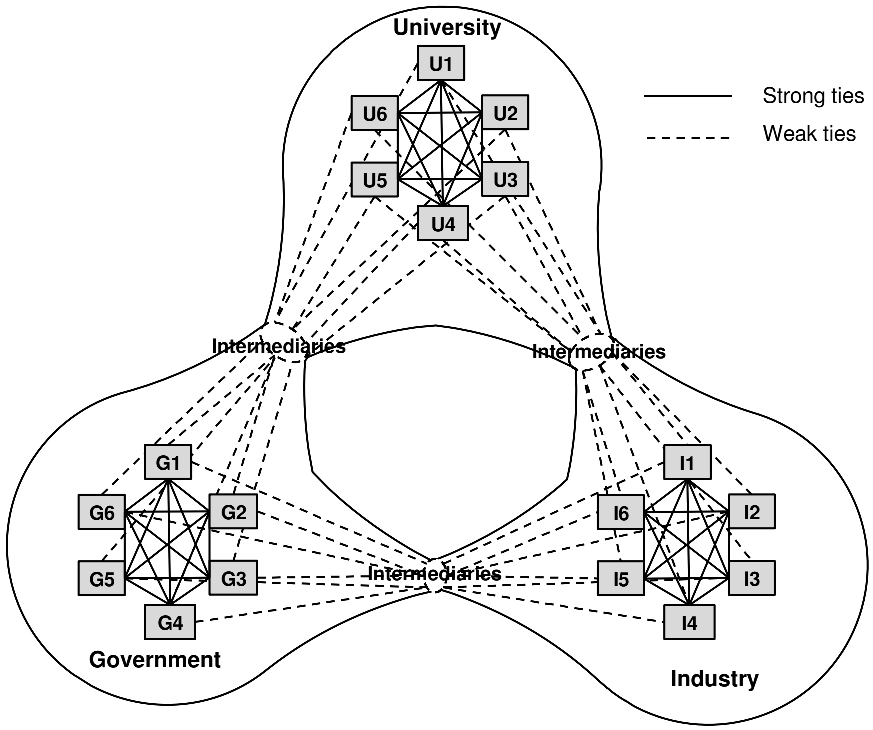



Figure 3.8 Network closure within institutional actors and brokerage between institutional actors in triple helix

Note: Strong ties can be created through closing structural holes within an institutional sphere. Weak ties can be created through bridging structural holes between institutional spheres.
U1,…, U6 represent universities 1-6
G1,…,G6 represent government agencies 1-6
I1,…, I6 represent firms 1-6

## 3.4 Conclusion

This chapter has discussed the significance of triple helix networks, which is more dynamic than inter-firm networks, including vertical supply chain and horizontal industrial networks. These two types of inter-firm networks are likely to be dense networks lacking in diversity of knowledge and network dynamics. On the other hand, triple helix networks provide the opportunity for firms to collaborate with heterogeneous actors possessing diverse knowledge and resources. Combination of diverse knowledge can culminate in radical innovation through the operation of network dynamics involving the organisational learning processes of socialisation, externalisation, combination and internalisation (Nonaka and Takeuchi, 1995). Underlying these organisational learning processes are the mechanics of learning which evolve from single loop learning to double loop learning and then to triple loop learning. While single loop and double loop learning can be associated with learning processes in inter-firm networks, triple loop learning can be considered to be the basis for the evolution of activities in triple helix networks.

To develop triple helix networks and promote innovation, technological progress and sustainable economic growth, policy should aim to transform pre-existing inter-firm networks into triple helix networks through intermediaries.

The following are the main points arising from discussion in this chapter.

- Intermediaries operate as catalysts to stimulate the transformation of inter-firm networks into triple helix networks.
- Closure of ‘structural holes’ within institutional spheres leads to strong ties.
- Bridging of ‘structural holes’ between institutional spheres produces weak ties, albeit broadening the scope of relational capital, thus increasing relational capital.
- In triple helix networks, radical innovation can be created through knowledge exchange and collaboration between heterogeneous institutional actors involving intermediaries promoting the emergence of network dynamics.
- The absorptive capabilities of these three actors, especially in the industrial sphere, are necessary not only to exploit external knowledge and resources, but also to create network dynamics through the combination and internalisation of knowledge.

Based on these points, the following hypotheses are proposed for empirical investigation, which is carried out in Chapters 7 and 8.

- Firms are responsive to intermediaries to exploit access to resources and additional sources of knowledge through increased relational capital; and
- Firms engage in triple helix networks depending on their experiences in pre-existing networks.

This chapter has brought out the need for the role of intermediaries in the formation of triple helix networks and triple helix innovation systems. The significance of the roles intermediaries play in building social capital and promoting trust among network players at micro and macro levels, and the implication of this for the evolution of knowledge networks, and the emergence of network dynamics and the triple helix innovation system is discussed in the following chapter.

# CHAPTER 4

# The Role of Innovation Intermediaries in the Evolution of the Triple Helix Networks

This chapter aims to explore roles of intermediaries and intermediary organisations to develop a conceptual framework for the analysis of systemic roles of intermediaries and to show the characteristics of existing intermediary organisations. Underpinned by principal-agent theory, the roles of intermediaries are conceptually connected through the transmission of policy and resources. Intermediaries also function as institutional mechanism through which the role of the government in triple helix network development is expressed.

Intermediation is a policy process to bridge gaps, also known as ‘structural holes’, in the transformation of inter-firm networks into triple helix networks. In this chapter, the roles and types of innovation intermediaries are discussed. Innovation intermediaries play their networking roles as sponsors, brokers and boundary spanners. As such, they can be university-based, government-oriented and market-led in character, depending on the nature of the innovation actors they are liaising with.

This chapter is organised into four sections. The first section discusses the significance of intermediaries as crucial players in network management and argues that in the absence of intermediaries, network systems could become dysfunctional or devoid of network dynamics. In the second section, the three roles of intermediaries are discussed. The third section characterises the three types of intermediary organisations according to the orientation of the institutional actors they liaise with. The fourth section presents the conclusions of the chapter.

## 4.1 Intermediaries in network management

Intermediaries (e.g. research groups, liaison offices, technology transfer offices, incubators, research and technology organisations, government development agencies and leading firms) are agents in innovation networks assigned to fill learning, information, knowledge, managerial and systems gaps, and thus to ensure the emergence of network dynamics. Learning gaps arise from differences in norms and incentive systems of actors that prevent network actors from learning from one another's experiences. Information gaps arise due to information asymmetry in which network actors are unevenly informed about cooperation and partnerships and about each other's resources, experiences and competencies. Managerial gaps relate to shortfalls in the capabilities of network actors to acquire and assimilate new knowledge. Systems gaps involve path dependency and innovation implementation in which innovation is determined by the conditions that relate to the existing system. Intermediaries operate in inter-firm networks, clusters, triple helix networks and innovation systems (Klerkx and Leeuwis, 2009).

The network approach to policy making and public management processes has largely been influenced by inter-organisational theory (Kickert et al., 1997). 'Policy network' refers to networks of interdependent actors with different interests and goals in policy processes. Relationships of these actors involve resource dependency. Each organisation possesses some resources in the forms of capital, personnel and knowledge. Organisations need to interact with each other to acquire and exchange resources to achieve their goals. Networking creates zero-plus games or win-win solutions by reconciling the different goals and interests of actors, thus producing a collective action of networks.

Management of networks involves three activities, including intervention in the existing network; consensus building through the creation of rules and mechanisms for coordination; and problem solving by managing interaction and changing institutional arrangements and cultures. These activities are often carried out by a third party playing a brokering role as network manager. The role of the network manager is aimed at creating a coordination mechanism for mitigating the opportunistic behaviour of network players that would potentially undermine the functionality of networks. Thus the network manager would engage in activities involving network activation, arranging and facilitating interaction, mediation, brokerage and arbitration. Where government organisations assume the intermediary role, the role of network manager would include protecting the interests of groups unrepresented in the network (Kickert et al., 1997).

In this chapter, intermediary organisations are discussed, playing their roles as sponsors, brokers and boundary spanners at policy, strategic and operational levels, as shown in Figure 4.1. The broker acting as a network manager could be a specialised centre/institution specific to each industry, established as an *ad hoc* organisation. It is responsible for initiating interactions, pooling resources and ‘satisficing’ across different goals and interests. The resources of sponsoring intermediaries at policy level can be pooled and reallocated to boundary-spanning intermediaries at operational level through initiatives that are mutually agreed through decision-making processes. The boundary spanner provides operational services to industry to achieve collective goals and interests of the network.

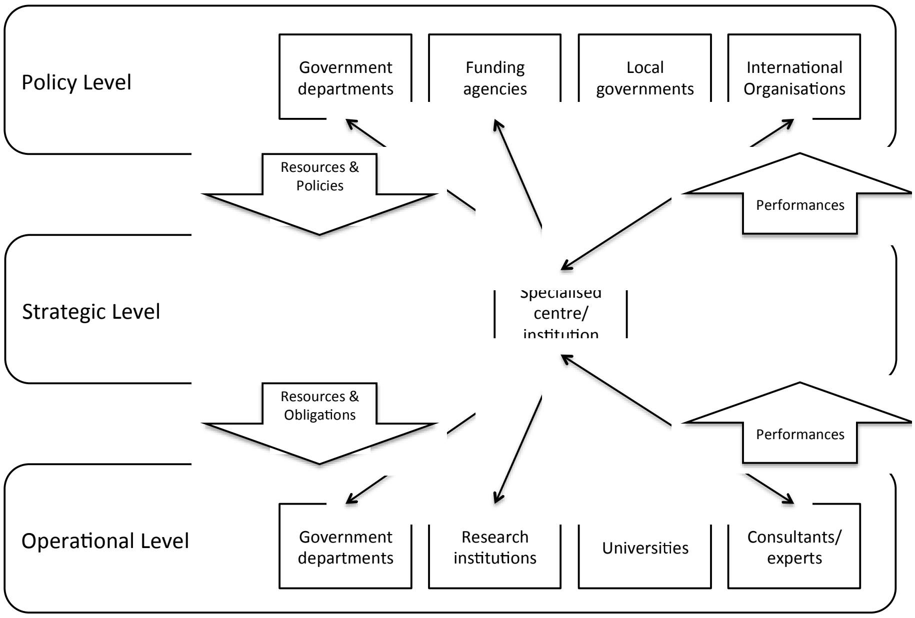



Figure 4.1 System of intermediaries linked through intermediaries playing role at strategic level

Source: Based on discussion of literature

## 4.2 Roles of innovation intermediaries

In this study, the triple helix model of interaction between the three institutional spheres, namely, university, industry and government (Etzkowitz and Leydesdorff, 1995), is used as the overarching analytical framework. However, the triple helix system is not coherently established in developing countries partly because of differences in mission orientation and culture between the triple helix actors, but mainly because of gaps in institutional capacity development. As seen in Figure 4.2, each institutional sphere is kept different from the others by its own boundaries. The role of intermediaries is to bring these institutional spheres in the triple helix domain close together to interact intensively, blurring the boundaries between them, thus making way for the evolution of trilateral networks or network dynamics. Intermediary organisations can arise from any of the three triple helix spheres to expedite interactions between the actors across the three spheres. In this regard, the success of triple helix networks would depend largely on the roles and capabilities of intermediaries. Thus, intermediaries would initiate collaborative initiatives, liaise with actors from the knowledge, production and policy/governance spheres, spanning their boundaries to promote knowledge circulation across the triple helix domain. In a network, there could be more than one intermediary to connect and create knowledge circulation.

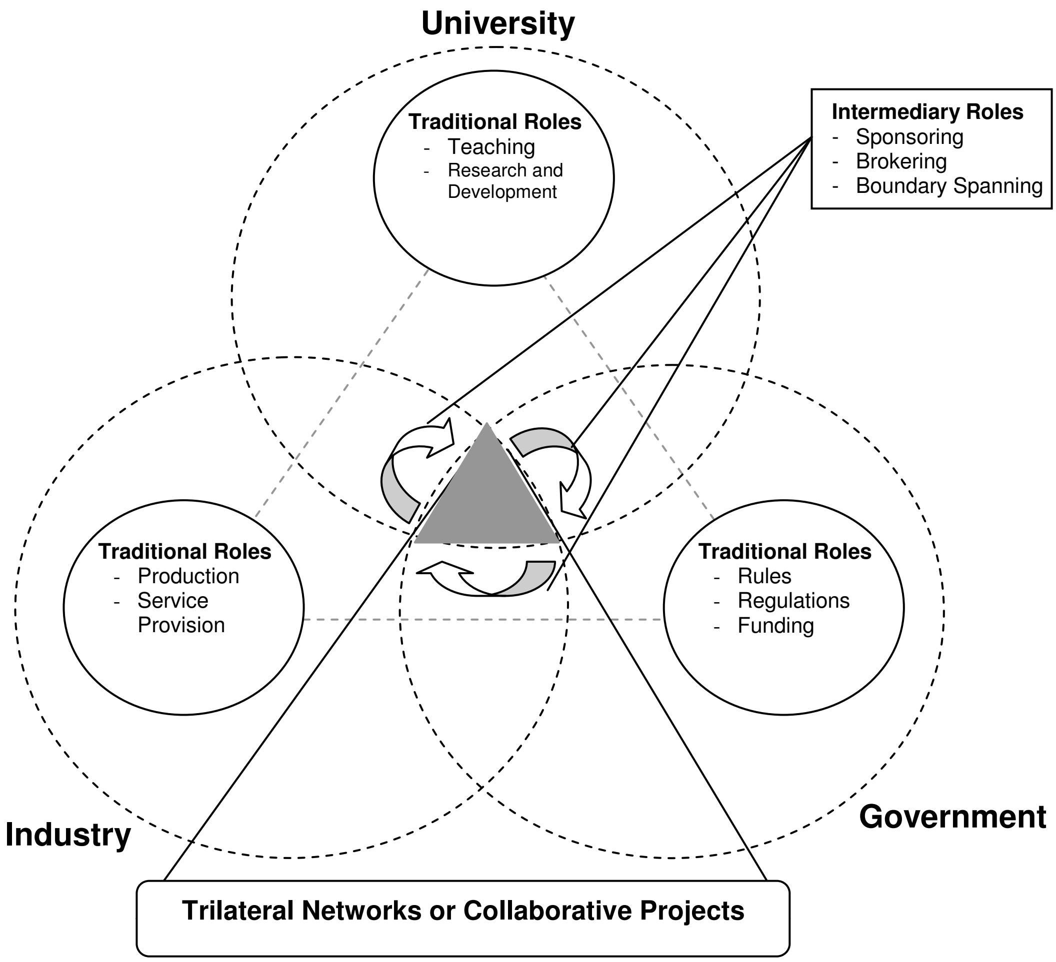



Figure 4.2 Roles of innovation intermediaries in the triple helix framework

Innovation intermediaries are classified into three roles operating at three levels:

- Sponsoring at the policy level;
- Brokering at the strategic level; and
- Boundary spanning at the operational level.

Smedlund (2006) classified the roles of intermediary organisations according to geographical boundaries at three levels: national intermediaries at the macro level; regional intermediaries at the meso level; and local intermediaries at the micro level. At the macro level, national intermediaries involve government policy in creating enabling environment for firms to innovate. Regional intermediaries at the meso level create linkages and collaboration not only between key actors in the region, but also between intermediaries at the macro and micro levels, promoting triple helix interactions. Local intermediaries assist firms to obtain knowledge through networks and the provision of resources on the basis of trust and communication. Smedlund's classification of the roles of intermediaries is based on the experience of a well-planned region in Finland in which intermediaries' roles at the three levels can be distinctly identified. However, in developing countries, the roles of intermediaries cannot be clearly identified with respect to geographical boundaries due to the prevalence of centralised administration and poorly-planned regional development systems. In the circumstances of developing countries, it would be proper to use levels of implementation – i.e. policy (at macro level), strategic (at meso level) and operational (at micro level) – as criteria for classifying the roles of intermediaries.

In many of the studies conducted on innovation intermediaries, the sponsoring role of intermediaries is seen to be of secondary significance in relation to the brokering and boundary-spanning roles (see, for example, Hargadon, 2002; Täube, 2004; Fleming and Waguespack, 2007; Morrison, 2008; Youtie and Shapira, 2008; Klerkx and Leeuwis, 2009; Kirkels and Duysters, 2010). The focus on the brokering and boundary-spanning roles resulted from the concern of policy with technology transfer and its utilisation rather than with its development through innovation. Brokers connect disconnected actors within the community through network building, thus increasing social capital and enhancing possibilities for more effective interactions in terms of knowledge exchange. Boundary spanners work across communities to provide technical services thereby creating the capabilities required for the effective choice and transfer of technologies. The roles of brokers and boundary spanners complement; and while it is possible for boundary spanners to play the role of brokers, brokers would not be able to undertake the role of boundary spanners without technological expertise (Fleming and Waguespack, 2007). Yang et al. (2008) classified the roles of innovation intermediaries at strategic and operational levels. The strategic level relates to the brokering role in building collaboration; and the operational level involves technological and managerial services, which could be considered as the boundary-spanning role.

In addition to the brokering and boundary-spanning roles, Howells (2006) argued that innovation intermediaries should play policy roles to build new possibilities and dynamism. Innovation intermediaries can play the policy role of steering the directions of technological development through sponsoring. Policy makers play a sponsoring role when implementing government policy through the provision of government funding and other mechanisms of support. For Howard Partners (2007), innovation intermediaries are resource providers as well as consultants, brokers, and mediators. Johnson (2009) categorised the roles of innovation intermediaries into five: sponsor, filter, management provider, broker, conflict mediator. Johnson's categories can be reduced to two main roles: sponsoring and brokering. Filtering and management providing roles can be done by sponsors as these roles are necessary for sponsors to ensure that their resources are efficiently utilized through monitoring and management (Braun and Guston, 2003). Brokers can be conflict mediators connecting various types of actors whose interests and cultures are different. In addition to these two roles, innovation intermediaries also play a boundary-spanning role. These roles of intermediaries are discussed in detail below.

### 4.2.1 Sponsoring role

Sponsoring is essentially the primary role of intermediary organisations such as funding agencies, government departments and government development agencies. It involves the task of providing knowledge and technological infrastructure to promote the development of the triple helix culture (Johnson, 2008), and the creation of knowledge networks that facilitate knowledge circulation and enable collaborative projects to thrive (Smedlund, 2006). The sponsoring role of innovation intermediaries covers the tasks of screening, filtering, monitoring, and assessing projects prior to funding (Braun and Guston, 2003).

The principal-agent theory can be used to analyse the principle underlying the sponsoring role of intermediaries (Van der Meulen, 1998). As seen Figure 4.3, an intermediary organisation can be a funding recipient from the government (the principal) and a funding allocator at the same time. The funds are allocated to scientists (the agent) in the knowledge sphere on condition that players in the knowledge sphere work with players in the production sphere (i.e. firms). This is in line with the triple helix framework of strategies designed for promoting innovation and national competitiveness. Sponsoring intermediaries thus act as a catalyst in the evolution of short-term political interests into long-term research policy engagements; in the transmission of policy and allocation of resources to the appropriate agents in the knowledge sphere (Van der Meulen, 1998); and in the monitoring of agents in the knowledge sphere to avoid shirking behaviour (Klerkx and Leeuwis, 2008).

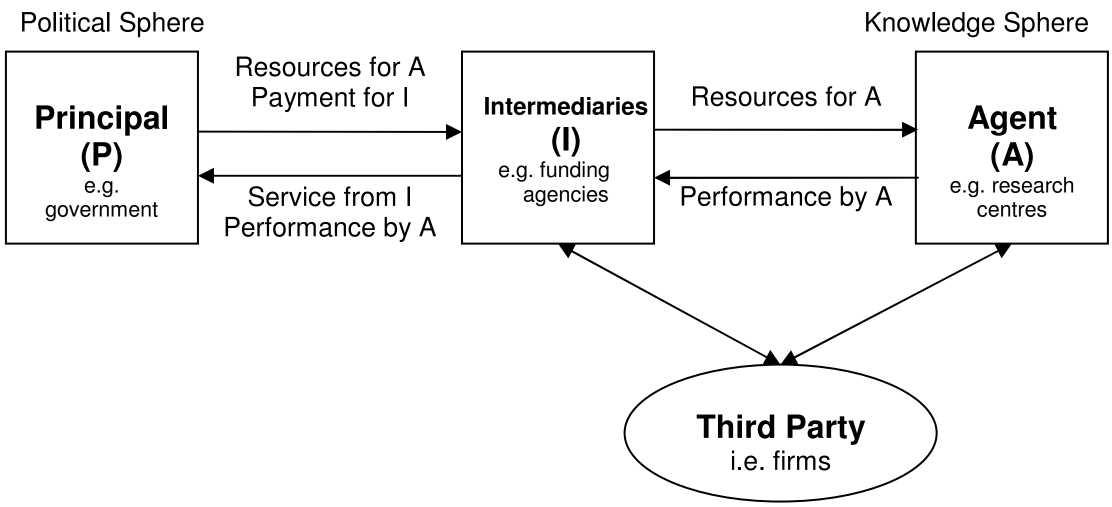



Figure 4.3 Nexus between the principal, the intermediary organisations, and agents in the knowledge and production spheres in the network building process

Source: Adapted from Braun (1993, p. 141) and Van der Meulen (2003, p. 325)

### 4.2.2 Brokering role

As shown in Figure 4.1, the roles that intermediaries play as sponsors, brokers and boundary spanners result not only in the expansion of the domain of activities in the three institutional spheres of the triple helix system, but also in the blurring of boundaries following interactions between the actors across the three spheres. At the strategic level, networks of innovators are formed by brokering intermediaries; so, brokering intermediaries play an important role in forging links between universities, industrial enterprises and government agencies through engagement in collaborative schemes. Intermediaries playing brokering role take, for example, the form of industrial liaison offices, technology transfer offices and research and technology organisations (RTOs).

There is, however, more to the brokering role than this, as networking involves not merely linking actors across institutional spheres, but equally importantly actors within these spheres, so that the gains to be had from the circulation of knowledge can be maximised. Each institutional sphere can be expected to constitute multiple networks. Burt (2004) points out that the behaviour of actors within a network is more homogeneous than that observed between networks. When actors neglect information flow outside their groups and are not connected to each other, ‘structural holes’ arise. The existence of structural holes in open networks creates gaps in information and knowledge flows thus giving rise to the ‘moral hazard’ problem and making the network system somewhat dysfunctional (Ahuja, 2000). According to Burt (2004), structural holes should be closed to minimize opportunistic behaviour and the ‘moral hazard’ problem and to maximize opportunities for social capital formation through brokerage. To do so, brokers require sufficient technological capability to mediate networks by creating trust and recognising possibilities of combination of existing knowledge to create new knowledge.

Activities of brokers involve communication, learning and knowledge exchange. Hargadon (2002) defined ‘knowledge brokers’ or ‘technology brokers’ as intermediaries who connect disconnected actors and recombine their existing knowledge to create new knowledge. Five steps of brokering processes were proposed by Hargadon (2002) as follows:

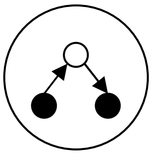
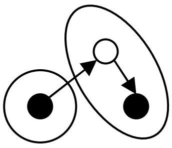
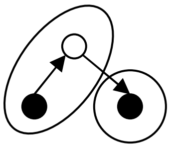
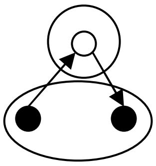
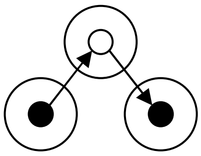
1) Access – to explore existing knowledge of multiple disconnected domains;
2) Bridging – to move existing resources of multiple actors;
3) Learning – to learn existing problems and knowledge;
4) Linking – to share existing knowledge; and
5) Building – to build network ties among disconnected actors and to embed new knowledge or innovation in the actors.

Brokering intermediaries could be one of the innovators or knowledge-based business service providers. Kirkels and Duysters (2010) found that most of the innovation intermediaries linking the science and industrial sectors through the provision of innovation information were science-based non-profit organisations. Brokering might not be the main mission of these organisations, but their main activities involve other actors as third party members (Klerkx and Leeuwis, 2009).

Depending on the nature of its organisation, its resources and the circumstances of its business, a broker can also undertake responsibilities as a coordinator, a gatekeeper, a representative, a cosmopolitan and a liaison as shown in Figure 4.4 (Fernandez and Gould, 1994; Kirkels and Duysters, 2010).

### 4.2.3 Boundary-spanning role

Boundary-spanning intermediaries provide operational services to promote knowledge circulation within and between universities, government agencies and industry. Organisational and technical boundaries are barriers on the interface between different communities (Fleming and Waguespack, 2007). Boundary spanners help to enhance the blurring of institutional boundaries, thus facilitating information and knowledge circulation between different institutional spheres (Wright et al., 2008). Boundary-spanning intermediaries are actors who expand their missions and activities to be able to play additional roles that would help facilitate knowledge circulation. The additional roles involve managerial and technical services at operational level. Thus, boundary spanners would access resources from diverse sources (Aldrich and Herker, 1977). Intermediaries playing boundary-spanning role include, for example, university research centres, government laboratories, and government research institutes.

| Flow of knowledge | Functions of brokers |
|---|---|
|  Coordinator | Enhancing interaction between members of the group they belong to |
|  Gatekeeper | Absorbing knowledge from a group and passing its to the group they belong to |
|  Representative | Diffusing knowledge originating from own group to another group |
|  Cosmopolitan (Itinerant) | Mediating as an outsider between members of the same group |
|  Liaison | Promoting and enabling interactions between different groups of none of which the liaison is not a member |

○ represents brokers ● represents other types of organisations

Figure 4.4 Functions of Brokers and Flow of Knowledge[1]

Source: Fernandez and Gould (1994, p. 1459) and Kirkels and Duysters (2010, p. 377)

[1] A *coordinator* can be seen as a 'local broker' connecting two members of the same group (Gould and Fernandez, 1989). In the triple helix model, a coordinator links and communicates with actors within an institutional sphere. *Gatekeepers* have three main functions in the transmission of knowledge (Morrison, 2008). Firstly, they search for external knowledge related to their firms by connecting with external actors. Then, they adopt such knowledge and adapt it to suit their purpose. Finally, they share their knowledge with actors in the groups or communities they liaise with. A *representative's* work is to connect members of its the group with members of another group. It functions in a similar way as gatekeepers function, except that the flow of information in this case is in the reverse direction. Representatives are in the business of broadly diffusing information and knowledge originating in their groups. *A cosmopolitan* or *'itinerant broker'* mediates between two members of a group of which he/she is not a member. A *liaison* is an outsider who, as an agent, mediates between two actors from two different groups, receiving a command from a principal, who is an initiator, and transmitting it to an agent who is a recipient. An intermediary can simultaneously play the various roles played by brokers. For example, the intermediary can act as a gatekeeper and a representative at the same time, depending on aspects of the actors he/she is liaising with.

In a knowledge-based economy, the new institutional boundaries of actors are expected to be broader than the traditional ones as shown in Figure 4.1 (Benner and Sandström, 2000) because of the active role of boundary spanning intermediaries. Boundary-spanning roles can be played by either individuals, such as well known scientists, academic leaders, industrial executives and government agency heads, or knowledge-based firms and research and technology organisations, such as research institutes and entrepreneurial universities.

## 4.3 Intermediary organisations

Many studies, focusing on knowledge and technology transfer between universities and industry, classified intermediary organisations by considering universities as focal points. For example, Wright et al. (2008) classified types of intermediaries into two: internal and external intermediary organisations. Internal intermediaries are established by universities, such as technology transfer offices (TTOs), incubators and science parks. External intermediary organisations include independent collaborative research centres, entrepreneurs, venture capitalists and regional development agencies. Yusuf (2008) classified intermediary organisations into four types according to the innovation process as follows:

1) *General intermediaries* playing a role as boundary spanners in creating and diffusing knowledge in universities, such as students and university departments;
2) *Specialised intermediaries* playing a role as brokers facilitating transfer of knowledge from universities to industry, such as technology licensing offices;
3) *Financial intermediaries* playing a role as sponsors providing funds and managerial skills in the early stage of commercialisation, such as venture capitalists and business angels; and
4) *Institutional intermediaries*, such as government agencies, playing a role as brokers stimulating knowledge circulation and development of collaboration between universities and industry.

In addition to universities and government agencies, it was argued that industrial and professional consortia, such as trade/industrial associations and professional bodies, should be included as intermediary organisations (Howells, 2006). In this study, intermediary organisations are classified based on the triple helix model into three types: university-based, government-oriented, and market-led intermediary organisations.

### 4.3.1 University-based intermediary organisations

With prospects for the transformation of universities from research-based universities to entrepreneurial universities has emerged the intermediary role of universities. Universities with high research capability attempt to go beyond their traditional role that qualifies them as 'knowledge factories' to be 'knowledge hubs' for economic and social development. The new roles they assume following fundamental restructuring involve them in collaborative research programmes, incubators, spin-off company establishment and university-industry technology transfer and knowledge exchange activities. These activities are considered as the boundary-spanning roles of intermediaries (Youtie and Shapira, 2008).

In the triple helix model, university-based intermediaries are interface organisations stimulating the triple helix interaction by playing their roles as sponsors, brokers and boundary spanners. Intermediary organisations in universities have progressively evolved as cooperative research centres, industrial liaison offices, technology transfer/licensing offices, and incubators (Etzkowitz, 2002):

#### *4.3.1.1 Cooperative research centres*

In the early-stage of university-industry link activities, research units in universities play roles as brokering and boundary-spanning intermediaries. Research groups conducting research have direct access to knowledge and technology from which industry can benefit. Firms can connect with universities directly through personal contacts with academics and students. After the institutionalisation of technology transfer activities, the brokering role of research groups was seen to be on the wane (Etzkowitz, 2002). Since 1980, cooperative research centres (CRCs), representing a new form university-industry liaison sponsored by governments, have been widely established. The difference between CRCs and traditional research units is that CRCs are established as autonomous centres with their own organisational structures, independent of academic departments. The mission of CRCs could, however, strongly appeal to sponsors, including government agencies and industry (Gray, 2000).

#### *4.3.1.2 Industrial liaison offices*

Industrial liaison offices in universities play a role as brokers to initiate cooperation between universities and individual firms or groups of firms (Van Lente et al., 2003). Typically, industrial liaison offices are established to turn personal and informal connections between students, academics and industrial contacts into a formal university-industry relationship. Liaison offices are aimed to serve as intermediaries linking university research groups with industry (Etzkowitz, 2002).

#### *4.3.1.3 Technology transfer/licensing offices*

Technology transfer offices (TTOs) or technology licensing offices (TLOs) are considered to represent organisational innovation, which formalises technology transfer from university to industry on a systemic basis. TTOs generate income for universities and academics through the commercialisation of research results based on the recognition of intellectual property rights (IPR). Thus, the main functions of TTOs/TLOs relate to intellectual property management in liaison with industry, and stimulating researchers to be aware of the benefits to be had due to the commercialisation of their research or the use of their research as a basis for the establishment of spin-off companies. TTOs/TLOs play the role of brokers connecting knowledge producers in the academic sphere and knowledge users in the industrial sphere, thus matching potential partners with the best licensing opportunities (Etzkowitz, 2002).

#### *4.3.1.4 Incubators*

In addition to playing a role as boundary spanners providing subsidised space and entrepreneurial services, university incubators also play a role as brokers linking academic entrepreneurs, who are their tenants, with other entrepreneurs and local organisations (Youtie and Shapira, 2008). Incubators stimulate triadic relationships between university, industry and government and the creation of hybrid organisations arising from trilateral collaborations through the provision of incubation place and managerial supports. Thus, incubators as brokers and boundary spanners stimulate innovative activities through cross-fertilisation of ideas and industrial practices. They also link newly established firms with their existing networks, including business, financial and technical networks (Etzkowitz, 2002). Lyons (2002) showed that incubators in the USA assisted their tenants to analyse obstacles and seek potential partners helping overcome these obstacles. This led to increases in the survival of early-stage companies. In addition to the brokering and boundary-spanning roles, incubators also play a sponsoring role providing financial supports through venture capital services at various stages of firm development (Etzkowitz, 2002).

### 4.3.2 Government-oriented intermediary organisations

Government intervention is necessary in the innovation process and in the process of knowledge creation and its use (Afuah, 2003). First, knowledge is a public good, which is given to non-rivalrous and non-exclusive consumption. Consumption is non-rivalrous when a good or service consumed by one does not pose the problem of diminishing the stock available for consumption by others. Consumption is non-excludable when individuals cannot be effectively excluded from the consumption of a good once the good is made available. These characteristics of non-rivalry and non-exclusivity in the use of education as a public good create a disincentive for individuals to invest in knowledge creation as a business enterprise without the provision of property rights to protect them against free-riders. Moreover, investment in knowledge creation is risky with social benefits arising from it far outstripping private benefits, so that firms would not be keen to invest in it.

Government intervention in the process of knowledge production and innovation takes the following activities: financing R&D; being lead user; providing complementary assets; playing regulatory role; managing macroeconomic fundamentals; ‘babysitting’ and ‘godfathering’ to open market operations; providing training programmes and information centres; and providing political stability (Afuah, 2003). Government uses these roles to stimulate development of the triple helix system through intermediary organisations, including development agencies; funding agencies; and research and technology organisations.

#### *4.3.2.1 Development agencies*

Development agencies play sponsoring, brokering and boundary-spanning roles in the context of a triple helix system. They provide grants and financial supports for regional/rural development, such as investment in community-based enterprise formation. They also stimulate interaction by providing public services (Lee et al., 2005). In Europe, regional development agencies (RDAs) play an important role to bridge knowledge gaps between university and industry through the provision of subsidies and assistance to SMEs. RDAs in Belgium, for instance, created an innovation centre programme hiring consultants to give advice to SMEs (Wright et al., 2008). Development agencies also provide technical assistance to private sector operators by using consultants from the private sector and universities. A development agency, hiring experts to assist firms in the private sector, plays the role of sponsoring intermediary. It becomes a brokering intermediary when it engages in "matchmaking" between consultants and firms (Bessant and Rush, 1995).

#### *4.3.2.2 Funding agencies*

Government funding agencies play a sponsoring and brokering role of intermediaries stimulating triple helix interaction through their resourcing initiatives. Funding agencies and research councils in several countries adopted new system of funding to stimulate collaboration between industrial and academic sectors (Kaukonen and Nieminen, 1999; Benner and Sandström, 2000).

Government financing can be used for the provision of public goods, like knowledge creation, that cannot be expected to be readily provided by firms in the private sector for reasons of non-rivalry and non-exclusivity of consumption characteristics of such goods. Governments also invest partially in some R&D projects to share risks with private sector firms. Financing R&D includes direct and indirect financing measures. Direct funding involves R&D grants for public and private R&D projects. Indirect financing involves tax reduction, soft loans, loan guarantees, export credits and quotas.

#### *4.3.2.3 Research and technology organisations*

Research and technology organisations (RTOs) receive funds from government to play a role as boundary spanners by providing services to industry. RTOs can be considered as hard knowledge-intensive business service providers. In many countries, RTOs were established to facilitate knowledge transfer from R&D organisations and universities to industry. RTOs usually target several users instead of individual firms (Van Lente et al., 2003).

### 4.3.3 Market-led intermediary organisations

Market-based intermediary organisations are ideally placed to play a brokering role in triple helix interactions. As cooperation between players is a zero-plus game, it is possible for profit-seeking firms to operate as intermediaries; and due to the rigidity of the network system in the short term, brokers would benefit from bridging 'structural holes' or disconnected actors across the network (Burt, 2004). Therefore, market-led intermediaries can replace the intervention of short-term government supports where structural holes prevail. Market-led intermediary organisations include: leading firms; consultants; professional and trade associations; and venture capitalists.

#### *4.3.3.1 Leading firms*

Leading firms can act as intermediaries in the circulation of knowledge across networks. For example, in the study of Morrison (2008), leading firms play a brokering role as gatekeepers by seeking and acquiring knowledge from external sources and then diffusing it to local firms. External knowledge mainly involves codified knowledge originating from universities and research organisations. Leading firms have the capability to translate external codified knowledge into firm-specific knowledge. Leading firms, liaising with internal and external actors, span boundaries through the exploitation of external sources of knowledge. However, knowledge sharing largely depends on future benefits arising from use of the knowledge and the level of technological capability of the knowledge recipients.

In addition to playing a brokering role, leading firms in supply chain networks can act as boundary-spanning intermediaries. For example, Japanese automotive assemblers have created networks among their suppliers in order to share knowledge (Robertson and Langlois, 1995). They also provide training and technical assistance to their suppliers to enable them to assimilate new technologies that are essential for upgrading their technological capabilities (Techakanont and Terdudomtham, 2004).

#### *4.3.3.2 Consultants*

Consultants play roles as brokering and boundary-spanning intermediaries, bridging gaps in knowledge transfer processes. In knowledge transfer, recipients would need to have adequate capabilities to explore, select and assimilate appropriate knowledge. Consultants can be either source of technology or assistance providers ready to meet the needs of firms. Consultants can assist firms as boundary spanners by providing technologies, skills and human resources, financial support, business and innovation strategies, operational services, and knowledge about implementation of new technologies (Bessant and Rush, 1995). Consultants also offer training to facilitate assimilation of codified knowledge and experience sharing. Van Lente et al. (2003) considered consultants as knowledge-intensive business services, and classified their services into two categorises as hard services, related to engineering and R&D, and soft services, related to managerial services.

Consultants also play a brokering role through demand articulation and supply identification, and so by connecting knowledge users and suppliers (Bessant and Rush, 1995). In this role, they interface with firms to diagnose and articulate specific needs, and with suppliers of knowledge to identify appropriate solutions. They also engage in the process of learning to recombine existing knowledge deriving from multiple domains to generate innovative ideas and practices that can be applied in new domains of production (Hargadon, 2002).

The relationship between consultants and firms need to be based on trust, which takes time to be firmly established, so that demand and supply are well matched. Consultancy services can be provided either by private sector players in business and industry or players in the academic sector as in the case of entrepreneurial universities. As universities become increasingly autonomous, consultancy is one of the services they provide to business enterprises to generate income. Their activities as intermediaries are, therefore, essentially demand-driven or market-led.

#### *4.3.3.3 Professional and industry/trade Associations*

Industry/trade associations are formed to represent the common interests of firms within the same industry and to enable firms in the industry to share relevant information and knowledge (Van Lente et al., 2003). These organisations play a brokering role functioning as representatives diffusing knowledge of their own groups to other groups and as gatekeepers absorbing outside knowledge to their own groups. In general, industrial/trade associations are established by governments or local authorities to act as intermediaries between sources of knowledge and users of knowledge. In addition to brokering role, professional and industrial/trade associations play a boundary-spanning role facilitating knowledge transfer (White and Christopoulos, 2011).

#### *4.3.3.4 Venture capitalists*

Venture capitalists play intermediary roles as sponsors, brokers and boundary spanners. They engage in the setting up of innovation networks as brokers, while at the same time functioning as sponsors. They have access to technologies and to the ventures they invest in. They can potentially match the technology portfolios of these ventures and are well positioned to create new applications of the technologies at hand and to bridge technology gaps through incremental or radical innovation. They also play a boundary-spanning role providing entrepreneurial and managerial assistance to their customers and monitoring processes with the aim to have the risk of business failure is minimised (Robertson and Langlois, 1995).

Based on the discussions in sections 4.2 and 4.3, Table 4.1 summarises the roles and activities of intermediary organisations, and the capabilities of innovation intermediaries at policy, strategic and operational levels.

Table 4.1 Summary of roles of innovation intermediaries in different implementation levels

| Level of implementation | Policy level | Strategic level | Operational level |
|---|---|---|---|
| Roles | Sponsoring | Brokering | Boundary Spanning |
| Activities | - Formulation and transmission of policy<br>- Provision of supports to implement policy | - Formation of strategy for collaboration and provision of collaborative mechanisms<br>- Creation of linkage between key institutional actors and between intermediaries | - Provision of technical services to facilitate knowledge circulation |
| Intermediary organisations | Government agencies, venture capitalists | Government agencies, universities' industrial liaison offices, leading firms | Government service providers, university research units, cooperative research centres, consultants, leading firms |
| Capabilities | Ability to move funds from government departments to funding agencies | - Ability to create trust through initiation of collective actions<br>- Technological capability to combine existing knowledge to create new knowledge | - Ability to build capacity of other actors<br>- Ability to circulate knowledge between actors |

Source: Nakwa et al. (2012, p. 55)

## 4.4 Conclusion

In the context of the triple helix model, intermediaries act as agents of transformation of institutional actors, enabling them not only to exchange knowledge but also to expand the boundaries of their responsibilities into each other's domain. They thus help create the culture of partnership and collaboration, or network dynamics, which is crucial for the advance of knowledge and the occurrence of innovation (Etzkowitz, 2008). Thus, intermediaries occur as instruments of policy intervention to develop the organisational capacities of the triple helix institutional actors in the knowledge sphere (universities and research centres), production sphere (industry) and policy sphere (government agencies); to stimulate them to interact; and to promote the emergence of network dynamics.

The role of intermediaries is all the more important in the case of developing countries where triple helix relations are dysfunctional with institutional spheres fragmented and the potential actors marginalized while 'structural holes' abound.

The following points arise from the discussion in this chapter.

- Initially, intermediaries would provide resources for the implementation of policies promoting development of the triple helix culture. But they would go further to liaise with actors from knowledge, production and policy/governance spheres, spanning their boundaries to promote knowledge circulation across the triple helix domain.
- Intermediaries intervene as sponsors, brokers and boundary spanners at policy, strategic and operational levels, respectively.
- Intermediaries playing these three roles at three levels should be connected to pool resources, as they mutually agree on different goals and create collective actions.
- Triple helix network can be categorised into three types: university-based, government-oriented and market-led intermediaries. In the long run, market-led intermediaries would be expected to supersede short-term government supports provided by government-oriented intermediaries, as they are less bureaucratic and more efficient and motivated than government-oriented and university-based

intermediaries (Nakwa et al., 2012). The promotion of market-led intermediaries and systemic supports are discussed in section 9.2.1.

These points provide the basis for the following to be explored in Chapters 7 and 8.

- Firms engage in triple helix activities depending on the availability of intermediaries.
- Firms engage in triple helix activities depending on the effectiveness of intermediaries in playing these three roles.

The following chapter will set the empirical context for the hypotheses derived from this chapter and also from Chapters 2 and 3 through a discussion of policy and institutional development in Thailand.

# CHAPTER 5

# A Profile of Industrial and Technology Development and Science and Technology Policies and Plans in Thailand

This chapter aims to set the context for the empirical investigation of the hypotheses of this study. It, therefore, provides a review of the state of policy and institutional environments underpinning industrial and technology development in Thailand. It presents a profile of contemporary Thailand in terms of its economic performance and its achievements in science and technology (S&T).

Thailand has an emerging economy with moderate competitiveness compared to other 59 countries. The main factor which constrains the competitiveness of the Thai economy is considered to be the weakness of the existing science and technology infrastructure (STI, 2012b). As a response to this challenge, a number of policy initiatives have been adopted to improve the S&T infrastructure in the country, including the network system, and facilitate the generation and effective use of knowledge for wealth creation. However, in spite of these initiatives, the S&T basis of the economy still remains too weak to allow the innovation culture to thrive. What then are prospects for triple helix network development in terms of the record of the Thai Government in institutional capacity building, in general, and intermediary institutions, in particular? This chapter is an attempt to address this question.

The chapter is organised into five sections. The first section shows the major features of the macro economy of Thailand, including characteristics of Thai economy and current competitiveness. In the second section, policies and plans promoting economic, industrial, science and technology development are discussed. The third section reviews government supports for promoting technology development in the private sector. The fourth section discusses the characteristics of triple helix institutional actors in Thailand. The last section is conclusion.

## 5.1 Thailand's macro economy

In this section, the macro economy of Thailand is reviewed with focus on the experience of economic development and on factors that bear on the competitiveness of the economy.

### 5.1.1 Economic development

Thailand's economy ranked 30th among 58 countries in a comparative study of the world competitiveness of economies conducted by the International Institute for Management Development (IMD) in 2010 (STI, 2012b). In 2011, its gross domestic product (GDP) was 10.54 trillion baht (351.5 billion USD). It is an upper-middle income country with GDP per head at 160,556 baht in 2011 (approximately 5,350 USD). As seen in Table 5.1, the three most important sectors of Thai economy include manufacturing, trading and agriculture, respectively accounting for 34 per cent, 13 per cent and 12 per cent of GDP in 2011.

Table 5.1 Gross Domestic Product at current market prices of Thailand in 2008-2011

| **Products (million baht)** | **2008** | **2009** | **2010** | **2011** |
|---|---|---|---|---|
| Agriculture | 1,049,743 | 1,036,586 | 1,256,288 | 1,412,191 |
| Agriculture, hunting and forestry | 955,710 | 931,907 | 1,147,416 | 1,301,692 |
| Fishing | 94,033 | 104,679 | 108,872 | 110,499 |
| Non-agriculture | 8,030,723 | 8,004,965 | 8,858,121 | 9,132,077 |
| Mining and quarrying | 315,273 | 306,529 | 346,867 | 384,707 |
| Manufacturing | 3,163,683 | 3,087,741 | 3,603,992 | 3,579,982 |
| Electricity, gas and water supply | 262,027 | 278,108 | 296,733 | 291,109 |
| Construction | 259,223 | 246,076 | 269,376 | 270,027 |
| Wholesale and retail trade | 1,288,332 | 1,272,556 | 1,324,149 | 1,354,892 |
| Hotels and restaurants | 440,173 | 439,720 | 479,056 | 518,675 |
| Transportation, storage and communication | 645,300 | 647,319 | 688,081 | 716,764 |
| Financial intermediation | 354,619 | 368,831 | 410,289 | 482,210 |
| Real estate and renting | 216,681 | 215,839 | 228,860 | 239,919 |
| Public administration and defence | 399,094 | 416,087 | 441,317 | 475,506 |
| Education | 384,444 | 414,924 | 435,339 | 459,890 |
| Health and social work | 168,839 | 177,188 | 185,809 | 198,656 |
| Other service activities | 123,353 | 123,912 | 138,089 | 149,294 |
| Private household | 9,682 | 10,135 | 10,164 | 10,446 |
| **Gross Domestic Product (GDP)** | **9,080,466** | **9,041,551** | **10,114,409** | **10,544,268** |

Source: National Economic and Social Development Board

The Thai economy depends largely on the export of manufactured products. In 2011, the value of its export was 6.7 trillion baht (223.6 billion USD), accounting for 64 per cent of GDP. The manufacturing sector plays an important role by contributing 84 per cent to total exports. As seen in Table 5.2, the top three export industries in the manufacturing sector are electronics, agro-manufacturing and automotive industries, in which each industry accounts for more than 10 per cent of total exports.

The top largest export industries are dominated by multinational corporations (MNCs). As seen in Table 5.3, the top three industries dominated by FDIs are machinery and transportation equipment, electronics and electric appliances and chemicals. From Tables 5.2 and 5.3, it can be seen that Thailand is the manufacturing base of MNCs in electronics and automotive industries, the products of which are mainly destined for exports.

Table 5.2 Thailand's manufacturing exports by product in 2008-2011

| Products (million baht) | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|
| Agro-manufacturing products | 613,645.17 | 605,271.90 | 684,370.14 | 827,195.68 |
| Apparels and textile materials | 240,743.79 | 222,870.90 | 245,968.06 | 251,229.05 |
| Footware and parts | 31,967.30 | 27,117.85 | 25,923.53 | 27,913.05 |
| Electronics | 1,055,664.00 | 945,463.49 | 1,062,980.20 | 985,220.60 |
| Electric appliances | 317,161.57 | 273,705.50 | 332,055.69 | 339,950.99 |
| Metal and Steel | 295,683.81 | 258,846.72 | 263,788.98 | 283,654.22 |
| Automotive | 649,003.22 | 498,955.78 | 709,186.57 | 700,573.07 |
| Aircrafts, ships and floating structures and locomotive | 70,040.47 | 56,298.32 | 53,600.43 | 94,287.60 |
| Machinery and equipment | 406,859.47 | 354,268.93 | 472,557.88 | 505,627.86 |
| Jewellery | 157,732.19 | 137,171.74 | 161,276.60 | 189,294.95 |
| Chemicals | 140,320.17 | 149,986.84 | 180,180.79 | 247,645.38 |
| Petro-chemical products | 265,452.33 | 225,971.13 | 286,035.89 | 359,184.48 |
| Petroleum products | 316,329.14 | 226,694.70 | 273,231.62 | 340,669.27 |
| Photographic and cinematographic instruments | 43,099.75 | 46,548.07 | 60,022.25 | 66,421.95 |
| Optical appliance and instruments | 52,071.70 | 53,764.43 | 65,363.08 | 62,103.57 |
| Toiletries and cosmetics | 63,432.54 | 52,025.91 | 66,199.56 | 73,195.85 |
| Furniture and parts | 44,748.07 | 37,229.66 | 40,644.93 | 38,312.47 |
| Other manufacturing products | 266,923.38 | 246,135.75 | 218,612.60 | 222,898.31 |
| **Total exports** | **5,030,878.09** | **4,418,327.61** | **5,201,998.78** | **5,615,378.36** |

Source: Bank of Thailand

Table 5.3 Stock of foreign direct investments of Thailand in 1970-2010

| Sectors | Stock of FDIs (million USD) |
|---|---|
| Manufacturing sector | 49,634.95 |
| Food and sugar | 2,783.94 |
| Textiles | 1,231.73 |
| Metal and materials | 4,211.23 |
| Electronics and electric appliances | 10,955.75 |
| Machinery and transportation equipment | 14,032.10 |
| Chemicals | 4,835.93 |
| Petroleum products | 967.16 |
| Construction materials | 327.70 |
| Others | 10,288.18 |
| Financial institutions | 7,623.91 |
| Trading | 12,198.61 |
| Construction | 1,927.65 |
| Mining | 3,915.49 |
| Agriculture | 213.76 |
| Services | 6,517.40 |
| Investment and holding companies | 3,196.57 |
| Real estates | 8,221.02 |
| Others | 4,521.54 |
| **Total** | **97,972.21** |

Source: Bank of Thailand

Although large firms, including MNCs, significantly contribute to GDP in general, and exports, in particular, small and medium enterprises (SMEs) are also essential, particularly from the vantage point of employment creation. In 2011, the numbers of large firms and SMEs in the manufacturing sector were 2,274 and 472,195 respectively. Although large firms accounted for only 0.48 per cent of total number of firms, they contributed 66.3 per cent to GDP and 62.37 per cent to total export in 2011. However, SMEs accounted for about 70 per cent of total employment in the manufacturing sector. In manufacturing sector, the top five industries with high proportion of SMEs include printing, wood products, chemicals, metals and furniture. Manufacturing in these industries are resource-based and labour-intensive, thus contributing a relatively small amount to GDP (OSMEP, 2012b).

In addition to registered companies, community-based enterprises (CBEs) also play an important role in employment generation, especially during non-harvesting season when activities in the agricultural sector tend to slow down. The Thai agricultural sector accounts for 37.65 per cent of the total labour force available to the economy, and contributes 12.4 per cent to GDP. Community-based enterprises (CBEs) are driven by self-employed entrepreneurs. In 2011, there were 71,190 CBEs and 280 networks of CBEs with 1,210,177 members. Eighty-two per cent of these CBEs are in manufacturing sector. The largest and second largest industries of CBEs are food processing and local textile industries. The majority of CBEs are located in the north-eastern and northern regions, accounting for 45 per cent and 29 per cent of total number of CBEs.

### 5.1.2 Competitiveness of the Thai economy

At present, Thailand's world competitiveness stands at moderate level. If the economy has not made a major stride yet to improve its international competitiveness standing, it is because productivity growth is constrained as a result of production being resource intensive rather than knowledge intensive (STI, 2012b). The weakness of the country's science and technology infrastructure has much to account for the fact that the knowledge economy has not yet come of age in Thailand.

In 2011, the country's overall ranking in the world competitiveness league table was 30th out of 59 countries (STI, 2012a). Its rankings with respect to economic performance, government efficiency and business efficiency were at medium levels, ranked 15th, 26th and 23rd respectively, which were all above the median rank (see Figure 5.1). However, overall infrastructure, ranked 49th, was well below the median rank. Specifically, infrastructure includes basic, technology, scientific, health and environment, and education infrastructure. The various components of infrastructure, relating specifically to technology, science, health and environment, and education, ranked very low at 50th, 40th, 52nd and 52nd respectively. The main criteria used in the ranking of scientific infrastructure included R&D expenditure, R&D personnel, science graduates, published scientific articles, patents, R&D quality, scientific research legislation, intellectual property rights (IPR) protection, knowledge transfer and innovative capacity of private sector. The factors ranked very low are R&D expenditure, full time equivalent R&D personnel (FTE) per 1,000 people and IPR protection. In addition, education infrastructure was ranked very low. All these are reflective the relatively low labour productivity performance of the country, which was ranked 56th (STI, 2012a).

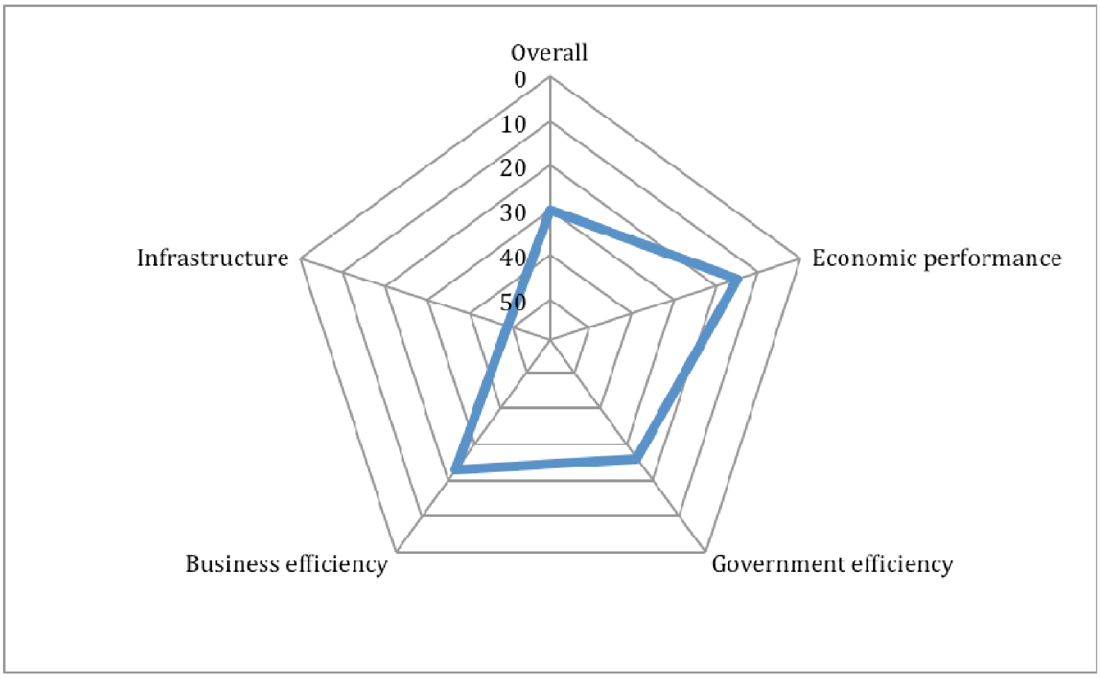



Figure 5.1 Thailand's competitiveness rankings in 2011

Source: IMD (2012)

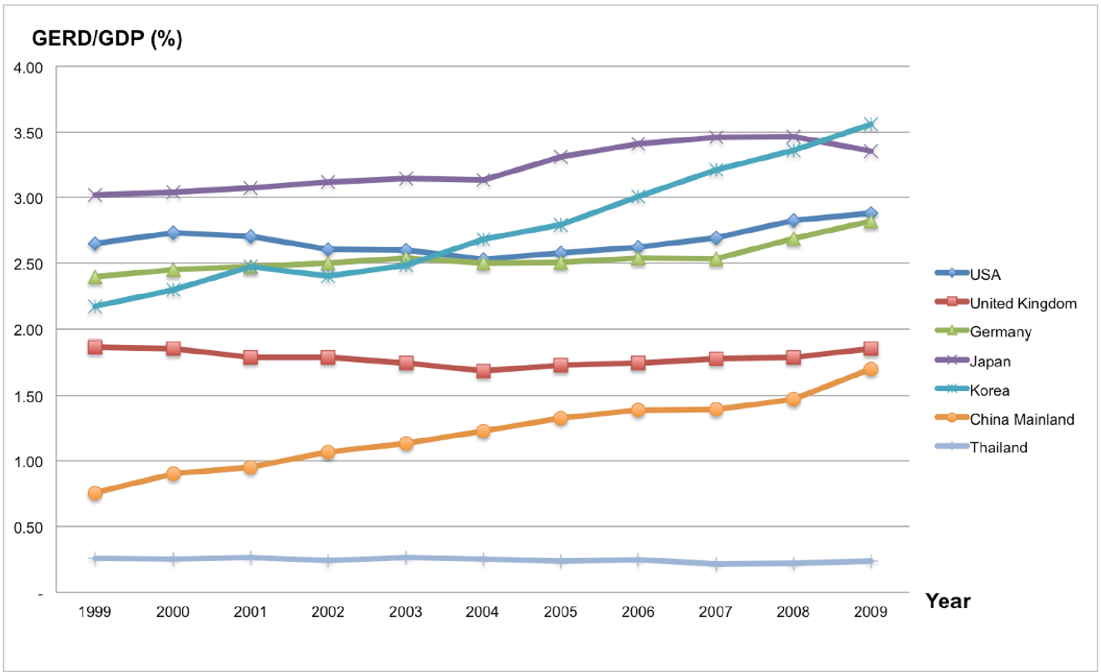



Figure 5.2 Gross expenditure on R&D (GERD) per GDP in 1999-2009

Source: IMD (2012)

Due to the weakness of the science, technology and education infrastructure, the role of knowledge in underpinning economic performance has been limited, particularly in the industrial sector where growth of activities is generally sensitive to technological progress. As it is, production in the manufacturing sector is resource-based, not knowledge-based. Gross annual expenditure on R&D (GERD) remained low at an average level of 438.67 million USD, which amounts to about 0.23 per cent of GDP during the period 2000-2009. Compared to other industrialising countries, Thailand fares low with respect to GERD as a proportion of GDP (see Figure 5.2). In contrast, GERD as a proportion of GDP has increased sharply in other industrialising countries like China and Korea, suggesting that little attention has been paid to knowledge creation activities in Thailand.

Thailand is the manufacturing base of many world-class MNCs, but in-house R&D is not a main activity to improve production. Over the last 10 years, Thailand has doubled its market share of technology products from 1.04 per cent in 2000 to 2.06 per cent in 2010. In 2010, it exported high technology products to the value of about 34,156 million USD, which accounted for 24 per cent of the total export of the manufacturing sector. However, the number of R&D personnel in the private sector was low as was the R&D expenditure. For example, in 2009, business expenditure on R&D was 238.44 million USD, accounting for 38 per cent of GERD. R&D personnel of Thailand were about 57,220 FTEs, or 0.86 FTE per 1,000 people. There were only 8,720 FTEs working in the private sector, accounting for only 15 per cent of total FTEs (IMD, 2012). This means that the majority of researchers worked in government and academic sectors. Moreover, university-industry linkages as well as linkages between government labs and industry are known to be limited in scope in Thailand (Intarakumnerd and Schiller, 2009). During the period 1999-2008, average score on knowledge transfer between universities and firms, surveyed by IMD through interviewing 3,700 mid- and top-executives in 58 countries, was 3.8 (STI, 2012b). This reflects that knowledge created by the government and academic sectors is rarely utilised by the industrial sector.

## 5.2 Policies and plans for development

### 5.2.1 Economic and social development plans

Thailand launched its first National Economic and Social Development Plan in 1961. The first few plans focused on economic and infrastructure development. In the first seven plans (1961-1996), the focus was on economic development, and hence on promoting foreign direct investments and imported capital goods and raw materials to foster the country's strategy of industrialisation. During the course of these plans, conditions of social development and other non-economic objectives of policy were relegated to the background, with the result that the problems of poverty and environmental degradation had become ever so acute (NESDB, 2012).

In the eighth plan (1997-2001), human capital and public participation were the main concerns in policymaking. The aim was to draw balance between the economic, social and environmental objectives of policy and planning. Thus, the eighth plan sought to address social problems by improving the status of human capital through increased investment in education and training programmes. However, the intervention of the financial crisis in 1997 distracted policy focus from long-term strategies for human capital improvement to short-term preoccupation with the challenges of economic recovery (NESDB, 2007).

The focus on economic recovery continued through the ninth plan, which also went further to restore the long-term planning and policy objective of laying the foundation for the development of a self-sustaining economy with thriving economic, social and environmental conditions. In this plan, economic restructuring was intended to increase the contribution of the SME and agricultural sectors to the overall economy. The tenth and eleventh plans continued with the implementation of what was set out in the ninth plan, with particular focus on the task of addressing social problems and providing the conditions for sustainable economic development (NESDB, 2012).

Since the fifth plan (1982-1986), science and technology (S&T) development has been considered as a factor to drive and sustain economic development. The policy and planning trend since has been to develop a knowledge-based economy through the development of the S&T infrastructure of the country.

Although the plans put emphasis on the significance of S&T to industry, this was not matched with success in implementation. As discussed earlier, GERD in Thailand has remained as low as 0.2 per cent of GDP since 2000. The ninth and tenth plans, aimed to raise this proportion to 0.5 per cent; and it was increased to 1 per cent in the eleventh plan. The Ministry of Science and Technology (MOST) was designated to stimulate the private sector to conduct R&D to achieve these targets so that the target of raising GERD to 1 per cent of GDP can be met. However, MOST lacked the capability to connect with firms.

In both the tenth plan (2007-2011) and the eleventh plan (2012-2016), cluster development has featured as a major strategy of industrialisation and the development of knowledge economy in Thailand. The cluster approach was proposed by the National Committee on Competitive Advantage established to follow the Competiveness and Capability Enhancement Strategy in the ninth plan (2002-2006). Questions have been raised, however, as to the effectiveness of the cluster approach there was no evidence of engagement in a deep technology development cooperation. Yet, there was consensus that the problem was not so much with the approach per se, as it was the implementation of it. The cluster approach is necessary to develop supply chains of existing and new industries, and developing a network as a basic S&T infrastructure for the development of triple helix network dynamics and the evolution of the triple helix innovation system (MOI, 2012).

### 5.2.2 Science, technology and innovation plans

Thailand has so far had two science and technology plans. The first plan, i.e. the National Science and Technology Strategic Plan (2004-2012), was proposed by National Science and Technology Development Agency (NSTDA). The second plan, i.e. the National Science, Technology and Innovation Policy and Plan (2012-2021), was proposed by National Science Technology and Innovation Policy Office (STI). The first plan focused on science and technology for supporting the economic sector based on the framework of the national innovation system. The second plan, which encompasses economic, social and environment aspects, is based on the principles of sustainable development.

*5.2.2.1 The first Science and Technology Plan (2004-2012)*

In the first plan, five strategies were drawn up underpinned by the concept of national innovation system (see Figure 5.3). The first strategy addressed target groups of the plan, covering industries that were considered to be of strategic significance for the economy. These industries, including food, automotive, software and microchip, textile, tourism, health and bio-industry, formed the basis for implementing the cluster development strategy. Moreover, the plan sought to promote social development through the provision of support to the development of community-based enterprises (CBEs) in line with the 'One Tumbon (district) One Product (OTOP)' policy. The second and third strategies are about the development of science and technology (S&T) human resources and infrastructure to support the activities of the target industries. The fourth strategy aimed at raising public awareness about the significance of S&T; and the fifth strategy sought to improve and rearrange the S&T management system.

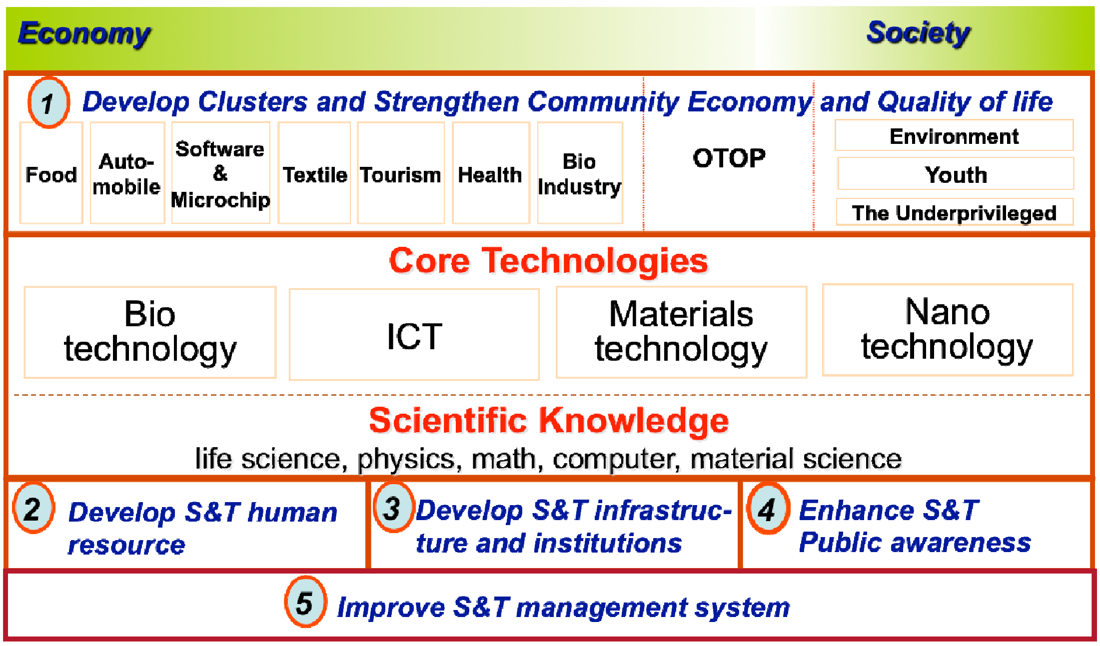



Figure 5.3 National Science and Technology Strategic Plan (2004-2013)

Source: NSTDA (2004, p. 35)

Implementation of the first S&T plan was bedevilled by budgetary constraints. As the centre of plan management, NSTDA designed projects for plan implementation. However, as some national level projects did not match NSTDA's mission, NSTDA's resources could not be committed for their implementation, or else was inadequate for such projects as the development of centres of excellence in universities as S&T infrastructure, which required huge government budget.

Following the failure of the first plan, the National Science, Technology and Innovation Act of 2008 established the National Science Technology and Innovation Policy Office (STI) in 2009 as a government agency under the Ministry of Science and Technology (MOST). STI was then charged with the responsibility of drawing up a new S&T plan that would provide the policy framework for Thailand to evolve as a knowledge-based economy with much enhanced prospect for sustainable development.

#### *5.2.2.2 The second Science and Technology Plan (2012-2020)*

The scope of the second plan is broader than the first one, but the main strategies are quite similar. The second plan is based on the concept of sustainable development, balancing between the objectives of economic and social development and environmental conservation. As can be seen in Figure 5.4, the underlying theme of the plan is 'green innovation' for 'green society', 'green economy', 'green energy' and 'green environment'. The plan identifies five strategies for the development of 'green innovation'. The first strategy is to use S&T to strengthen the environmental awareness and commitment of communities. This is what is meant by 'greening' communities or 'green society'. The second strategy is to use S&T to develop capabilities and innovation with environmental bias to achieve 'green economy'. The third strategy is to use S&T to strengthen energy security, conserve natural resources and protect the natural environment. The fourth strategy is to develop human capital, especially in S&T, to serve the first three strategies. The fifth strategy is to develop the S&T infrastructure and other enabling factors to improve competitiveness of the economy (STI, 2012b). The target groups of the second plan, including industrial sectors, communities and society, are not different from the first plan. The 12 target industries are drawn from new creative industries as well as from agriculture, traditional manufacturing and service sectors. In addition, the last two strategies of the second plan are the same as the second and third strategies of the first plan.

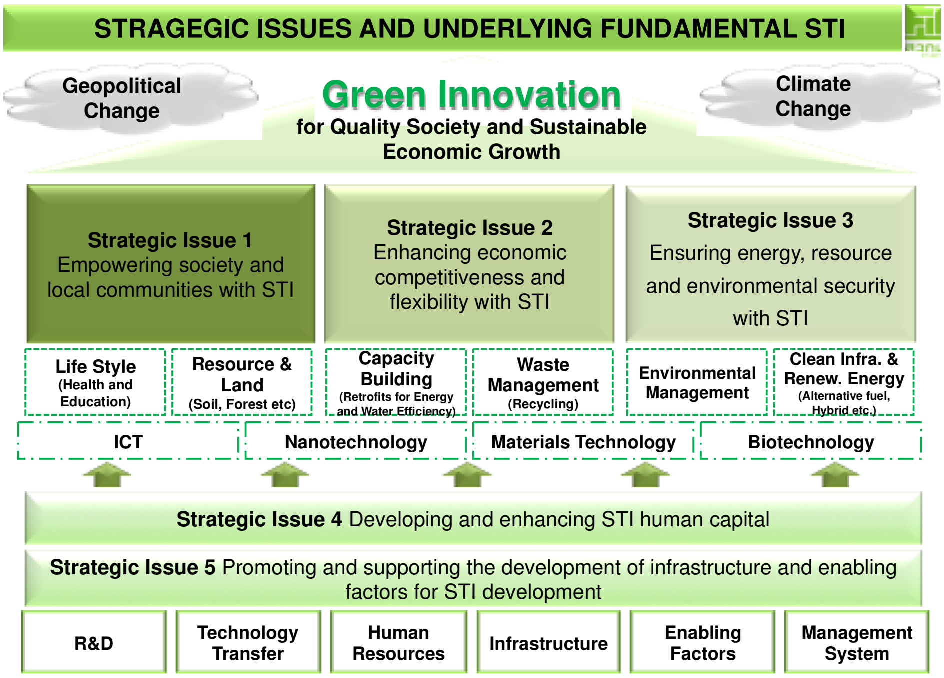



Figure 5.4 The First National Science, Technology and Innovation Policy and Plan (2012-2021)

Source: STI (2012b, p. 71)

Interestingly, the two plans differed significantly in terms of the process of policy formulation and implementation. In the first plan, policy formulation and implementation were carried out as a top-down process, driven by subcommittees, consisting of senior academics and experts in S&T. The second plan is based on a bottom-up process of policy formulation and implementation, taking all stakeholders into consideration through several focus group meetings to provide forum for public participation. The first plan was orchestrated by NSTDA, and did not come to much fruition at the end of the plan period. The second plan was designed as an improvement on the first plan with STI running the show creating action plans and coordinating all stakeholders and related government agencies in the formulation and implementation of the plan.

### 5.2.3 Industrial policy

Thailand has never had national industrial plan until 2012. The former plans of the Ministry of Industry (MOI) are in the form of master plans for specific industries. In addition, there were plans for development in specific areas, such as, Industrial Efficiency and Productivity Master Plan and Intellectual Infrastructure Master Plan (2008-2012). In the 2011, the MOI launched the National Industrial Master Plan 2012-2031 to be a platform for other specific industrial master plans. The plan targets SMEs as objects of policy focus highlighting their significance for the economy and the need for them to be protected against the adverse consequences of globalisation.

Following the eleventh National Economic and Social Development Plan, the first industrial plan, like the second S&T plan, is also implicitly based on the concepts of sustainable development, seeking to draw balance between the economic, social, and environmental objectives policy.

The aim of the plan is to develop the Thai industrial sector to a stage that would establish it as a competitive global market player. It is envisaged that this would be achieved through engagements during the short-term period (5-years); the medium-term period (10 years); and the long-term period (20 years). During the short-term period, policy would focus on the cluster approach to grow and strengthen the SME sector and pave the way for its active participation in the wider Association of Southeast Asian Nations (ASEAN) production system. The plan sets out a strategy for the clusters to be vertically integrated into global value chains and for the capabilities of entrepreneurs to be upgraded through the horizontal cooperation of firms at the same level of value chains. The main aim for the medium term period is to develop the technological capabilities to make Thailand the production, management and R&D centre of the ASEAN region. The aim for the long-term period is to create Thai brands and Thai MNCs, and to move manufacturing bases to other cheap labour countries, like those in sub-Saharan Africa that are also richly endowed with natural resources, while and also exporting services, including knowledge-based workers.

The plan is, needless to say, ambitious in its aims and objectives. For instance, the plan appears to overestimate the country's capacity in human capital development when it stakes the aim to export knowledge-based workers to other countries given the country's current low position with respect to the productivity and efficiency competitiveness of Thai labour. In 2012, the country was ranked 56th on this particular profile in a panel of 59 countries; and its human development index at only 0.3, ranked 54th (IMD, 2012). In view of these limitations, it would be difficult, if not impossible, for Thailand to achieve its planned objectives in the space two decades without huge investment to improve quality of education and human capital, which are the most important for learning and knowledge creation process.

A second critique of the plan is that it lacks internal consistency and joined up thinking as reflected by the discrepancy between the aspiration and the content of it. For example, the focus of the plan is for the most part on economic objectives. Surprisingly enough, the plan did not pay much attention to social development and environmental issues.

Thirdly, the planning process as a whole appears somewhat loose and ineffective as some strategies of the industrial plan are similar to that of the STI plan. This lack of integration, which results from a fragmented approach to planning and decision making, would cause duplication of in the implementation of the budgeting process without enhancing implementation of plan objectives, but wasting resources instead. This raises questions about adequacy of the country's institutional capacity to provide the basis for the transformation of Thailand to a knowledge-based economy over a period of 20 years. There is no evidence as yet to show that significant inroads have been made to mitigate the institutional fragmentation that has hitherto bedevilled the development of the national innovation system (NIS) in the country (Intarakumnerd et al., 2002). This is not, however, to say that the Thai Government has not yet made a serious start in promoting capacity building as a basis for innovation and technology development.

## 5.3 Government supports promoting technology development

The Thai Government promotes R&D in private sector through the provision of tax incentives. All firms conducting R&D can apply for tax deduction of 200 per cent of R&D expenditure through Revenue Department and would be subject to assessment by NSTDA. From 2002-2011, 389 firms with total project value of 4,233 million baht were approved for tax deduction of R&D expenditures (NSTDA, 2011). In addition, the Revenue Department would offer concession for higher depreciation R&D equipment, thus reducing tax of firms conducting R&D. It was found that majority of firms – (about 72 per cent of all applicants) – who applied for this scheme were large firms with registered capital over 200 million baht. About 91 per cent of all applications for project funding relate to small projects with project values less than five million baht (NSTDA, 2011). It should be noted that this scheme might not be attractive and effective to stimulate R&D in SME sectors as mentioned in the National Economic and Social Development Plans.

Apart from the across-the-board type of promotion scheme, Thailand also has other support schemes specific to some industrial groups to promote technology development. Several government agencies are responsible for policies to promote technology development of these industrial groups. These are highlighted in the discussion below.

### 5.3.1 Promotion of multinational corporations

In Thailand, the main government agency supporting MNCs is the Thailand Board of Investment (BOI). Thailand started promoting private investment with the coming into force of the Industrial Promotion Act in 1954. The Board of Industrial Investment was established in 1960 according to the new investment promotion act. Following the establishment of the Board, the Office of the Board of Investment was established in 1966 to work permanently. In 1972, the name of the Board was changed to the Board of Investment with its remit broadened to cover agriculture and service sectors as well. Although the role of the BOI encompasses both domestic investments and foreign direct investments, it is the latter which were preponderant as Thai investors did not have investment capability in the early stage of industrialisation.

In general, the BOI provides exemption of corporate income tax (generally for five years) and import duty on raw materials and machinery for FDIs in several industries i.e. agricultural products, ceramics, basic metals, light, metal products, machinery and transport equipment, electronic and electric appliances, chemical, paper and plastic industries. Recently, however, the focus has been on the promotion of investment of high technology industries – albeit not merely limited to MNCs – to serve industrial policy for sustainable development. Such industries included alternative energy, eco-friendly material products, automotive, biotechnology, electronics, advanced ceramics, aircraft parts and maintenance and medical industries.

The BOI also promotes the technology development activities of the private sector, especially R&D initiatives. It offers additional tax exemption for approved MNC firms conducting in-house R&D and advanced technology training, or supporting funds for academic and research institutions to conduct these activities. This programme is known as the Skill, Technology and Innovation Scheme. The major features of this scheme are shown in Table 5.4. The number of additional years for tax exemption depends on the magnitude of technology development expenditures.

The BOI also has tax incentives to promote R&D collaboration between industry and academic institutions for local firms that have contract-based or joint R&D schemes with universities and research institutes. The provision is that firms with at least 51 per cent of their shares held by Thai residents can be exempted from import duty for R&D equipment and from corporate income tax at 70 per cent of R&D expenditure for three years, but not in excess of 10 million baht.

Table 5.4 Skill, Technology and Innovation Scheme by Thailand Board of Investment

| **Skill, technology and innovation activities** | **Additional years (but not exceed 8 years)** | **Expenditures (the less amount)** |
|---|---|---|
| - R&D<br>- Design<br>- Advance technology training<br>- Supporting universities or research institutes<br>- Donating to technology and human resources development fund | 1 year | Not less than 1 per cent of sales in the first 3 years, or less than 150 million Baht |
| | 2 years | Not less than 2 per cent of sales in the first 3 years, or less than 300 million Baht |
| | 3 years | Not less than 3 per cent of sales in the first 3 years, or less than 450 million Baht |

Source: Thailand Board of Investment

Apart from the provision of tax incentives, the BOI established the BOI Unit for Industrial Linkage Development (BUILD) in 1992 to provide the framework for the creation of linkages between local firms and MNCs in strategic industries, including the automotive and electronics industries. BUILD creates both backward and forward linkages of local firms through, for example, participation in exhibition fairs both locally and abroad, negotiated arrangements and technology visits. It also helps matching buyers and manufacturers in related industries through its website.

### 5.3.2 Promotion of small and medium enterprises

As SMEs constitute an important component of the Thai economy, several government agencies are charged with the responsibility for promoting the sector. For example, the Office of Small and Medium Enterprises Promotion (OSMEP) are responsible for the formulation of policy and plans for supporting SMEs. With respect to access to credit facilities, there are few specialised financial institutions providing financial support to SMEs. The SME Bank provides loans and financial services. Thai Credit Guarantee Corporation provides credit guarantee for SMEs to easily access loans from commercial banks. There are also several government agencies providing a variety of services to SMEs, but insofar as these government agencies did not coordinate to integrate their activities, they are known to have been more costly than effective in their services to SMEs (OSMEP, 2012a).

There is consensus among planners and policy makers that technology and innovation development in SMEs would contribute significantly for the sustainable growth of the Thai economy. The competitiveness of SMEs can be improved through skill creation, knowledge accumulation and the promotion of creativity culture. The plan targets SME development in those industries that are creative and technology-related, and that are engaged in agro-business, trading services and tourism. In the implementation of the plan, the OSMEP is designated to coordinate related government agencies. However, there is no clear mechanism that would allow these related government agencies to collaborate in providing services to SMEs (OSMEP, 2012a).

For all that, there is no shortage of government supports for promoting technology development in SMEs. For example, the Industrial Technology Assistance Program (ITAP) of NSTDA provides technical assistance for Thai SMEs by matching SME-based projects with researchers from universities and providing partial funding for firms to develop projects. In addition, technical assistance programmes are provided by several government agencies, like ITAP by NSTDA; Consultant House by Department of Industrial Promotion; and consultancy services by government specialised institutes.

The government also provides financial incentives for technology development activities in SMEs. For example, Company Directed Technology Development Programme by NSTDA provides low interest loans, not exceeding 75 per cent of project value on product development, process improvement, laboratory establishment, reverse engineering, prototype development and R&D commercialisation. Similarly, the National Innovation Agency supports innovation investment by paying 3-year interest on loans of SMEs with good innovation portfolio eligible for commercialisation.

### 5.3.3 Promotion of community-based enterprises

In Thailand, a programme of ‘rural industrialisation’ has long been pursued to create alternative occupations to agriculture. In 2001, the government launched the so-called ‘One Tambon (district) One Product’ (OTOP) programme to encourage communities to establish community-based enterprises (CBEs) manufacturing products indigenous to each district. In this programme, government supported the improvement of product quality and the marketing of products locally and abroad. In addition, government provided financial resources through a village fund programme that aims to support microcredit for marginalised people who cannot access bank loans. The cluster approach launched by government in 2004 has been widely adopted in the CBE sector. CBEs are encouraged to create networks with other CBEs that are in spatial and technological proximity to share knowledge and capture larger markets. Recently, the notion of local identity, which is believed to provide a stimulus for increasing trust, cooperation and social capital (Lee et al., 2005), was introduced for branding and marketing CBEs products.

The CBE Promotion Act came into being in 2005 to register and certify CBEs to apply for government support. The Act provides for the Department of Agricultural Extension to be responsible for promoting CBEs. In addition, each province has its own provincial CBE Promotion Committee to formulate policy, plans and support systems specific to its community of enterprises and to coordinate with related government agencies to pursue CBE promotion policy.

CBEs draw support from local government as well as central government in form of grants, loans, training, certification, technology transfer and technical assistance. Local universities play an important role in creating knowledge supporting CBEs through technology transfer and technical assistance. Because CBE products are traditional with specific marks of local identity, the technologies used for supporting their production are usually indigenously developed by local experts. Some universities have specialised centres to assist CBEs by providing consultancy services as part and parcel of their 'third mission' initiatives to assist communities. Universities are supported in this effort through additional budget allocation by both central and local governments.

Some government agencies also have mission to assist the CBE sector. For example, Clinic Technology Programme of the Office of Ministry of Science and Technology provides technical assistance in the form of consultancy and training in collaboration with universities and other government agencies. Similarly, the Department of Industrial Promotion also provides technical assistance to CBEs in the management and development of local knowledge and innovation. The Department of Science and Service also conducts R&D services specific to CBEs. Its R&D covers areas of industrial activity, like materials, ceramic, herb and food in which Thailand has competitive advantage.

## 5.4 Institutional capacity for knowledge production and wealth production in Thailand

### 5.4.1 State of institutional capacity in the knowledge sphere

Universities are essential vehicles in knowledge production and its transfer to local firms. In developing countries, like Thailand, knowledge used in manufacturing sectors comes from MNCs, or comes with technology hardware acquired by local firms. The Thai knowledge sector, including institutions of higher education, has low capability to provide effective service to the industrial sector. Most universities in Thailand have only ability to absorb knowledge from outside and assist local firms to absorb such knowledge. In Thailand, knowledge flows from MNCs to universities (Liefner and Schiller, 2008; Intarakumnerd and Schiller, 2009). Therefore, university-industry linkages are more important for local firms than for MNCs (Techakanont and Terdudomtham, 2004).

The main problem impeding the development of university-industry linkages is the governance system in which a statist regime underpinned by a top-down bureaucratic administrative order would preclude options for the emergence of a university-industry network. Under such system of governance, the 'third mission of universities' would be an alien concept, as it was for Thai universities until the financial crisis in 1997 when universities were forced to be autonomous in order to reduce burden on government budget. The autonomy status would allow universities to create links with industry to gain additional revenue from industry to supplement the amount they are allocated by the government. Autonomous universities tend to develop entrepreneurial culture focusing on industrial R&D and providing skills in accord with the needs of industry. Autonomy has not however made all universities entrepreneurial, although it can be argued that this may be long coming. Some have yet to develop the capabilities to interact with industry on a commercial basis, and would in the meantime remain heavily dependent on government funding. Others have evolved enhancing their networking capabilities and their image nationally and internationally. For example, the first autonomous university of Thailand, King Mongkut's University of Technology Thonburi, which has established links with several industries over the last 10 years, is currently the only Thai university in the top 400 of Times Higher Education World University Ranking in 2012-2013 (THE, 2012).

Another factor impeding the development of university-industry links in Thailand is the lack of investment in infrastructure to underpin sustainable knowledge production. The competitiveness of Thailand's education infrastructure was, for example, ranked

52nd among 59 countries (IMD, 2012). Moreover, the interviews conducted for this study confirm that most Thai universities cannot engage with industry because they do not have the required equipment and expertise to cater for the technology needs of industry.

### 5.4.2 Constraints on the production sphere

Although Thailand has been a popular manufacturing base for many MNCs that were attracted to it mainly by its cheap labour supply, it has not yet reached the stage of being the R&D base of MNCs, largely because it does not have the R&D capacity, especially in terms of the supply of qualified human resources (Wongdeethai et al., 2010). MNCs operating in Thailand used technologies that are for the most part developed in and transferred from their home countries. Some Thai subsidiaries of MNCs operate in-house R&D projects, but these projects are aimed to adapt the technologies they use for production to local market circumstances. The extent of innovation deriving from such R&D exercises is limited. At best, the exercise could result in incremental innovation (Intarakumnerd and Schiller, 2009). In some industries, MNCs are quite isolated and do not have many links with local firms. This is because in the early stage of industrialisation when MNCs were attracted to Thailand, they were not under any policy pressure to engage local firms in their supply chain system (Intarakumnerd, 2005, 2007). In the circumstances, the transfer of knowledge from MNCs to local firms, especially SMEs, has been slow and shallow (Intarakumnerd and Schiller, 2009). Factors limiting the pace of technological learning and upgrading of SMEs include: lack of motivation and effort; lack of a mechanism of learning from MNCs; technological capability gaps between MNCs and SMEs; and low absorptive capacity of SMEs (Punyasavatsut, 2007). It was found from interviews conducted for this study that most Thai SMEs attempt to create their competitive advantage through marketing rather than through technology development. It was also found that CBEs that were established and supported by government policy are more initiated and motivated to learn and engage in technology development activities than SMEs. Unlike SMEs, CBEs have been helped in their effort by the intervention of some government agencies, creating networks between CBEs and providing them with mechanisms for knowledge exchange. However, CBEs rarely forge links with SMEs and MNCs because most of them produce final products that would not qualify them to participate as players in supply chain systems.

### 5.4.3 Issues relating to the governance and policy sphere

A major problem undermining the effectiveness of governance in knowledge production and wealth creation is the fragmentation of institutions and decision-making mechanisms, with the result that one government agency does not know what the other is doing and there is wasteful duplication of effort in, for example, the provision of incentives and supports. Government agencies are characteristically bureaucratic in their organisational culture given to delays and red tapes in decision making. Moreover, keen to extend their sphere of influence in keeping with the bureaucratic tradition of centralisation of power, they tend to compete with one another rather than complement each other. For instance, some government agencies, like ITAP and Northern Science Park in the local textile industry, are known to compete with each other for customers, as do the several government agencies under the Ministry of Industry and Ministry of Science and Technology engaged in the provision of technical assistance and consultancy services. Although policy direction is clear, the lack of coordination among different government agencies makes implementation of it ineffective. The prevailing organisational and management systems in Thailand, which is largely based on bureaucratic culture, has had the adverse effect of fragmenting governance, making it ineffective in the control and regulation of the processes of knowledge production and wealth creation. Thus, as will be seen in Chapter 9, for lack of an integrated policy and administrative framework, cluster networks, university-industry networks and triple helix networks have not yet fully evolved to generate network dynamics and transform knowledge exchange networks into self sustaining innovation systems. Thailand would need a major initiative in institutional capacity building to overcome this problem and set the basis for the development of well-functioning innovation systems at sectoral, regional and national levels.

Over the last 10 years or so, the Thai government has provided a range of measures to support the engagement of private sector enterprises in technology development activities. However, business expenditure on R&D (BERD) has hardly picked up from its low level. In 2009, BERD accounted for 38 per cent of GERD. As seen in Figure 5.5, the proportion of BERD to GDP has remained the same at less than one half of one per cent. This proportion for Thailand is much lower than that of its competitors in the same region, i.e. Singapore and Malaysia.

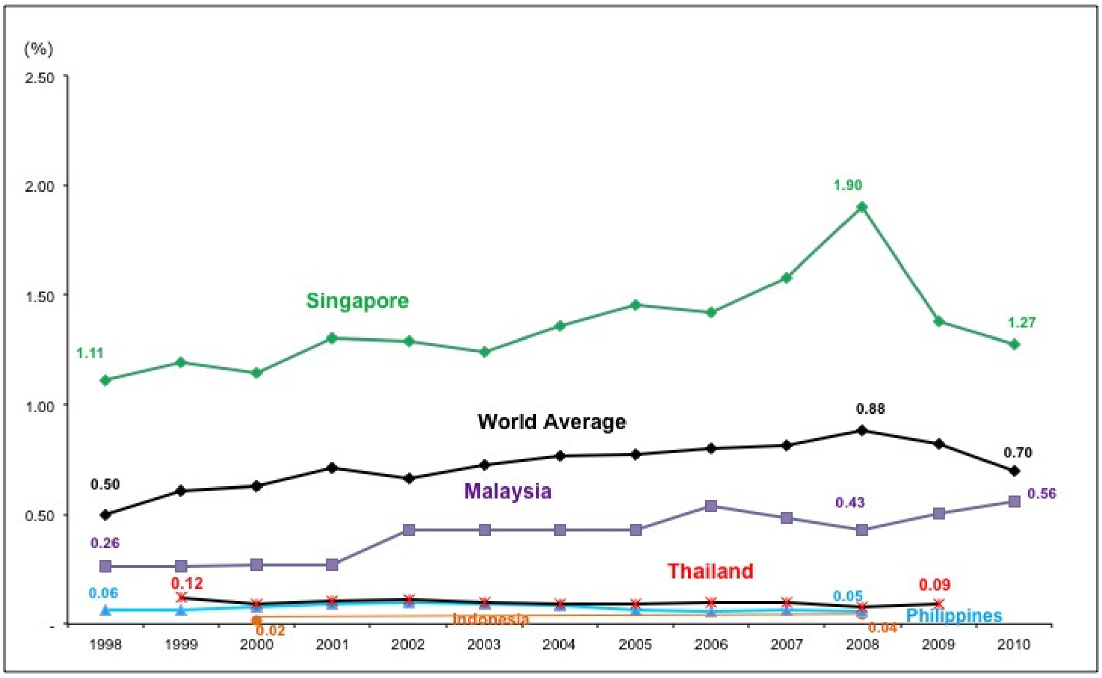



Figure 5.5 Proportion of business expenditure on R&D to GDP of ASEAN countries

Source: IMD (2012)

## 5.5 Conclusion

In this chapter, the status of economic, industrial and science and technology development of Thailand is reviewed. Thailand is a middle-income developing country, and its economy has grown quite rapidly over the last three decades. The question is whether this growth performance can be sustained over the long run insofar as much of it is attributable to growth in factor inputs without much learning, knowledge accumulation and the occurrence of innovation and technological change (Promwong, 2001).

To be competitive on a sustainable basis, Thailand has yet to develop its knowledge infrastructure, including R&D, science and technology and general education infrastructure. Attempts have been made to promote knowledge infrastructure development through several plans. However, these attempts have been found to be either inconsistent, ineffective or inadequate to stimulate the emergence of a knowledge economy and improve the position of the country's standing in the international competitiveness league table.

The current science and technology and industrial policies follow the National Economic and Social Development Plan, which recognises science and technology to be an essential basis for the achievement of sustainable development. But as discussed in this chapter, the problem is not in the plan as such but in the implementation of it because of the prevalence of institutional rigidities and fragmentation which limit the scope for network development; constrain the diffusion of knowledge and its effective use across the economic spectrum for wealth creation; and inhibit the development of network dynamics that translate learning and knowledge accumulation into innovation and technological progress.

Links between knowledge producers and users are essential to ensure that government R&D spending is put to effective use. However, in its present form, the triple helix network in Thailand is effectively dysfunctional with the triple institutional actors not being in a position to enable the triple helix system of innovation to emerge. In this study, it is argued that intermediary organisations are necessary to facilitate interactions between these triple helix actors.

From the discussion in this chapter, it can be surmised that the effectiveness of the roles intermediary organisations play is conditional on the prevailing state of institutional capacity and the stability of governance. Based on this understanding, the roles intermediaries play and the significance of their functions for the emergence of the triple helix innovation system are discussed in Chapters 7 and 8.

# CHAPTER 6

# Research Design and Methodology

In this chapter, the research design of the study, including data collection and data analysis, is discussed. Data for the study were collected through document reviews, interviews and questionnaire administration. Documents or archival reviews and interviews are used to collect network-level data, including data about the formation, operation and the principal actors of networks. Questionnaires are used to elicit firm-level data. Data collected through interviews are used in narrative analysis and case studies, while data from questionnaires are quantitatively analysed using statistical methods.

This chapter is organised in five sections. The first section explains the research design, including the methods of investigation used in this study. The second section is about the sample population surveyed by questionnaires. The third section describes the data collection methods, including document reviews for archival data, and interviews and questionnaire administration for primary data. The fourth section discusses the methods of data analysis. The fifth section draws the conclusion to the chapter.

## 6.1 Research hypotheses and framework

From the discussion in the preceding four chapters, it can be seen that:

- Participation in innovation network, especially the triple helix network, benefits networked firms by providing access to complementary resources and knowledge for technology development activities;
- The combination of these complementarities culminates in the emergence of knowledge and network dynamics and radical innovation;
- Networking between triple helix institutional actors in Thailand is constrained by differences in culture, inadequate technological capabilities of actors, and fragmented institutions;

- Intermediaries play three roles at policy, strategic and operational levels as sponsors, brokers and boundary spanners, thus making the triple helix network functional and enabling it to evolve into a system; and
- Intermediaries can play their roles in the formation of triple helix network through the transformation of pre-existing networks, which can be seen in two forms as vertical supply chain networks and horizontal industrial associations.

Based on these points and the conceptual underpinnings thereof, the following hypotheses are proposed to be empirically investigated (see Chapters 7 and 8):

H1: Firms are responsive to triple helix intermediaries in order to exploit access to resources, including technological and financial resources, through increased relational capital.

H2: Firms engage in triple helix networks activities depending on:

(I) the availability of incentives for participation, including the availability of intermediaries;

(II) the effectiveness of intermediaries providing resources and services;

(III) the degree of their technological capability development;

(IV) their experiences in pre-existing networks.

Figure 6.1 shows how the objectives and hypotheses of the study are linked throughout the thesis.

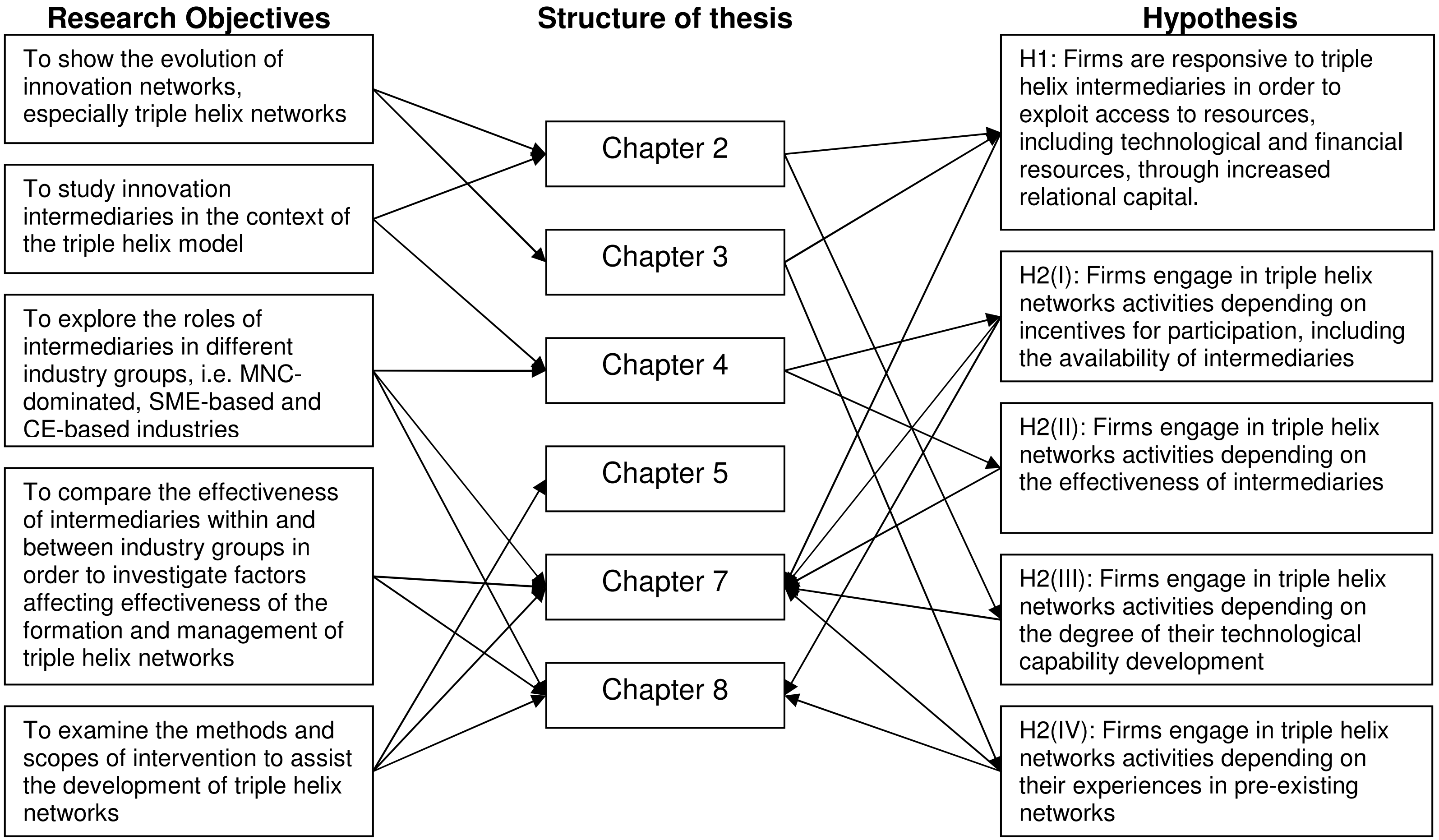



Figure 6.1 Linkages and structure of thesis

## 6.2 Research design

This study makes use of both qualitative and quantitative methods of analysis. Qualitative methods provide internal validity, in which causality can be identified. Quantitative methods provide reliability and external validity, in which indicators are equally measured, and the findings can be generalised (Bryman, 2008). Qualitative methods are applied to elicit and analyse data at network level, whereas quantitative methods are aimed at firm level.

Network-level data were elicited through interviews and document reviews; firm-level data were collected through questionnaire administration and structured interviews. The firm-level quantitative data are analysed using statistical methods. The network-level qualitative data are used in case studies to shed more light on the conceptual framework reviewed in Chapter 3 and Chapter 4 and to complement the findings from the analysis of the survey data in order to achieve reliability and validity of the findings. Figure 6.2 graphically summarises the research design of this study.

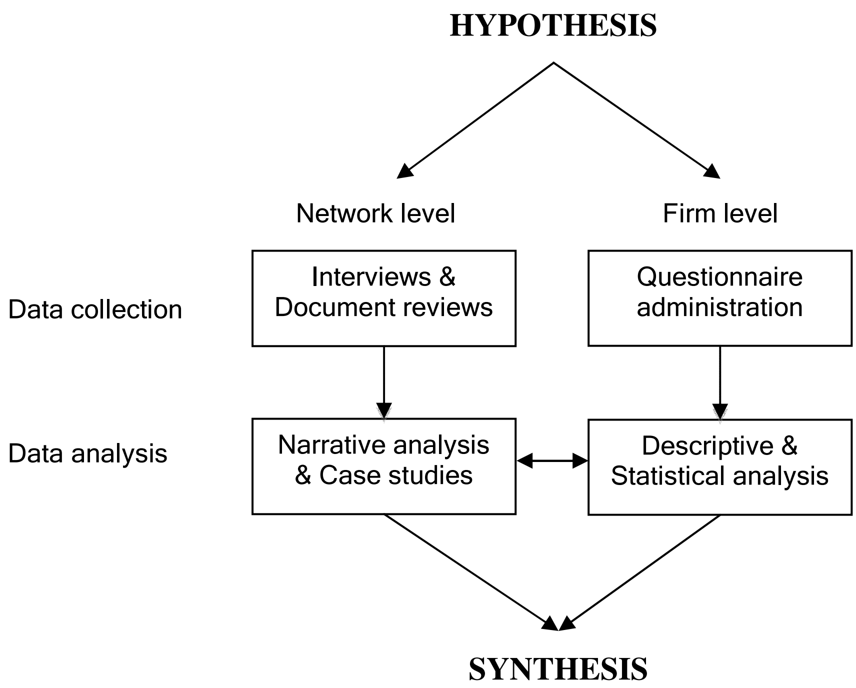



Figure 6.2 Research design

### 6.2.1 Network-level data

At network level, data needed relate to the formation, operation and specification of the principal network actors. The key actors playing dominant roles in the formation and operation of networks were selected for interviews to provide longitudinal data about networks. These key actors can be considered as representatives of industry, universities, and government agencies. They were asked about the initiation, formation, operation and management of networks, their roles and the roles of other actors in networks. They were also asked to identify actors playing sponsoring, brokering and boundary spanning roles of intermediaries in their networks. The feedback from the interviews was built into the questionnaires, thus making the sample survey more focused, the questions asked more pointed and clear and appealing to the respondents.

### 6.2.2 Firm-level data

The firm-level data collected through questionnaires relate to linkages of firms with other triple helix actors playing their 'traditional' and 'additional' roles (see sections 2.4.2 and 4.2). Various studies on intermediary organisations used linkages of firms with other actors to identify dominant actors playing intermediary roles (Kodama, 2008). Morrison (2008) explored the network of leading furniture firms in an industrial district by using structured questionnaire to elicit the number of links forged by firms with other firms and organisations. Kirkels and Duysters (2010) used a snowball approach to questionnaire survey to obtain lists of actors of a social network. These studies used the number of links and of partners to find dominant actors who could play the role of intermediaries, and to assess the effectiveness from the type of linkages.

Issues relating to linkages between firms and triple helix actors, including universities, government agencies and other firms, are the basis for the questionnaire design. Linkages in various activities with various kinds of actors were explored through the questionnaire. These data can be used to see the extent to which firms have linkages with intermediaries and triple helix institutional actors playing their traditional roles. In addition, questions about the basic information of firms, such as age of firm, sales, profits, technological resources and capability levels, were included in questionnaires. Firms were also asked to assess the benefits and effectiveness of intermediaries playing roles in the triple helix network as sponsors, brokers and boundary spanners.

### 6.2.3 Processes of data collection and analyses

Network-level data collection was conducted before firm-level data collection. Data about the existence of networks were explored through document reviews. Following the document reviews, interviews were conducted to elicit network-level data about the formation and operation of networks and about key actors in such networks. The organisations from which the key actors in the six industries were extracted were referred to in the questionnaires to enquire if the respondents have had any links with them. The questionnaire administration was conducted in three rounds by post, personal delivery and structured interviews to increase response rate.

Data were analysed using the narrative, descriptive, statistical and case study methods based on the following procedure. First, network-level data were analysed to tell stories and real-life events about the formation and operation of triple helix networks. Second, firm-level data collected through a questionnaire survey were analysed using descriptive statistics to validate the results of the narrative method. Third, parametric and non-parametric statistical analyses were used to test hypotheses H1, H2(II) and H2(III). Fourth, multi-case studies of three industry groups were conducted to corroborate the results of the quantitative analyses. In order to conduct the case studies, key persons from Hard Disk Drive Institute and TH Alliance (for HDD industry); Ceracluster and Ceramic Industries Development Centre (for ceramic industry); and Nadao Community Enterprise (for local textile industry) were interviewed again to obtain more details of their networks.

## 6.3 Population and sampling

The survey designed for this study covers six clusters in three industry groups of the Thai manufacturing sector. The industry groups include those that are MNC-dominated, SME-based and CE-based. Altenburg and Meyer-Stamer (1999) categorised industrial clusters into three according to firm size and market orientation: clusters of micro- and small-scale enterprises producing low quality goods for domestic markets; clusters of mass producers producing goods for import substitution; and clusters of multinational corporations producing for both domestic and international markets. In each industry group, two industries were selected according to cluster initiatives, significance and contribution to the economy as discussed in Chapter 5. For the MNC-dominated group, automotive and hard disk drive industries (covering the majority of electronics products) were selected, these being the two largest industries driven by foreign direct investments (FDIs). For the SME-based group, ceramic and furniture industries were selected. For the CE-based group, local textile and rice cracker industries were selected. The pilot projects of the government in cluster formation included these industries because of their economic significance and their locational concentration. Some of these selected industries are familiar to the researcher, which is an advantage, particularly with respect to the conduct of the survey.

### 6.3.1 Population of firms in the six industries

There is to date no database of firms across industries, and so the actual size of the population of firms is unknown. The existing databases are for members of specialised institutions who keep records the activities of their members. For example, the population of firms in the automotive industry can be obtained from the Thailand Automotive Institute. A list of producers in the hard disk drive industry was obtained from the Hard Disk Drive Institute report. The lists of firms in the ceramic and furniture industries were obtained from the websites of the Ceramic Industries Development Centre and the Federation of the Thai Industries, respectively. The list of local textile producers in the northern region was obtained from members of the Knowledge and Technology Centre of Northern Textile. The list of rice cracker firms was collected from Thaitambon.com, the website of CE-based firms. These lists of members were obtained from the websites of relevant institutions and also from pointers by those involved in the interview process. As can be seen in Table 6.1, the total population of firms in the six industries is 930. Almost half of these are in automotive industry. The smallest industry is rice cracker, which consists of only 25 firms.

Table 6.1 Populations and respondents of six industries

| Industries | Population of firms | Returned Questionnaires | Respondents | Response rate (per cent) |
|---|---|---|---|---|
| 1. Hard disk drive | 63 | 2 | 7 | 11.47 |
| 2. Automotive | 435 | 12 | 43 | 10.17 |
| 3. Furniture | 113 | 2 | 17 | 15.32 |
| 4. Ceramic | 225 | 10 | 30 | 13.95 |
| 5. Local textile | 69 | - | 31 | 44.93 |
| 6. Rice cracker | 25 | - | 17 | 68 |
| **Total** | **930** | **26** | **145** | **16.04** |

### 6.3.2 Respondents

Although questionnaires were sent to all firms in the six industries, most of them were not responsive. As can be seen in Table 6.1, only 145 responded to the questionnaires administered to them personally and by post. This gives a response rate of 16.04 per cent, which is far below acceptable response rate of at least 50 per cent, according to Bryman (2008). The low response rate is one of the limitations of postal questionnaire survey as acquired data may involve a risk of bias and high standard errors in the estimates of population parameters. The rice cracker industry has the highest response rate at 68 per cent, whereas the automotive industry has the lowest response rate at 10.17 per cent. This is because personal delivery was used to distribute and collect questionnaires in addition to postal survey in rice cracker, local textile, furniture and ceramic industries. However, this method of data collection could not be used with hard disk drive and automotive industries because of limited time and resource windows open to the researcher. In addition, there was a serious flood around the site of hard disk drive and automotive industries during survey period. Thus, it should not be surprising that the response rates corresponding to these two industries are low.

## 6.4 Data collection

Document reviews, interviews and questionnaire administration were consecutively conducted in the data collection process. Each method of data collection had its own difficulties, and so the researcher had to resort to some mitigating circumstances in order to make the data obtained usable, albeit subject to the recognition of the limitations.

### 6.4.1 Document reviews

Documents can be sources of both quantitative and qualitative data because they provide real events and information of organisations (Bryman, 2008). Documents, including official reports of several government agencies, articles, public relation and legal Acts were reviewed to understand the basic characteristics of the industries covered in the sample, including the extent of their network activities. Document reviews were also conducted to help in the drawing up of the initial list of interviewees in the six industries. These documents were obtained from Internet and personal contacts. They provide data about the existence of networks and the important institutional actors in the network process. The key triple helix institutional actors, including universities, government agencies, industry associations and intermediary organisations, were identified and were subsequently interviewed.

### 6.4.2 Semi-structured interviews

In the fieldwork study, semi-structured interviews were conducted from November 2010 to April 2011 to collect network-level qualitative data. Key triple helix institutional actors, representing university, government, industry and intermediary organisations, were selected through ‘purposive sampling’. This is a method used for selecting interviewees that are directly relevant to the research. It was expected that these sampled interviewees would readily respond to the research questions (Bryman, 2008). The lists of directly relevant interviewees were obtained from document reviews and informal discussion with colleagues. Typically, interviewees were contacted by the researcher to make appointments for face-to-face interviews. The researcher had to clear with them matters relating to the ethical aspects of data collection, indicating to them that the investigation would proceed upon their agreement of the modalities data use and storage. The arrangement agreed upon was that the data obtained in confidence would be anonymised, complying with the Code of Practice on Investigation on Human Beings (see Appendix 1). However, some of them offered telephone interviews instead of face-to-face interviews to save time.

Table 6.2 Numbers of interviewees in six industries by institution

| Institutions | Hard Disk Drive | Auto-motive | Ceramic | Furni-ture | Local textile | Rice cracker | Total |
|---|---|---|---|---|---|---|---|
| University | 1 | 1 | 1 | 1 | 2 | - | **6** |
| Government | 2 | 2 | 1 | 1 | 1 | 1 | **8** |
| Industry | 2 | 1 | 1 | - | 1 | 1 | **6** |
| **Total** | **5** | **4** | **3** | **2** | **4** | **2** | **20** |

Twenty-three persons were contacted for interview through a formal cover letter issued by National Science and Technology Development Agency (NSTDA) (see Appendix 2). Of these, 20 were interviewed. The other three persons were not available for interview during the period of the fieldwork. Two out of 20 were interviewed by telephone. As seen in Table 6.2, out of the 20 interviewed, six work for universities, six for industry, and eight for government agencies. In addition, a key person from a national policy planning organisation, namely the Office of National Economic and Social Development Board, was interviewed to provide the current status and future direction of national policy related to cluster and economic development discussed in Chapter 5. The interviews ranged between 45 minutes to 90 minutes.

Questions asked in the interviews were open-ended and sought to explore the experiences of interviewees in the formation and operation of networks and the roles of the interviewees and their institutions. The interview questions also queried the roles and motivation of interviewees in the process of network formation and how long they were engaged in the process. In addition, the roles, activities and knowledge exchange efforts of other important network actors were explored. Interviewees were also asked: to identify intermediaries in their networks; to assess the capabilities and resources of such intermediaries; and to evaluate the state of network development, the problems and obstacles of network management and the future direction the network is likely to evolve (see Appendix 3). Some interviewees were asked to provide lists of their members and asked for other important actors in order to arrange next interviews through the snowball sampling method. This was arranged subject to consideration and mutual understanding of the ethics of data use and storage, and particularly the arrangement that data obtained in confidence would be anonymised upon use.

### 6.4.3 Questionnaire design and administration

Following the interviews, three rounds of questionnaire administration were conducted from March 2011 to February 2012 through postal survey, personal delivery and structured interviews based on questionnaires. The 4-page self-completion questionnaires were mainly used to collect quantitative data. In the first round, questionnaires with a formal covering letter issued by NSTDA (Appendix 4) were sent by post to 930 firms in six industries as shown in Table 6.1 in March 2011. The postal survey was employed to save time and reduce the cost of administering questionnaires (Bryman, 2008). Together with questionnaires, envelopes with return address and stamps were provided to respondents. Twenty-six unanswered questionnaires were returned because firms had moved or closed. The response rate in the first round was very low. The second round of questionnaire administration was conducted in May 2011. In the second round, questionnaires were sent to those who did not respond in the first round. The response rate in the second round was still very low. In the third round, the questionnaires were delivered to the firms personally from October 2011 to February 2012. In this round, an enumerator was hired to help collect data. This enumerator was trained to be able to inform respondents about aims and objectives of the research and to elicit data needed through structured interviews. Some firms were interviewed through structured questions to complete questionnaires. Other firms were asked to complete questionnaires, and questionnaires were personally collected after a week. However, the personal delivery and structured interview methods were applied only to firms in the northern region of Thailand due to limitations imposed on the survey by budget and time provisions. In addition, there was a flood in the area where the hard disk drive and automotive industries are located during the third round of questionnaire administration. As a result, the third round of the questionnaire survey process could not be conducted in the hard disk drive and automotive industries.

The questionnaire survey was conducted mainly to collect quantitative data, relating to the roles and functions played by triple helix actors. Questions aimed at eliciting some qualitative data, such as benefits and effectiveness of innovation intermediaries, were also included in the questionnaire (see Appendix 5). The first and second parts of the questionnaire asked firms about basic information, relating to their technological characteristics and capabilities and resources. In the third part of questionnaire, questions relating to frequencies of activities that reflect the 'traditional' and 'additional' roles of triple helix actors are asked. In the fourth and fifth parts, firms are asked to rate the benefits and effectiveness of intermediaries. Levels of effectiveness are classified into 5-Likert scales ranging from very poor to very good. The broad categories of questions asked are shown in Table 6.3.

Table 6.3 Structure of the questionnaire

| Part of Questionnaire | Questions |
|---|---|
| I Firm's characteristics | Name, age, sale, profit, employees, fixed assets |
| II Technological resources and capabilities | • Number of technology development employees<br>• R&D equipment<br>• Number of database for technology development<br>• R&D Budget<br>• Level of technological capability |
| III Types of linkages in triple helix relationship | • Linkages with universities<br>• Linkages with government agencies<br>• Linkages with other firms |
| IV Benefits from innovation intermediaries | Cost reduction, process improvement, product development, human resource development, information and knowledge exchange and increase in trading relationship |
| V Effectiveness of innovation intermediaries | • Provision of financial supports<br>• Linkage with other actors<br>• Improvement of absorptive capacity |

The data collected at the firm level through the administration of questionnaires are of qualitative and quantitative nature. These are used to test the hypotheses discussed in Chapter 1, highlighting, inter alia, questions about firms' interactions with intermediaries; firms; technological resources and capabilities. Four variables were included in part II of the questionnaire to represent technological resources. Kim et al. (2010) used three variables as proxies for technological resources as follows: 1) the number of employees working on technology development; 2) R&D facilities and equipment; and 3) access to technology information. In addition to these technological resources, Kodama (2008) included financial support as being necessary for technology development.

In the questionnaire, technological capability is categorised at three levels following Lall (1992): basic, intermediate and advanced. Basic capability refers to simple routine that firms develop from experience. Intermediate capability refers to adaptive and duplicative capability. Firms would need to have search-based activities to develop this level of capability. Advanced capability refers to innovative capability that needs research-based activities to develop within firms. In line with Lall (1992), Kim et al (2010) used three variables to indicate technological capabilities in their questionnaire: technology acquisition; ability to solve technology problems; and ability to deploy technologically-oriented manpower.

The number of linkages between firms and other institutional actors and among firms can be counted from the number of collaborative activities. In part III of the questionnaire, firms were asked about the number of linkages they have with other firms and institutional actors as follows:

1) The number of linkages forged with universities can be counted from the number of projects that firms collaborate with universities – i.e. joint research, contract research, testing, training, seminar and conference.
2) The number of linkages forged with government agencies can be counted from the number of government support programmes in which firms participated – i.e. activities controlled by laws and regulations; activities related to setting preferential rules and regulations; financial supports for individual firms; and testing and calibration.
3) The number of linkages forged with industry can be obtained from the portfolio of inter-firm partnerships related to trading – i.e. the number of suppliers and customers and testing services.
4) The number of linkages forged with intermediaries can be read from the number of interactions between firms and the three triple helix actors playing their ‘additional’ roles as intermediaries. These ‘additional’ roles are, as discussed in Chapter 4, crucial for the development of triple helix networks.

*4.1) Universities as intermediaries*

According to Etzkowitz and Zhou (2007), universities can act as intermediaries and hybrid organisations when they assume the following additional roles: technology patenting and licensing, consultancy, spin-off company formation, training advanced manpower and providing R&D facilities. In the questionnaire designed for the survey, firms were asked to provide the types of linkage they had with universities. The intermediary role of universities is explored in terms of technology licensing; consultancy service; R&D equipment sharing and R&D personnel exchange.

*4.2) Government agencies as intermediaries*

Government agencies can play a role as intermediaries to induce the triple helix system. For example, funding agencies may focus on giving priority to collaborative projects. In addition, government agencies with technological expertise can act as intermediaries through technology brokerage; and the provision of consultancy services, education and training, R&D equipment and personnel services.

*4.3) Firms as intermediaries*

Firms can be intermediaries of networks if they are centres of networks linking actors through collaborative activities such as developing information sharing platform; providing consultancy services; developing new products and processes with alliances; R&D equipment and personnel sharing; and participating in industrial association.

However, in the questionnaire, linkages between firms and these three types of intermediary organisations are not separately asked as activities of intermediaries. As discussed earlier, intermediaries could arise from three triple helix actors. Thus, activities of these intermediaries are implicitly included in those of three triple helix actors. This is to avoid difficulty and the risk of confusing of firms about the rather hazy boundary where their traditional roles stop and their additional networking roles as intermediaries start.

Benefits deriving from interactions with intermediaries are meant to be captured by dummy variables, which are identified from the review of literature in Chapters 2 and 3 – i.e. cost reduction, process improvement, product development, human resource development, information and knowledge exchange and increase in trading relationship. Firms were asked in part IV of the questionnaire if they gained these benefits from their interactions with intermediaries playing sponsoring, brokering and boundary spanning roles. In part V, firms were asked to rate intermediaries playing these three roles through 5-Likert scales.

Questionnaires were specifically adjusted to suit each industry; and those sent out to firms were scripted in Thai language (see Appendix 6). Interviews were incorporated into industry-specific questionnaires to gain more in-depth knowledge about the networking role of the actors and to mitigate the problem of missing data, which is common in questionnaire surveys (Bryman, 2008).

Although the questionnaire was designed to obtain data on frequency of linkages in terms of number of cooperative projects between firms and other actors, most firms provide only names of institutional actors with ticks (✓) instead of number of projects. Thus, in most cases, the actual frequency data collected took the form of the number of institutional actors the firm engages with.

In addition, firms were asked to provide basic information about sales and profits to look into their profitability and market size; but such data proved difficult to obtain because firms considered these confidential.

## 6.5 Data analysis methods

Qualitative and quantitative data obtained from documents, interviews and the questionnaire survey were analysed using the narrative, descriptive, statistical and case study methods as shown in Table 6.4. These four methods were used to ensure accuracy, reliability and validity in view of the weaknesses inherent in each case (Bryman, 2008).

Table 6.4 Methods used to test hypotheses

| Hypotheses | Methods of Analysis |
|---|---|
| H1: Firms are responsive to triple helix intermediaries in order to exploit access to resources, including technological and financial resources, through increased relational capital. | Statistical analysis: multiple regression |
| H2: Firms engage in triple helix networks activities depending on: | |
| (I) the availability of incentives for participation, including the availability of intermediaries | Narrative analysis and case studies |
| (II) the effectiveness of intermediaries providing resources and services | Descriptive analysis and Statistical analysis: analysis of variance (ANOVA) |
| (III) the degree of their technological capability development | Statistical analysis: nonparametric test |
| (IV) their experiences in pre-existing networks | Descriptive analysis and case studies |

### 6.5.1 The narrative method

The narrative method was used to present stories or sequencing events by presenting actors and complex real-life events in ways that quantitative analyses of data from questionnaire cannot provide (Bryman, 2008). Qualitative data obtained from interviews were analysed using this method and presented to tell stories about the emergence and activities of the triple helix networks considered in this study. Interviews with key institutional actors can provide round pictures of networks. The compilation of interview transcripts can reflect the emergence of triple helix interactions. In addition, the roles of key actors can be seen as depicted in the six narratives corresponding to the six industries covered in this study. Narrative analysis was used to test hypothesis H2(I) by investigating association between availability of intermediaries and the state of triple helix activities in the six networks.

### 6.5.2 The descriptive method

The descriptive method was used to initially to characterise the data collected through the administration of questionnaires. This descriptive account is used to complement the findings obtained from the application of the narrative method. It enhances reliability in the comparison between the six industries and the three industry groups. However, it cannot be used to identify the sequencing of events in the evolutionary process of network development. Triangulation between narrative (qualitative) and descriptive (quantitative) methods may be useful to achieve accuracy and reliability (Bryman, 2008).

Quantitative data were used as basis for descriptive accounts involving comparisons of these six networks to test the following hypotheses:

H2(II): Firms engage in triple helix networks activities depending on the effectiveness of intermediaries providing resources and services; and

H2(IV): Firms engage in triple helix networks activities depending on their experiences in pre-existing networks.

### 6.5.3 The statistical method

Data obtained from questionnaire survey were also analysed using parametric and non-parametric statistical methods. The Statistical Package for Social Science (SPSS) programme was used to estimate statistics for testing hypotheses. The robustness of this method in terms of efficiency and reliability of estimates is constrained by the small size of the sample. Consequently, the results to be obtained from this analysis cannot be expected to be conclusive. However, they have their usefulness insofar as they can be suggestive and worthy of corroboration by the case study method.

The first hypothesis (H1) – that firms are responsive to triple helix intermediaries in order to exploit access to resources, including technological and financial resources, through increased relational capital – was tested using multiple regression to see the relationships between linkages with intermediaries and technological resources. Thus:

$$IILINK_{ij} = \alpha_i + \beta_{1i} TECHEM_{ij} + \beta_{2i} TECHEQ_{ij} + \beta_{3i} INFO_{ij} + \beta_{4i} RDBUD_{ij} + \mu \quad (6.1)$$

As $IILINK_{ij}$ = number of links with intermediaries (of firm j industry i);

$TECHEM_{ij}$ = number of technological development employees;

$TECHEQ_{ij}$ = level of proportion of technological equipment to fixed asset;

$INFO_{ij}$ = number of information sources;

$RDBUD_{ij}$ = level of proportion of R&D budget to annual sale;

$\alpha_i$ is the constant term;

$\beta_{1, 2, 3, 4}$ are the regression coefficients; and

$\mu$ is the error term.

For testing hypothesis H2(II) – the effectiveness of intermediaries providing resources and services – the one-way Analysis of Variance (ANOVA) technique was used to compare means of effectiveness of intermediaries within and between industry groups. ANOVA was used to see the association between a scale variable and a nominal variable, which is the factor or independent variable. However, normality and homogeneity of population are the condition for the use of ANOVA. These conditions can be tested by Kolmogorov-Smirnov and Levene tests, respectively (Carver and Nash, 2009). In this hypothesis, association between effectiveness and industries are tested through comparison of the means of two industries within an industry group. Moreover, association between effectiveness of intermediaries and industry groups are tested by comparing the means industries across the three industry groups, including MNC-dominated, SME-based and CE-based industry groups.

For testing the hypothesis H2(III), Spearman' Rank Order Correlation (Spearman Rho) was estimated to test the significance of association between the level of technological capability of firms and the links firms have forged with the three triple helix actors. Spearman Rho is a nonparametric statistic based on the conditions that data are not normally distributed, and the relationship of variables may not be linear (Morgan, 2004). Spearman Rho, ranging from -1 to 1, can be used to test the degree of association and the direction of association between a scale variable and an ordinal variable (Bryman, 2008; Carver and Nash, 2009). In hypothesis H2(III), for instance, the level of technological capability is an ordinal variable, ranging from 1 to 3, while the number of linkages between firms and the three institutional actors is a scale variable. However, Spearman Rho cannot be used to show causality.

### 6.5.4 The case study method

Multi-case studies were used to answer the research question on how firms in the various industry groups would respond to the different roles of intermediaries. This question is investigated through hypotheses H2(I) and H2(IV) – that firms engage in triple helix networks activities depending on: the availability of incentives for participation, including the availability of intermediaries; and their experiences in pre-existing networks. Although the case study method can be used to test propositions, its weakness is in its limited generalisability. To be generalisable, comparison of multiple case studies can be used because the replication logic in multiple case studies can provide external validity (Yin, 2002).

The case study method provides details of real-life events to answer research questions and to test theoretical propositions. It establishes internal validity though the identification of causality and the sequencing of complex events (Yin, 2002). Case studies of the type considered in this study are descriptive, considering the events happening in network formation and management. In addition, theories of knowledge exchange, learning and knowledge creation processes within networks are analysed by following the conceptual framework reviewed in Chapter 3.

Although the research question was set at industry group level, the case studies look at the level of a group or network of firms in each industry group. In other words, the unit of analysis is a network, consisting of a group of firms. These networks were identified based on the feedback from the interviews. Three case studies representing three industry groups were selected. These include: the TH Alliance in the hard disk drive industry; Ceracluster company in ceramic industry; and Toobkeawma Knowledge Centre in local textile industry. Comparison of these three cases is expected to shed light on the formation and evolution of triple helix networks in Thailand.

## 6.6 Conclusion

As discussed in this chapter, both quantitative and qualitative methods of data collection and analysis were used to complement with each other and ensure validity and reliability. The data obtained are categorised at network level and firm level. The former was collected through interviews and documents, while the latter was collected through questionnaire administration. Data collection methods were explained in this chapter by discussing the process of interviews and the questionnaire design. Data analysis was conducted using different methods to investigate hypotheses relating to factors affecting activeness of firms participating in triple helix networks.

However, there are some limitations to the methods used for data collection and data analysis, which means that there is significant scope for enhancing the validity of the results of the analysis through further fieldwork-based study. As already indicated, although questionnaires were sent to virtually all firms in the six industries, the response rate at 16.04 per cent is very low. Follow up of the distributed questionnaires was constrained by the fact that the principal investigator was able to afford to employ only one enumerator for the fieldwork, and there was a set time limit for the completion of the fieldwork. The problem was aggravated by the occurrence the major flood disaster that hit a good part of the country during the course of the fieldwork.

In the circumstances, data that were collected through questionnaires can hardly be expected to nicely conform with the normal distribution pattern; and the possibility of sampling bias could further wreak havoc with the robustness of the statistical findings. However, as an attempt to mitigate this problem of data robustness, multiple-case studies, providing external validity (Yin, 2002), are used to complement the statistical analysis. To do this, second round interviews were conducted by telephone and email to elicit details of activities of the networks selected as case studies. In addition, follow-up interviews were conducted a year later to see the progress of the networks.

Analysis and findings of the data are presented in the next two chapters. The narrative, descriptive and statistical accounts are presented in Chapter 7, and case studies are discussed in Chapter 8.

# CHAPTER 7

# Data Analysis and Evidence of Triple Helix Network Development in Thailand

This chapter analyses data collected through interviews and the administration of questionnaires. The data were used to test the following four hypotheses of this study discussed in Chapters 1 and 6:

- H1: that firms are responsive to triple helix intermediaries in order to exploit access to resources, including technological and financial resources, through increased relational capital;
- H2(I) to H2(IV): that firms engage in triple helix networks activities depending on:
  - (I) the availability of incentives for participation, including the availability of intermediaries;
  - (II) the effectiveness of intermediaries in providing resources and support services;
  - (III) the degree of their technological capability development; and
  - (IV) their experiences in pre-existing networks.

In this chapter, as elsewhere in this study, networks are classified into two: triple helix networks; and pre-existing networks. The latter, which predate triple helix networks, refer to vertical networks along the value chain and horizontal networks as in industry associations. The nature of networks has been fully discussed in Chapter 3.

The remainder of this chapter is organised in four sections. The first and second sections investigate H2(I) and H2(IV) in the light of the evidence borne by the survey data. The first section is an analysis of data corresponding to a sample of six industries collected from secondary sources and through interviews. The second section is a descriptive characterisation of the data collected through questionnaire administration. In the third section, hypotheses H1, H2(II) and H2(III) are tested. The last section presents the conclusion to the chapter.

## 7.1 Current status of the triple helix network in three major industry groups

Firms in the manufacturing sector were classified into three categories according to size and industry family nomenclature of firms as multinational corporation (MNC)-dominated, small and medium enterprise (SME)-based, and community enterprise (CE)-based industries. MNCs are dominant in high technology industries, which invariably involve foreign direct investments of sizeable proportions. Typically, MNC-dominated industries consist of both foreign and local firms; and these come in large and medium sizes since economies of scale are necessary for production in these high technology industries. In conventional industries, most firms are local firms and come in small and medium sizes. Initial investments are not too high nor the technology levels too complex and sophisticated for locals to invest in such firms. CBEs consist of micro and small firms in traditional products and based on the application of traditional knowledge and skills.

The MNC-dominated industries considered in this study include automotive and hard disk drive (HDD) industries; the SME-based industries include furniture and ceramic industries; and the CE-based industries include local textile and rice cracker industries. These are chosen for their strategic significance for triple helix network development in Thailand. The aim is to investigate, through the empirical analysis later on in this chapter, where, among these industry groups, network formation and development has been, if at all, more apparent; and the factors that have prompted or else constrained firms in the various industry groups to engage in triple helix network activities.

Figure 7.1 shows the geographical distribution of firms in the six industries considered in this study and the geographical proximity of firms within the respective industries. It is apparent from the figure that with the exception of firms in furniture industry, firms in the other industries are regionally clustered. The clustering pattern can be explained by the regional distribution of resource endowment (as in the case of furniture industry) and the proximity to knowledge centres (as in the case of HDD industry).

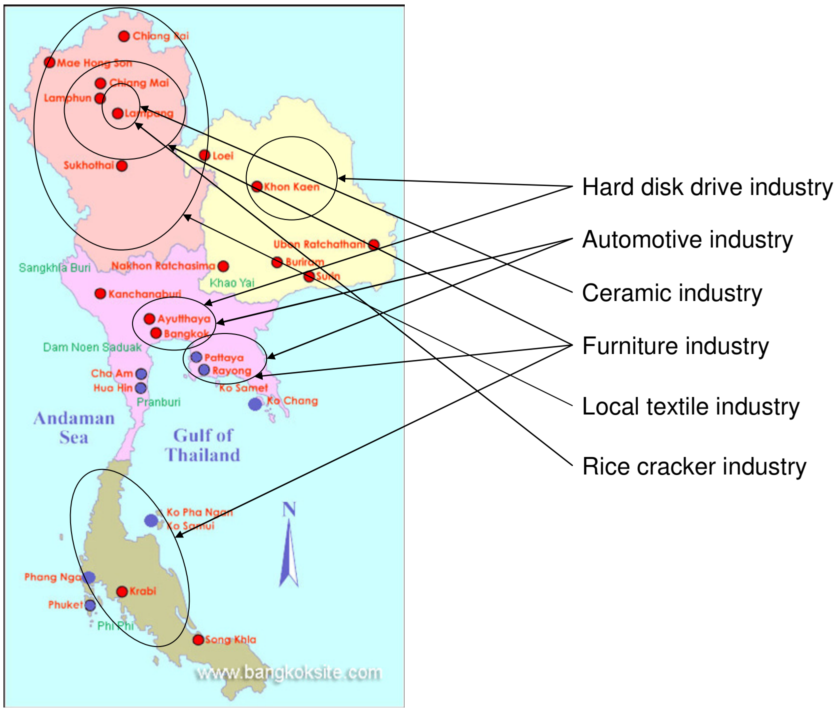



Figure 7.1 Distribution of six selected industries

Source: www.bangkoksite.com

### 7.1.1 MNC-dominated industries

In growing economies like that of Thailand, FDIs have become the main source of industrial development. Thailand started promoting FDIs through the enforcement of the Investment Promotion Act in 1960 and the subsequent establishment of the Board of Investment of Thailand (BOI) in 1966. Since 1970, there has been a shift of industrialization strategy from import substitution to export promotion. This shift has entailed a rapid expansion of FDIs. As can be seen in Figure 7.2, the FDI turnover in Thailand has dramatically risen since the late 1980s. Following the financial crisis in 1997, the investment policy relaxed the restrictions on joint venture ownership in order to attract more inward investment. Thus, in 2000, the investment regime was liberalized by abolishing the local content requirement and allowing wholly-owned MNC subsidiaries to operate in the manufacturing sector (Brimble and Urata, 2006). After 1997, the FDI turnover fluctuated and reached the highest level yet at 10,480 million USD in 2006.

In Thailand, FDIs in the manufacturing sector are concentrated in two industries, namely, the electronics and automotive industries. As discussed in Chapter 5 (Table 5.3), the machinery and transportation equipment is the largest industry in the manufacturing sector attracting the FDIs. The second largest is the electronics and electric appliance industry. The third and the fourth in the rank order are, respectively, chemical and metal and materials industries, which received less than half of the largest and the second largest industries.

For the purpose of this study, the HDD and the automotive industries are selected from the MNC-dominated category on grounds of the significance of their contributions to the Thai economy. These industries are known to create the scope and potential for technological learning and improvement, and to contribute significantly to the development of the knowledge capital of the country (UNCTAD, 2005; Brimble and Urata, 2006; Hobday and Rush, 2007).

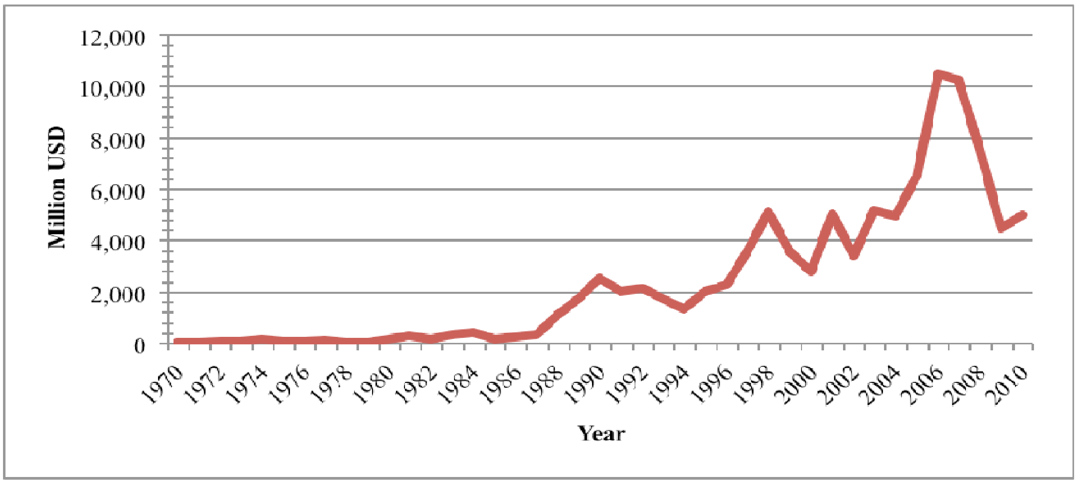



Figure 7.2 Foreign Direct Investments in Thailand in 1970-2010

Source: Bank of Thailand

Multinational corporations (MNCs) are dominant in the manufacturing sector. In Thailand, 37.7 per cent of the manufacturing GDP in 2000 was generated from FDI stock (Punyasavatsut, 2007). Although large firms, like MNCs, can improve their technological competence through in-house R&D, external resources are also essential for upgrading their technological capability (Bessant and Rush, 1995). However, MNCs tend to use their affiliates abroad rather than local centres of knowledge as sources of knowledge transfer (Kirkels and Duysters, 2010). In an attempt to promote the development of the local knowledge network and maximize the advantages of knowledge spillovers from MNCs (Dzisah and Etzkowitz, 2008), the Thai government attempted to link these MNCs with local firms so that the local firms could use the MNCs are sources of knowledge (Punyasavatsut, 2007).

Links between MNCs and local firms, however important, have proved difficult to forge because of the policy of trade liberalisation as local firms lack the technological capability and competitiveness to establish themselves in the global supply chains (Punyasavatsut, 2007). This means that intervention by intermediaries is necessary to link local firms with MNCs by improving the technological capability and market access of the local firms.

*7.1.1.1 The hard disk drive industry*

Thailand has been the largest manufacturing base of HDD industry in the world since 2005 with a market share of 42 per cent of the global market. Already, four big HDD manufacturers, including Seagate, Hitachi, Western Digital and Fujitsu, operate from their bases in Thailand. There are also about 60 HDD parts manufacturers grouped in three tiers with 34, 17 and 9 firms in the first, second and third tiers respectively (NSTDA, 2008). In 2009, the HDD industry contributed 4.5 per cent to GDP, creating local value added of about 100 billion baht and local employment of about 220,000 jobs.

The HDD network was set up in 1999 to provide opportunities for the improvement of local technological capability development. In 1999, four MNCs established the Thailand branch of an international industrial association, namely the International Disk Drive Equipment and Materials Association (IDEMA), to mutually develop human resources and share information about global trends of the HDD market. A triple helix type arrangement then emerged around the HDD industry involving interactions between government and industry. At the initial stage, IDEMA negotiated with the National Electronics and Computer Technology Centre (NECTEC), a research centre under the National Science and Technology Development Agency (NSTDA), for more support, apart from the tax incentives of the BOI. NSTDA is a government agency acting as a research institute and a funding agency and even used to be a key player in science and technology policy making. IDEMA and NSTDA funded policy research undertaken by the Asian Institute of Technology (AIT) and the Asia Policy Research Co., Ltd. (APR). An outcome of the policy research was the recommendation, among other things, for the establishment of the Hard Disk Drive Institute (HDDI) and for the preparation of a technology roadmap for the industry.

As part of the wider policy process, IDEMA was set on the institution and promotion of a triple helix network to facilitate access of HDD makers to the research and knowledge sector. After all, high-level manpower development was needed not only for existing production activities, but also for new investment in more advanced activities. NSTDA, the government agency, considered this crucial for technological capability upgrading, lest the country be locked into labour-intensive production and retrograde technologies in the face of an increasingly competitive global market environment. As a result, the government went headlong into the global market with the objective to attract the big HDD makers to move their more advanced manufacturing bases to Thailand. To achieve this objective, it provided the policy environment that would make the opportunity cost of investing in Thailand favourable. Thus emerged in the HDD sector the ground for collaboration between the two institutional actors in the triple helix network, namely industry and government. Indeed, subsequent interactions among IDEMA, NSTDA, AIT and the APR saw the HDDI evolve as a triple helix hybrid organisation.

Based on the recommendations of policy research, NSTDA attempted to build the HDD cluster, consisting of nine universities, six government agencies, 60 firms and an industrial association (NESDB, 2006). The HDDI was established in 2005 to be coordinator of the HDD cluster. For the first five years of its life, the cluster was led by a manager supported by a steering committee consisting of representatives from the NECTEC, the BOI, the Ministry of Industry (MOI), AIT, Thammasat University (TU) and the four HDD manufacturers.

The emergence of the triple helix system around the HDD cluster was based on the establishment of a government-industry axis, which, building on the network, later brought the universities into the fold. Thus the establishment of the triple helix system around the HDD network in Thailand was not university initiated as was the case elsewhere and as is expected by the theory underlying the development of triple helix networks (Etzkowitz and Leydesdorff, 2000; Etzkowitz, 2008).

The HDDI sponsored three universities to engage in the establishment of Industry/University Cooperation Research Centres (I/UCRCs) to be innovation intermediaries connecting firms, universities and government agencies as sub-networks in specific technology areas. Universities are motivated to collaborate with the HDDI and industry because government supports, such as grant for basic research, matching fund for industrial R&D and student scholarships, could expand their activities and enhance their profiles. Moreover, since state universities in Thailand are autonomous with little or no public funding, they would need to attract external resources, mainly from industry, in order to be financially solvent. Securing industrial funding for their teaching and research programmes is therefore one of their principal missions. Firms could also benefit from higher profitability due to lower R&D expenses consequent upon engagement in collaboration with local universities.

However, discontinuities in the functioning of government systems and policies – with one government scrapping the policies of the other, or even with the same government reneging its own policy in favour of political expediencies – have interfered significantly with the development of triple helix interactions. For instance, in 2011, the newly installed government declined to award NSTDA the budget it required to undertake phase II of the development of the Thailand Science Park; and NSTDA had to make up for this budget shortfall by cutting the budget for HDDI. Consequently, the number of collaborative projects between university and industry that were maintained through the support of HDDI decreased significantly. Some support mechanisms, such as overseas training for advanced technology transfer, had also to be discontinued.

Given the central role of the government, the triple helix system can hardly be expected to thrive under such circumstances of changing priorities. In principle, this situation can be seen to have implications for the way the triple helix system in the HDD sector has to evolve, possibly involving a shift of the lead role from the government to the universities. The question, however, is whether the universities in Thailand are entrepreneurial enough to provide the impetus for a robust university-industry axis to thrive in place of the government-industry axis that initiated the triple helix network around the HDD cluster.

*7.1.1.2 The automotive industry*

The automotive industry has been in operation in Thailand since 1971 (TAPMA, 2011). It is the second largest export industry of Thailand and ranked fifteenth in the world in terms of production capacity (TAI, 2007). In the early phase of industrial development, production was promoted mainly for import substitution. Thailand has been exporting cars since 1996, and now provides manufacturing bases for Japanese and American assemblers of 1-ton pick-up trucks and passenger cars. Of the 100 world largest parts manufacturers, 55 have established their bases in Thailand to supply to these Japanese and American assemblers; and over 1,000 local firms were established to supply the assemblers and the first tier parts manufacturers (TAI, 2007). The automotive industry creates local value added of approximately 210 billion baht and has generated about 230,000 jobs. In 2011, the export value of the automotive industry alone was 547.25 billion baht, accounting for 7.94 per cent of total export value (BOT, 2013).

In 2000, free trade agreements and globalization forced the Thai Government to terminate its protectionist policies. The ensuing competition in the automotive industry resulted in cost reduction and quality improvement. Previously, local firms had acquired technology and technical assistance (TA) from assemblers and their higher tier customers. According to global sourcing strategy, automotive firms would need to develop their design and engineering capabilities in order to reduce cost and improve quality to maintain their status in the global supply chain. Although local firms have long been developed, they still remain weak in terms of engineering capability, production management, productivity improvement and business administration (TAI, 2007).

A new form of government policy for the development of the Thai automotive industry was launched in 2002 in the form of the first master plan of the automotive industry (2002-2006), based on the ‘diamond model’[2] and the cluster approach innovated by Michael Porter to promote the growth and competitiveness of the industry, with particular focus on human resource development, standardisation, IT and market expansion. The Thailand Automotive Institute (TAI), established in 1998, serves as specialised management centre for the master plan of the automotive industry in the same way as HDDI was set up to serve the HDD cluster. Unlike the HDDI, which was established by NSTDA and is operating as a unit under it, TAI is an independent government agency established by the Ministry of Industry (MOI) in cooperation with private sector and operates as a private organisation under the MOI. TAI’s activities cover business analysis, technological consultancy, R&D, and human resource development, and the provision of testing and management of database services for automotive parts.

TAI has been engaged in industrial cluster development, such as the Banpong Bus Body Cluster and the SME007+ Cluster for motorcycle parts. It also provided training in design engineering by hiring experts from abroad to teach firms in some local clusters. It used foreign experts instead of researchers from Thai universities because local universities do not have the requisite expertise and R&D equipment to cater for firms in the clusters. Not surprisingly, the university-industry linkage in the automotive industry is weak, so that there is a long way before the triple helix system of interaction could be established in earnest. For instance, some clusters in automotive industry cannot operate without government support. Even so, government budget is at present provided only for short-term projects. Moreover, government agencies provide support and assistance only in the initial stage of cluster development. But this type of support, which is limited to basic activities like training and raising awareness, is not enough for cluster deepening which requires investment in R&D.

As a government intermediary, TAI has not succeeded like HDDI to create triple helix interactions. This is mainly because it is poorly budgeted and equipped. Not

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[2] The diamond model is a tool to analyze competitiveness of industrial clusters through consideration of six factors: factor conditions; demand conditions; related and supporting industries; firm strategy, structure and rivalry; government; and chance.

surprisingly, its relationship to the automotive cluster has been one of ‘arms length’ type; and it has done little or nothing to promote R&D collaboration with local universities.

### 7.1.2 SME-based industries

The SME sector constitutes the heartland of the Thai economy, accounting for 99.6 per cent of the population of industrial firms; 38.2 per cent of GDP; and 76 per cent of total employment in 2010. The majority of SMEs are in the service, manufacturing and trading sectors (OSMEP, 2010). In the manufacturing sector[3], there were 668,185 SMEs (28.2 per cent of all SMEs) in 2007. These manufacturing SMEs contributed 38.9 per cent to SMEs’ employment and 30.1 per cent to total exports (OSMEP, 2009b). The SME sector is now, however, threatened by higher energy costs and the emergence of new global competitors from countries like Vietnam and China, among others.

To achieve competitive edge, Thai SMEs would need to engage in vertical and horizontal networking processes. Thus, through the pooling and sharing of resources SMEs would be able to reduce fixed costs and benefit from economies of scale. Vertical integration with other SMEs in the value chain creates specialisation in which firms have competitive advantage, leading to division of labour (Ceglie and Dini, 1999). Engagement in the triple helix network would also enable them to access the knowledge sources they would need to be innovative and competitive.

In this study, ceramic and furniture industries were selected to provide ‘windows’ for the investigation of the development of SMEs in triple helix network. These industries are classified as resource-based manufacturing industries, using locally developed technologies. The ceramic industry is concentrated in Lampang, a northern province of Thailand. The furniture industry is, on the other hand, widely distributed across every region of Thailand to take advantage of ease of access to different kinds of woods.

[3] Definition of Thai manufacturing SMEs is as follows:
1) small enterprise - either employment less than 50 jobs or fixed assets less than 50 million baht
2) medium enterprise - either employment between 50-200 jobs or fixed asset between 50-200 million baht

#### *7.1.2.1 The ceramic industry*

In 2007, there were 5,760 firms in the ceramic industry creating 53,382 jobs. Most of these firms (99.22 per cent) are SMEs, and 61.34 per cent of employment in this industry was hired by SMEs. The major markets for Thai ceramic products are Japan, USA, UK, Australia, Germany, South Korea, and South East Asian countries. In 2007, the ceramic industry generated export income to the tune of 879.9 million USD (OSMEP, 2009a). In this study, the ceramic products selected include tableware and gifts, which are produced mainly in Lampang Province in a northern part of Thailand. These two products generated export income of about 225.2 million USD in 2007 (OSMEP, 2009a).

From SWOT analysis, main strengths of Thai ceramic industry are resources, including high skilled labour and raw materials. Weaknesses include: lack of design and branding capabilities; lack of management skill of SMEs; production with low technologies leading to inconsistent quality; lack of human resource development in design; and higher costs comparing with competitors. There is opportunity in production of advanced ceramic for high technology industry. Moreover, Thailand is a potential location for FDI in ceramic industry. Threats include: low wage competitors, such as China and Vietnam in both production and FDI; and non-tariff barriers (OSMEP, 2009a).

The ceramic industry in Lampang, developed more than 50 years, is one of the strategic industries for cluster development in Thailand. Since 1997, the government has launched an Industrial Restructuring Plan and an Industrial Development Master Plan for the ceramic industry. These plans aimed to make the Lampang ceramic industry globally competitive to qualify as the centre of the Association of Southeast Asian Nations (ASEAN) ceramic industry. In 2003, the industrial cluster approach was introduced as a strategy for industrial development in Thailand, the Lampang ceramic industry was selected as one of the industries for the application of the strategy, as it possessed most of the factors such as geographical concentration, supporting industries and supporting institutions that would make it naturally amenable to cluster development.

The history of the Lampang ceramic cluster development can be set into two periods. During the first period (2002-2004), the Industrial Finance Corporation of Thailand (IFCT), a specialised government-owned financial institution, was assigned to play host to the cluster development. Five pre-existing horizontal sub-networks, consisting of seven to ten firms with similar products in each network, were formally established as a cluster. The government allocated budget for the cluster through the IFCT and the provincial government. The activities of the cluster included human resource development, information sharing, order sharing and staging exhibitions and trade fairs. However, in due course, the IFCT was merged with the Thai Military Bank to form a commercial bank, the TMB Bank in 2004. Consequently, the financial support for the Lampang ceramic cluster was stopped and the cluster was left in a complete disarray and dysfunction for lack of trust and mutual commitment among those operating within the closed networks of the cluster. The situation created the environment for opportunism to thrive with cluster members seeking to undercut one another in a wasteful competition and firms being reluctant to share their knowledge and information for fear of losing their proprietary rights to free-riders (Altenburg and Meyer-Stamer, 1999; Ahuja, 2000). For example, some of the relatively larger members felt that under the circumstances, they would lose their benefits if they continued to share their advanced knowledge and production and marketing skills with smaller firms. While such suspicions persisted among firms in the cluster, there remained only informal information sharing among some members of some sub-networks.

The second period of the cluster development (2006-present) started when the government assigned a new host, the Ceramic Industries Development Centre (CIDC), to set up a new cluster and act as a cluster development agent (CDA) to continue the implementation of the cluster approach. The CIDC, which came under the authority of the Minister of Industry, was based in Lampang, in the northern part of Thailand where the ceramic clusters are located. CIDC had to start delivering the responsibilities assigned to it with a challenge in its hands. For instance, it was realised that the cluster established during the first period did not include firms in supporting or upstream industries of the ceramic industry, and other supporting institutions, such as government agencies and universities. Moreover, trust among cluster members was weak, which meant that real collaboration would not take place while firms scrambled for the small local market by engaging in wasteful price competition. The establishment of the new cluster called for making up for the gaps left by developments during the first period through engagement in the establishment of horizontal to vertical networks. This helped to restore trust, which is an essential ingredient for the consolidation of networks through, among other things, the minimisation of the moral hazard arising from opportunistic behaviour (Ahuja, 2000). In an attempt to achieve this, arrangements were made for firms constituting the cluster to attend the Entrepreneurship Development Programme (EDP) provided annually by the Department of Industrial Promotion. This would enable firms to understand the concept of cluster and mutual benefits from cooperation based on trust within the cluster.

About 20 small firms are known to have participated in the new cluster by jointly establishing and investing in an alliance company, called Ceracluster. Ceracluster would collect and distribute client orders to firms within the cluster as well as providing a channel for members to access government financial supports; technical assistance provided by the Support Arts and Craft International Centre of Thailand (SACICT); and R&D funding for product development of clusters provided by National Innovation Agency (NIA). These supports have been crucial in leveraging the creation of a triple helix network in the ceramic cluster.

#### *7.1.2.2 The furniture industry*

A characteristic feature of the furniture industry in Thailand is that the firms falling under it – large, medium, small – are located in every region in line with the distribution of forest wood resources across the country. The furniture industry created value added to the tune of about 3 billion baht (990 million USD) in 2006. In 2007, the total number of firms in furniture industry was 21,512, of which 99.79 per cent were SMEs supporting 176,926 jobs. Prior to the forest blockade in 1989, the domestic market was served with hard wood furniture as the main product of the industry. After the blockade, soft woods, such as rubber wood, have been used to substitute for hard woods; and soft wood furniture products have become export products, generating income of about 1.5 billion USD per annum. The main export markets for the Thai furniture industry are the USA, Japan and the EU countries. Those engaged in the export of furniture products are large and medium sized firms (OSMEP, 2009b). Most of the small firms produce only for the domestic market. Shortfalls in the supply of wood throughput for the Thai furniture industry are met by imports from neighbouring countries, including Malaysia, Burma and Lao.

Because the firms are scattered all over the country, the industry is not amenable to cluster formation, and, mainly for this reason, cooperation based on triple helix network development has not been clearly seen in the wood furniture industry. However, the industry has for long had loose networks in the form of national trade associations, like the Thai Furniture Industries Association (TFA), Thai Parawood Association (TPA) and Thai Furniture Industry Club under Federation of Thai Industries (FTI). These associations were formed mainly for information sharing and have had some connections with universities, albeit on *ad hoc* basis. For example, some researchers in universities are invited to be advisors of these associations. Some members of the industry associations, especially the large firms, are known to have had contractual agreements with universities for research services, thus giving a semblance of the existence of university-industry links, albeit without a specialised government institution responsible for assisting firms in this industry to form cluster-based networks. Thus, although there were signs of triple helix interactions in the industry, these were conducted on a one-to-one basis, not on networking basis.

Triple helix interaction in the wood-based furniture industry emerged when the Industrial Technical Assistance Program (ITAP) started providing technical and financial supports to the furniture industry in 2004. ITAP was established as a subordinate of a government research institute, namely the National Science and Technology Development Agency (NSTDA). Its task was initially focused on the provision of technical assistance to firms by diagnosing technical problems in collaboration with universities. Later, it expanded to include activities, including the organisation of seminars and training programmes for firms located in several regions. ITAP also built an expert network specifically related to the technology of wooden furniture manufacturing to facilitate the provision of technical assistance and training programmes for firms. The ITAP expert network draws on local university researchers, representatives of industrial associations and overseas experts. ITAP also provides support for furniture firms to have overseas visits to gain knowledge about best practice technologies in the field. In addition, it liaises with other government agencies providing supports for the furniture industry to integrate government supports for larger projects. ITAP thus operates as a triple helix intermediary for the furniture industry.

From interviews, in 2011, the ITAP budget was suddenly cut significantly, and ITAP itself was reduced to the role of an agency providing technical assistance on one-to-one basis – a role it was assigned to play during the first phase of its operation. Meanwhile, the networking between firms, government agencies and universities to establish clusters was discontinued before it took root for lack of financial supports from government. Recently, a syndicate of furniture firms were reported to have established a few rubber wood clusters in the southern region of Thailand; and it is too early to say how effective these clusters would be in terms of the creation of joint activities based on networking.

### 7.1.3 CE-based industries

Community-based enterprises (CBEs) are considered important from the vantage point of both job creation and income generation, particularly in rural areas. CBEs are supported by the government as a component of its strategy of reducing poverty in the regions. In 2011, there were 71,190 CBEs with 1,205,470 members. Of these, 66.8 per cent were manufacturing CBEs. Most of the CBEs are located in north-eastern and northern regions, with 45 per cent in the former, and 29.3 per cent in the latter region (SCEB, 2011).

CBEs came into being in Thailand when the government launched the ‘One Tambon (District) One Product’ (OTOP) project in 2001 to help people in rural areas generate income based on the utilisation of traditional and indigenous knowledge. In the early phase of this project, the government stimulated people in local communities to engage in industrial activities using indigenous knowledge. This initiative gave rise to many low value-added products in the OTOP market, produced with the application of low level technologies. In recent years, several government agencies have sought to improve the technological capabilities of CBEs by introducing them to new ideas of modern science and technology using the competence of local universities to build on traditional or indigenous knowledge (Hongladarom, 2002).

CE-based firms are characteristically concentrated in geographical areas that offer high opportunity for firms to collaborate and innovate within their communities (Yokakul and Zawdie, 2010). In the manufacturing segment of the CBE sector, the largest and the second largest industries are processed foods and local textile industries, accounting for 19.8 and 18.5 per cent of the population of CBEs, respectively (SCEB, 2011). In this study, local textile and rice cracker industries are selected for close investigation. Textile firms are concentrated in the northern and north-eastern regions of Thailand; and rice cracker firms in Lampang Province, in the northern region. These two industries have been targets of the government's cluster policy to develop production and knowledge networks in the CBE sector.

#### *7.1.3.1 The local textile industry*

In 2011, there were 1,884 CBEs producing textiles in the northern region. However, only 182 CBEs were members of the Knowledge and Technology Centre for Northern Textile (KTC), which was set up to provide supports for the industry.

Network development within the local textile industry in the northern region began when Chiang Mai University (CMU), a leading university in the region, set up a 'cotton and silk' project under its Science and Technology Institute in 2000 to upgrade the managerial and technological capabilities of CBEs through technology transfer and supply chain management. The cotton and silk project was upon government support upgraded to be a KTC, and play a networking role as an agent of knowledge management, technological capability development and technology transfer for textile CBEs in 17 northern provinces. The KTC has collaborative projects with other government department on upgrading technological capability in several fields, such as waste management, organic plant and dyeing and alternative textiles. For example, the Department of Environmental Quality Promotion would hire experts to work with the KTC to improve production processes related environmental issues. Funding agencies would provide R&D funds for exploring alternative textiles and for supporting knowledge exchange across communities through researchers.

To keep close connection with the community and generate wider impacts, the KTC would select community members who have good exposure to traditional knowledge to train as local experts and to share their new knowledge with their communities. KTC also funded these local experts to transform their production sites into local knowledge centres that would enable exchange traditional knowledge within and across communities.

#### *7.1.3.2 The rice cracker industry*

The rice cracker industry is a small part of processed food industry in the CBE sector. In 2011, there were 30 producers concentrated in Lampang Province (PIO, 2007). A few medium enterprises have developed the capability to export, while small enterprises and CBEs sell their products only in domestic market.

In 2008-2010, the Provincial Industry Office (PIO) undertook the project on competitiveness improvement of an agro-industrial product in each province. In Lampang, the rice cracker industry was selected as most important agro-industrial product. It was found that firms in this industry faced similar problems, relating to product quality, international food standards, energy costs, packaging, productivity, energy efficiency, raw material and supply chain management. Under this project, consultants were provided to solve these problems and improve the competitiveness of producers.

In addition, funding agencies, such as the Thailand Research Fund, provide support for universities to conduct R&D with the aim to improve the processes and products of firms to meet international food standards. In this industry, the Thailand Institute of Scientific and Technology Research, a government research institute, provides food standard certification, such as Good Manufacturing Practice (GMP) and Hazard Analysis and Critical Control Points (HACCP).

Based on interviews, PIO also attempted to organise rice cracker firms into an industrial cluster in Lampang. Apart from creating a basis for generating economies of scale, the cluster served as a basis for leveraging the negotiating power of firms, which on their own are too small to be able to negotiate effectively with suppliers and customers without being taken advantage of. In 2010-2011, the rice cracker producers and suppliers and the local universities were invited to share their visions about cluster development, in general, and the creation of collective actions, such as joint purchasing, in particular.

## 7.2 Characterisation of the survey data

### 7.2.1 Pre-existing inter-firm linkages

Inter-firm linkages are of two types: vertical and horizontal. As can be seen in Table 7.1, vertical linkages of business relationships in value chains include trading, testing and consultancy. Horizontal linkages are about cooperation of firms in the same industries, sharing equipment, and exchanging or sharing knowledge and information about markets and product development. Firms also interact horizontally through the formation of trade associations.

As can be seen in Table 7.1, the six industries considered in this study have different patterns of pre-existing inter-firm networks. Those that depend only on vertical value chain linkages are the HDD and the rice cracker industries. As seen in Table 7.1, firms in the HDD and rice cracker industries have vertical links more than horizontal links. This is because these two industries are not self-contained, but stand as part of big industries i.e. electronics and food industries. Moreover, these industries are relatively new, having been in operation for about 10 years. Consequently, they have not gone far by way of developing horizontal links. As seen in Table 7.1, a few firms in these two industries have horizontal linkages and participate in trade association. Unlike these new industries, old industries, like the automotive, ceramic, furniture and local textile industries, depend on both vertical and horizontal linkages for their operation, as seen in Table 7.1 firms in the old industries have more horizontal than vertical links.

Table 7.1 Inter-firm linkages between firms and industry

| Types of partners and linkages \ No. of firms and (links) | MNC-dominated | | SME-based | | CE-based | |
|---|---|---|---|---|---|---|
| | Hard disk drive | Automotive | Ceramic | Furniture | Local textile | Rice cracker |
| **1. With other firms** | **3 (6)** | **23 (51)** | **13 (30)** | **3 (4)** | **15(134)** | **10 (22)** |
| Trading | 2 (2) | 17 (24) | 8 (10) | 3 (3) | 13 (36) | 5 (8) |
| Testing | 1 (1) | 4 (4) | 2 (5) | - | 3 (4) | 1 (2) |
| Consultancy provision | - | 3 (3) | 2 (2) | - | 4 (24) | 1 (1) |
| Consultancy acquisition | 2 (2) | 3 (3) | 2 (2) | - | 4 (5) | 1 (1) |
| Information exchange | - | 5 (7) | 3 (5) | 1 (1) | 7 (43) | 2 (5) |
| Equipment sharing | - | 1 (1) | - | - | - | - |
| Product development with alliance | 1 (1) | 4 (9) | 6 (6) | - | 4 (22) | 5 (5) |
| **2. With trade associations** | **1 (1)** | **25 (31)** | **12 (16)** | **7 (7)** | **10 (13)** | **1 (1)** |
| **Total vertical links** | **5** | **34** | **19** | **3** | **69** | **12** |
| **Total horizontal links** | **2** | **48** | **27** | **21** | **78** | **11** |

Among the six industries, the local textile industry has the strongest network with dense ties between firms in the industry. As can be seen in Figure 7.3, firms in the local textile industry have the highest average number of links with other firms, including both vertical and horizontal links. Average numbers of vertical and horizontal links in local textile industry are above 2.00. The furniture industry has the loosest network with only 18 and 6 per cent of firms in the study sample having vertical and horizontal linkages with other firms, respectively, and the average number of links less than 0.2.

As already noted, the HDD and the rice cracker industries are new and product-specific as to fit well into value chains of vertical networks. Trade associations in these two industries have not been widely established, unlike in the case of the older industries. For instance, there is only one trade association in the HDD industry, namely, Thai branch of International Disk Drive Equipment and Materials Association (IDEMA). Members of the IDEMA are HDD makers, excluding suppliers. And in the rice cracker industry, there is no product-specific association. As seen in Figure 7.4, the percentage of firms and the average number of links with trade associations in these relatively new industries are very low compared with the older ones. In the case of the older industries, there are not only industry- and product-specific associations, but also industrial groups under the Federation of Thai Industry (FTI).

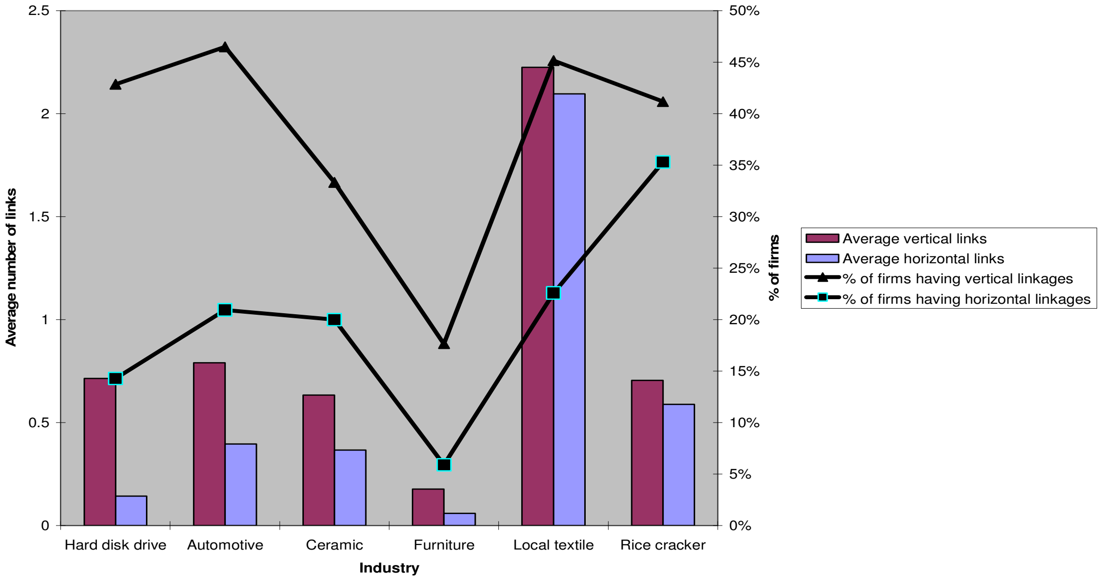



Figure 7.3 Frequency of vertical and horizontal linkages with other firms in the six industries

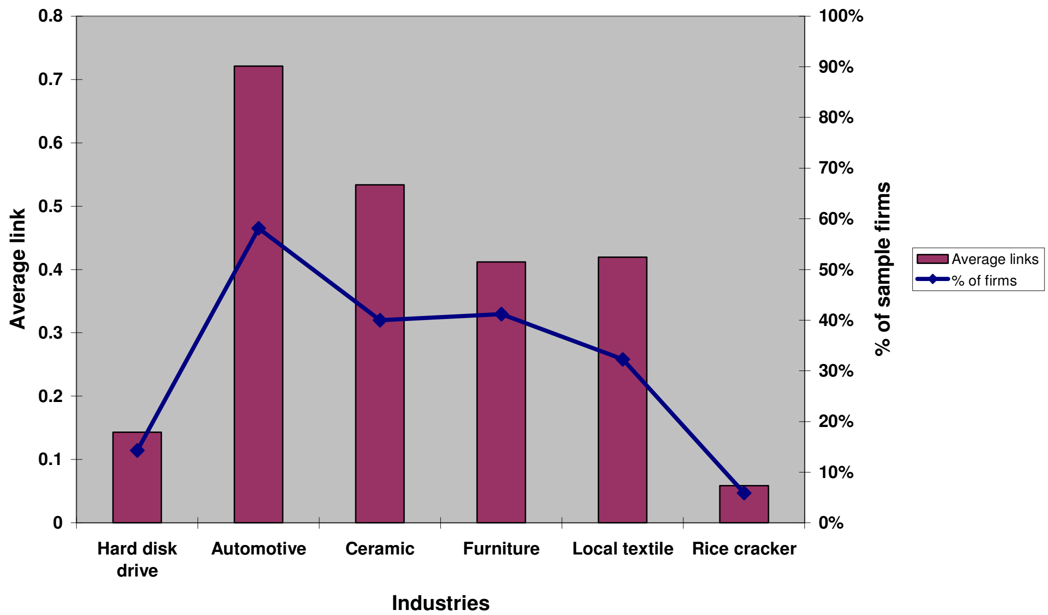



Figure 7.4 Frequency of linkages of firms and trade associations in the six industries

Most HDD makers in Thailand are MNCs who depend heavily on their global suppliers. The makers moved their labour-intensive manufacturing bases to Thailand to take advantage of the low wage regime in the country. Some of their global suppliers have also moved to supply parts to the HDD makers. Others supplying only small parts and located near Thailand have not moved, however. This means production in Thailand still depends on some imported raw materials. It is observed that the pre-existing inter-firm network in the HDD making industry is largely in the form of vertical value chain between MNCs.

Unlike the HDD industry, the automotive industry is far more developed. It has been operating in Thailand since the late 1970s when foreign suppliers also moved their manufacturing bases to Thailand. In subsequent years, over 1,000 local suppliers have been established following the government's protectionist policy for industrialisation, and to exploit the locational advantage offered by the high transportation costs for bulky parts. Assemblers played a major role in the development of local suppliers, providing, for instance, technical assistance and training for local suppliers. As seen in Figures 7.3 and 7.4, there is evidence of strong ties between firms in vertical value chains and also of the establishment of some trade associations in the industry. At present, there are at least three automotive associations, namely, Thai Autoparts Manufacturers Association, Thai Automotive Industry Association and Automotive Group in FTI. These associations provide the fora for information exchange and training, which can be considered as loose ties characterising horizontal networks.

The ceramic industry in Lampang was established in the 1960s and has thrived on the white clay deposits in the region, this being the main raw material for ceramic products. Similar to the experience of the automotive industry, the ceramic industry has seen supply chains and trade associations evolving. Inter-firm networks in this industry are in form of both vertical and horizontal linkages.

Unlike ceramic industry, the furniture industry is scattered across several regions following the wide dispersion of wood resources of different types across the country. For instance, the northern region is rich in the supply of hard woods; and the southern and eastern regions are the supply of rubber wood, also known as soft wood. Like the automotive and ceramic industries, inter-firm networks in this industry occur in the form of vertical and horizontal linkages. However, networks between firms are quite loose because firms are not in close proximity to one another. Moreover, trade associations are located in Bangkok, whereas the majority of firms are located in upcountry provinces.

In the case of local textile industry, production is concentrated in some rural districts. It is apparent from Table 7.1 and Figures 7.3 and 7.4 that there is a strong community spirit among firms in this industry, suggesting the existence of a high degree of social capital as would be expected of CBEs. Groups from several districts obtain training from the same sources, such as the Provincial Offices and Community Development Department. As seen in Figure 7.3, information and knowledge sharing between groups in horizontal networks occurs. Some producers have integrated the industry functions within them, thus undertaking all processes from growing raw materials to weaving. Others are relatively more specialised and product-specific and engage in value chain networks. Inter-firm networks in this industry occur in the form of both vertical and horizontal linkages.

Like the HDD industry, the rice cracker industry is a relative newcomer and is promoted as an outstanding OTOP product of Lampang. The rice cracker firms considered in this study are drawn from the SME and CBE categories. Most of them are too small to be able to negotiate with suppliers effectively. Recently, there was an attempt to form horizontal networks between producers, as can be seen from data in Table 7.1 which suggest evidence of a consortium initiative in product development and information exchange. However, the product development effort of this industry does not signal deep cooperation because it is not related to technological development. Inter-firm network in the industry, which involves loose vertical and horizontal linkages, is at best a reflection of shallow cooperation.

The firm-level data show that the depth of inter-firm linkage depends on age and scope of industry. Firms in new industries tend to have fewer horizontal linkages with competitors or firms at the same level of the value chain, and with trade associations, and depend only on vertical relationships. Firms in old industries tend to have higher vertical and horizontal linkages than their relatively new counterparts.

Trust may be an important factor underlying the reason for this. Firms and trade associations in well-established industries can be expected to have built trust among firms in the industries over the years, thus creating the condition for deep cooperation, involving equipment sharing and joint product development – activities which are rarely apparent in new industries.

In the case of product-specific industries, like the HDD and rice cracker industries, the scope for interaction – particularly interactions based on horizontal networks – is narrow as there are not many producers. In such instances, cooperation between producers hardly occurs due to the fear of exposure to the business hazard of opportunism and free-riding that can be exercised by potential competitors. On the other hand, product-specific firms like the HDD makers and rice cracker producers, might be expected to thrive better in a supply chain type vertical network.

### 7.2.2 Networking roles of triple helix actors

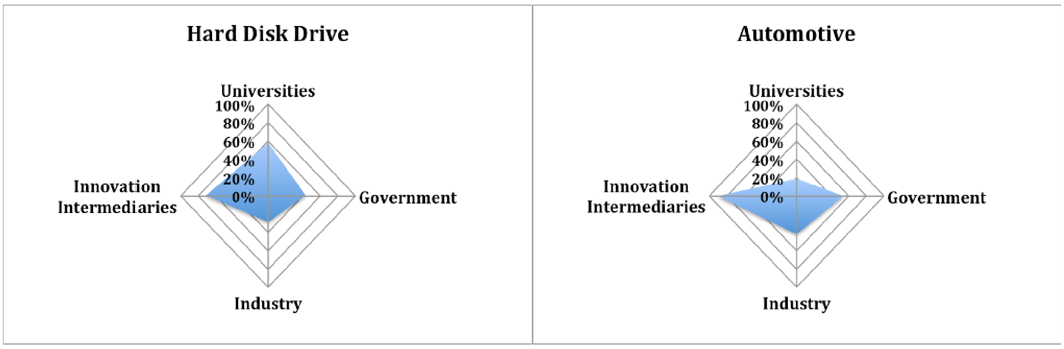
It is apparent from the data in Table 7.2 that the networking roles of innovation intermediaries are distinctly different from the traditional roles of institutional triple helix actors, including universities, industry and government. The role of universities is in knowledge production through engagement in research and development and in a range of activities involving knowledge exchange and transfer. The role of government is in the provision of regulatory, policy, control and support mechanisms. The role of industry is in production and wealth creation. The role of innovation intermediaries is to engage in activities that would enable each of the three institutional actors to play the roles of the others with the aim to stimulate interaction between the actors. For example, universities engage in the third mission, which involves promotion of utilisation of intellectual property rights (IPR), provision of consultancy service, equipment sharing and knowledge exchange. Government provides funding for collaborative projects through the creation of networks that would link firms with the other actors. The government sponsors the provision of seminars, consultancy and training programmes. Firms play roles apart from production, including, for example, participation in trade associations, equipment sharing, information exchange, consortium ventures in product/process development and provision and acquisition of consultancy services.

Table 7.2 Linkages with universities, government and innovation intermediaries

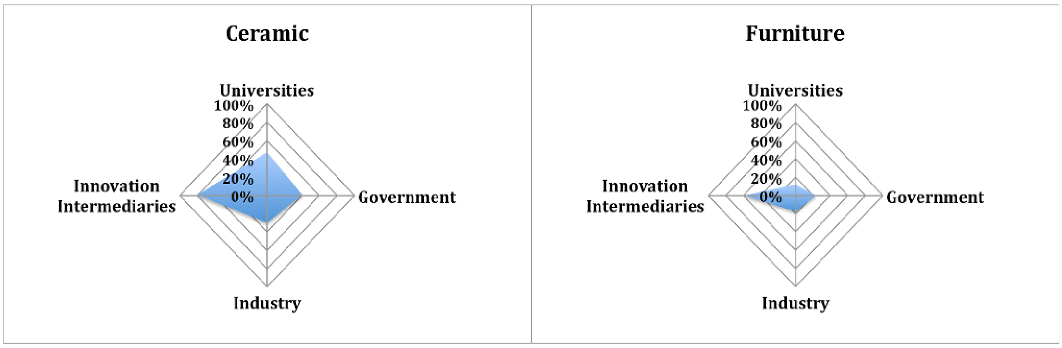
| Types of partners and linkages / No. of firms and (links) | Hard disk drive | Automotive | Ceramic | Furniture | Local textile | Rice cracker |
|---|---|---|---|---|---|---|
| **1. With universities** | **4 (36)** | **8 (14)** | **14 (28)** | **2 (2)** | **20 (76)** | **10 (26)** |
| Joint R&D | 4 (27) | 3 (4) | 9 (11) | - | 11 (27) | 8 (18) |
| Contract R&D | 1 (3) | 1 (2) | 1 (1) | - | 1 (1) | - |
| Testing | 1 (3) | 4 (4) | 4 (5) | - | 2 (3) | 1 (1) |
| Seminar and conference | 1 (3) | 3 (4) | 8 (11) | 2 (2) | 17 (45) | 6 (7) |
| **2. With government agencies** | **3 (10)** | **23 (38)** | **12 (23)** | **4 (5)** | **17 (65)** | **13 (36)** |
| Controlled by laws and regulations | 2 (3) | 5 (7) | 4 (5) | 3 (3) | 4 (9) | 10 (12) |
| Facilitating regulation | 2 (2) | 11 (11) | 3 (3) | - | 1 (7) | 1 (2) |
| Financial assistance | 3 (4) | 1 (1) | 5 (6) | 1 (1) | 15 (38) | 9 (20) |
| Testing | 1 (1) | 14 (19) | 8 (9) | 1 (1) | 5 (11) | 2 (2) |
| **3. With innovation intermediaries** | **5 (47)** | **39 (145)** | **24 (96)** | **10 (14)** | **23(276)** | **14 (80)** |
| **3.1 University-based intermediary organisations** | **2 (31)** | **5 (8)** | **6 (9)** | **-** | **9 (34)** | **7 (20)** |
| IPR utilization | 1 (3) | 1 (1) | 2 (2) | - | 5 (7) | 2 (2) |
| Consultancy | 1 (3) | 2 (5) | 3 (3) | - | 5 (14) | 4 (9) |
| Equipment sharing | 2 (9) | - | 3 (4) | - | 5 (6) | 4 (8) |
| Human resource exchange | 1 (16) | 2 (2) | - | - | 2 (7) | 1 (1) |
| **3.2 Government-oriented intermediary organisations** | **4 (12)** | **30 (77)** | **22 (56)** | **6 (6)** | **21(135)** | **13 (47)** |
| Funding collaboration projects | 3 (4) | 5 (6) | 6 (7) | - | 5 (11) | 4 (5) |
| Linking with other actors | 1 (1) | 18 (21) | 12 (12) | 2 (2) | 16 (48) | 7 (8) |
| Seminar and training | 2 (2) | 25 (40) | 17 (20) | 3 (3) | 19 (70) | 12 (29) |
| Consultancy | - | 6 (10) | 6 (8) | 1 (1) | 4 (5) | 2 (3) |
| Equipment sharing | 1 (5) | - | 9 (9) | - | 1 (1) | 2 (2) |
| **3.3 Market-led intermediary organisations** | **2 (4)** | **30 (60)** | **17 (31)** | **8 (8)** | **14(107)** | **6 (13)** |
| Trade association | 1 (1) | 25 (37) | 12 (16) | 7 (7) | 10 (13) | 1 (1) |
| Equipment sharing | - | 1 (1) | - | - | - | - |
| Information exchange | - | 5 (7) | 3 (5) | 1 (1) | 7 (43) | 2 (5) |
| Product/process development with alliance | 1 (1) | 4 (9) | 6 (6) | - | 4 (22) | 5 (5) |
| Consultancy provision | - | 3 (3) | 2 (2) | - | 4 (24) | 1 (1) |
| Consultancy acquisition | 2 (2) | 3 (3) | 2 (2) | - | 4 (5) | 1(1) |

As can be seen in Table 7.2, the number of links firms have with intermediaries is higher than with universities and government agencies in all industries. This implies that triple helix actors are transforming themselves by playing intermediary or 'additional' roles more than their traditional roles. Another possibility is that activities considered as intermediary roles were created to interface themselves with industry, so that firms would interact with their intermediary roles at frequencies more than with their traditional roles.

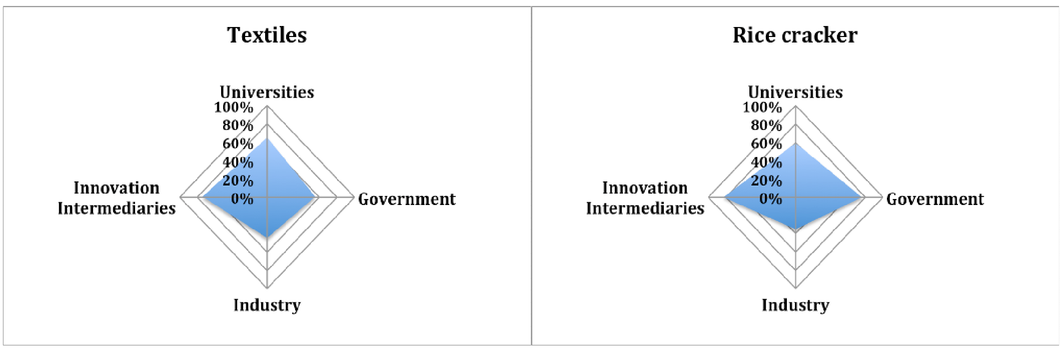
Different industries need different roles of intermediaries. The dominant activities of universities are joint R&D and the organisation and delivery of seminars, workshops and other training programmes for all industries. The dominant activities of government agencies and intermediaries in these industries are different depending on the needs of industry. For example, the dominant activity of government agencies in automotive and ceramic industries is testing, while that in local textile and rice cracker industries is financial assistance. The most dominant activity of innovation intermediaries in all industries is to run seminars and training programmes, this being a role befitting to government-oriented intermediaries.




a) MNC-dominated industries




b) SME-based industries




c) CE-based industries

Figure 7.5 Percentage of sample firms having linkages with institutional actors

It can be seen from Figure 7.5 that innovation intermediaries play the most important role in all six industries. Over 50 per cent of the firms surveyed have links with innovation intermediaries. It can be noted that industries that have higher links with innovation intermediaries are likely to have higher links with other triple helix actors. This is particularly apparent in the case of local textile and furniture industries.

In the case of the MNC-dominated industries, universities are observed playing more important roles in the HDD industry than in the automotive industry, as seen in Figure 7.5a. This is because Thai universities have insufficient capabilities to administer the advanced and complex technology needs of the automotive industry. For these universities, design and R&D equipment are too expensive to have. On the other hand, car assemblers have the investment capability to establish their own training schools for engineers and technicians. The government plays little role in these two MNC-dominated industries insofar as the policies of MNCs are made by their headquarters. The relationship within the automotive industry is denser than that in the HDD industry. This is because the automotive industry has long been established in Thailand. There are over 1,000 local suppliers to it. However, local suppliers in the HDD industry cannot enter to value chain of MNCs. At present, there are only about 60 foreign suppliers established in Thailand.

In the SME-based industries, firms in the furniture industry have very low links with triple helix actors as well as innovation intermediaries, as seen in Figure 7.5b. Firms in the ceramic industry operate with moderate level of technology, such as chemical and material technology; and production in furniture industry is labour-intensive with low technology base. Firms in such conditions would have little or no drive to engage in triple helix transactions, particularly since such transactions involve high transaction costs (Altenburg and Meyer-Stamer, 1999). The roles played by universities and the government in the furniture industry are limited to arm's length activities, such as the organisation of seminars and workshops and other forms of training programmes, unlike in the ceramic industry where their involvement is deep as reflected in activities, such as joint R&D, equipment sharing and collaborative initiatives in product/process development, as seen in Table 7.2. Moreover, there is an industry-specific institution for the ceramic industry, the Ceramic Industries

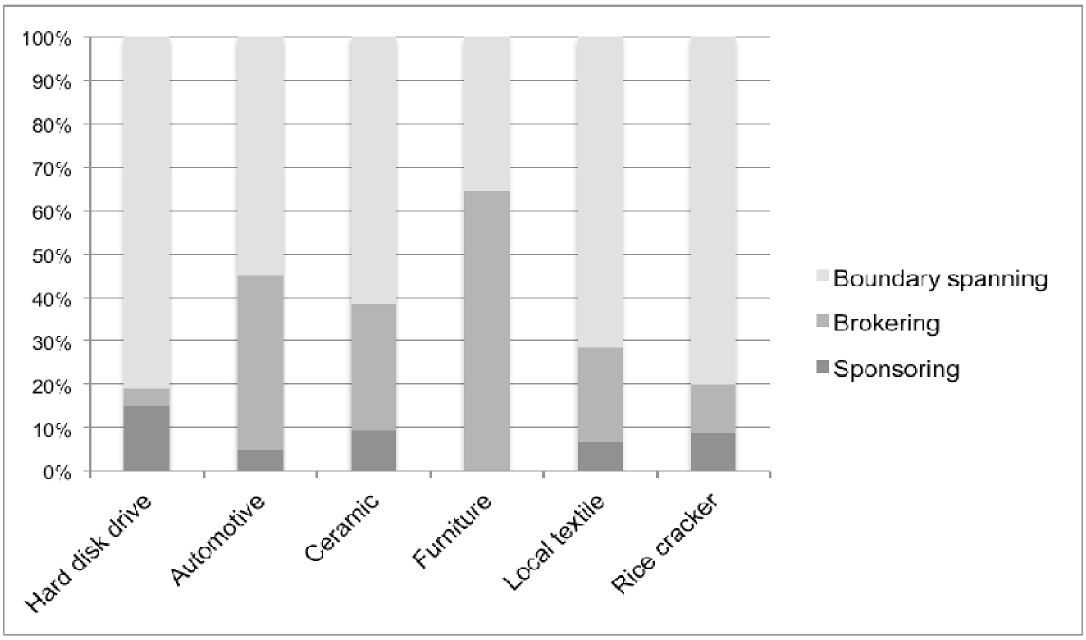
Development Centre (CIDC), to assist firms in technical issues. There is, however, no such organisation to assist firms in the furniture industry. The Knowledge base relating to furniture technology is shallow and disconnected with few universities and government agencies showing limited interest in its development.

In the CE-based industries, universities, government agencies and innovation intermediaries play significant roles in the local textile and rice cracker industries. This is because firms in these industries operate on the basis of traditional knowledge, the evolution of which calls for intervention through the provision of scientific knowledge-related activities. The government has been highly supportive of this type of industries by bringing into play universities and innovation intermediaries. However, the frequency of interactions among firms in these industries is lower than the frequency of interactions between firms and other actors.

### 7.2.3 The roles of innovation intermediaries in the transformation of pre-existing networks into triple helix networks

As discussed in section 4.2, the roles of innovation intermediaries can be classified into three: sponsoring, brokering and boundary spanning. Sponsoring involves IPR utilization and provision of funding for collaborative projects. Brokering involves linking actors and trade associations. Boundary spanning involves the provision of operational services, i.e. consultancy, equipment sharing, human resource exchange, organisation and administration of seminars and workshops, information exchange and product/process development. These roles of innovation intermediaries are compared in Figure 7.6.

As can be seen in Figure 7.6, boundary-spanning intermediaries play a major role in most industries. In the furniture industry, unlike in the other industries, brokering intermediaries are, however, observed being more dominant than boundary spanning intermediaries. Also, there is no evidence of any linkage between the furniture firms covered in the survey and the sponsoring intermediaries. In most industries, sponsoring intermediaries play less significant role than brokering intermediaries. But in the HDD industry, sponsoring intermediaries are observed playing more dominant roles than brokering intermediaries.




No. of samples 7 43 17 30 31 17

Figure 7.6 Roles of innovation intermediaries

In the case of the MNC-dominated industries, government intervention is frequent in the HDD industry where most firms are relatively new. Pre-existing inter-firm network in the HDD industry can be seen in form of vertical value chain with MNCs. The aim of government intervention is to promote backward linkages through triple helix interactions instead of employing the traditional protectionist policy, which has invariably been found wanting as it involves high domestic resource cost for the economy at large. This is apparent from the experience of protection of the automotive industry (Brimble and Urata, 2006). The Government now supports both MNCs and local firms through the sponsoring role of the Hard Disk Drive Institute (HDDI), which is a hybrid organisation steered by a trilateral committee. The HDDI established I/UCRCs in universities to play both brokering and boundary spanning roles. These I/UCRCs encourage local firms to form alliances and help them upgrade their technological capabilities, so that they can be potential suppliers, effectively substituting for foreign suppliers.

In the case of the automotive industry, there are both vertical and horizontal networks. Government intervention in the automotive industry is relatively less dense than that in the HDD industry. The Government does not provide financial support directly to firms in the automotive industries because firms in this industry are considered to have adequate investment capability. So its proxy, the Thailand Automotive Institution (TAI), plays only a brokering role by providing lists of experts for firms that need assistance. In addition, R&D funding for the automotive industry is quite limited because Thai universities have insufficient technological capability and inadequate equipment to provide technical services for the industry. This is the main obstacle to the development of a triple helix network in the automotive industry.

In the SME-based industries, brokering intermediaries play an important role in the development of a triple helix system. In the ceramic industry, the CIDC plays a brokering role linking firms with sponsoring intermediaries for the provision of R&D funding. It also plays boundary-spanning roles and links other boundary spanning intermediaries, especially universities, with firms because it has its own R&D and testing labs dedicated to the technology of the industry.

In the furniture industry, the sponsoring, brokering and boundary-spanning roles are all played by a research institute, namely NSTDA, as an ITAP programme. Unlike the ceramic industry, there is no industry-specific institute providing services for furniture firms. ITAP provides technical assistance and partial financial support for firms, thus playing sponsoring role. In providing technical assistance, it has created a network of experts in universities who play a boundary-spanning role. ITAP has also built networks of government agencies that play a sponsoring role. However, the significance of ITAP's roles might not be recognised widely because projects relating to the furniture industry are administered by four staff, but furniture firms are located nationwide.

From Figure 7.6, it can be seen that most brokering activities of furniture industry are played out by trade associations, not ITAP. Most firms in this industry are not interested in technological development, and so are least engaged in the development of triple helix networks. Although the ITAP approached trade associations in the early phase of network development, it was not so successful in resolving the technological concerns of the industry through inter-firm networks. The urgent concerns of industry rather related to marketing, and the industry's competitiveness position in the light of the restrictions arising from the enforcement of laws and regulations. Triple helix relationships were observed only in ITAP’s networks, not in industrial networks. However, collaboration and networking between universities and firms dramatically decreased after ITAP’s budget was significantly reduced; and while the funding constraint prevailed, the transformation of inter-firm networks into triple helix network could not be completed.

In the CE-based industries, boundary-spanning intermediaries, including universities and government agencies, play an important role in the transformation of inter-firm networks into the triple helix network. In the textile industry, a local university, CMU, plays brokering and boundary-spanning roles by enhancing the traditional knowledge base of the industry via cross-pollination with scientific knowledge; and by developing horizontal inter-firm networks through provision of programmes for training and technical assistance. It also networks CBEs with government agencies that play sponsoring and boundary-spanning roles.

Universities also play a major role in providing technical services to firms in the rice cracker industry. Although universities in Thailand have recently adopted a new policy that commits them to the so-called ‘third mission’, there is as yet no university playing a brokering role to form horizontal inter-firm networks in the rice cracker industry, unlike the role of CMU in the local textile industry. Instead, the Provincial Industry Office (PIO) under the Ministry of Industry has had to play the brokering role. PIO convinced SMEs and CBEs to establish industrial cluster in Lampang and invited universities to play a role in the industrial cluster. In addition, a funding agency, namely, Thailand Research Fund, plays a sponsoring role as an intermediary for the collaborative projects between firms and universities. In fact, any evidence of triple helix networks in the rice cracker industry is a result of the intervention of several intermediaries as sponsors, brokers and boundary spanners.

Lack of entrepreneurial spirit and trust are the main barriers of network development (Altenburg and Meyer-Stamer, 1999). This is corroborated by the evidence obtained from the industry group survey data. Apart from the active roles played by industry-specific institutes, trust underpinning firms’ engagement with universities as well as the vision of firms for the way forward were also found to be crucial for the transformation of pre-existing inter-firm networks into triple helix networks. In the case of the furniture industry, development of the triple helix system was not successful also due to the absence of a permanent intermediary, which, however, was not the case with the other industries. Firms in automotive industry were not observed to have any liaison with local universities because they perceived their technologies to be more advanced than what the universities would have to offer. They considered the R&D of universities to be too simple to apply their industrial works. As a result, they do not collaborate with universities. Thus, lack of engagement of firms in the automotive and furniture industries with universities appears to impede the development of triple helix networks in these industries.

### 7.2.4 Intermediary organisations

It can be seen in Figure 7.5 that the most links that firms in all industries have are with innovation intermediaries. As mentioned in section 4.3, intermediaries can arise from three triple helix actors, including universities, industry and government agencies. Intermediary organisation can be categorised into three: university-based, government-oriented, and market-led intermediaries. The proportion of links firms have with these three types of intermediaries can be seen in Figure 7.7.

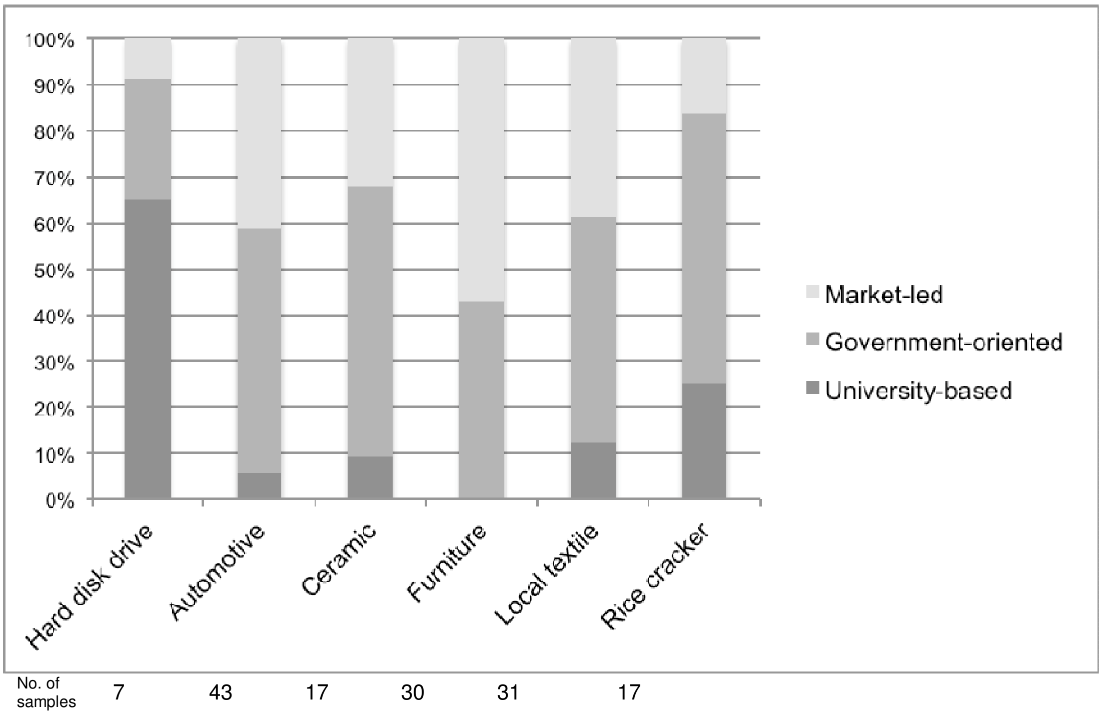



Figure 7.7 Links between firms and innovation intermediaries

As seen in Figure 7.7, university-based intermediaries play a dominant role in the HDD industry. Activities of university-based intermediaries include IPR utilisation, provision of consultancy services, equipment sharing and human resource exchange. In the HDD industry, universities play roles as brokering and boundary spanning intermediaries through the I/UCRCs.

As seen in Figure 7.7, government-oriented intermediaries play a dominant role in the automotive, ceramic, local textile and rice cracker industries. Activities of government-oriented intermediaries include securing funding for collaborative projects, linking with other actors, provision of seminar and training programmes, consultancy services and services for equipment sharing. Government agencies provide these services by playing all intermediary roles as sponsors, brokers and boundary spanners. These services, which were in the past provided to mitigate the effects of market failure, are now provided mainly assist firms to upgrade their technological capabilities.

Market-led intermediaries operate most visibly in the automotive, furniture and local textile industries, as seen in Figure 7.7. Most of the firms in these industries are relatively old having been in operation for a long time. Activities of these market-led intermediaries are related to trade associations, equipment sharing, information exchange, cooperation in product/process development and provision of consultancy services. Trade associations, horizontal networks and private technical services have been developed in these industries over a long period of time.

The new coming industries appear to be more keen than the older ones in the development of triple helix networks. In triple helix model, entrepreneurial universities play an important role in creating trilateral networks. University-based intermediaries tend to play more significant roles in the development of new industries, like the HDD and rice cracker industries, than those in other conventional industries.

### 7.2.5 Significance and effectiveness of innovation intermediaries

As seen in Figure 7.8, the most obvious perceived benefit deriving from liaison with innovation intermediaries is knowledge exchange. In most industries, except the furniture industry, over 50 per cent of the surveyed firms felt the benefit of networks accruing in terms of access to information through intermediaries. Consequently, firms in most industries rated highly services in information exchange provided by brokering intermediaries (Table 7.3). As seen in Table 7.3, information sharing is the most effective activity of intermediaries. This finding is in line with Nishimura and Okamuro (2011) that supports afforded in the form of networking and coordination are more effective than direct R&D supports in terms of their impact on cost-benefit performance in the promotion of cluster programme in Japan.

Apart from facilitating information sharing, boundary-spanning intermediaries providing technical services also perform better than other intermediaries, as seen in Table 7.3. The second most obvious benefit that most industries perceive to be deriving from the activities of intermediaries is process development, as this helps to reduce costs and enhance competitiveness.

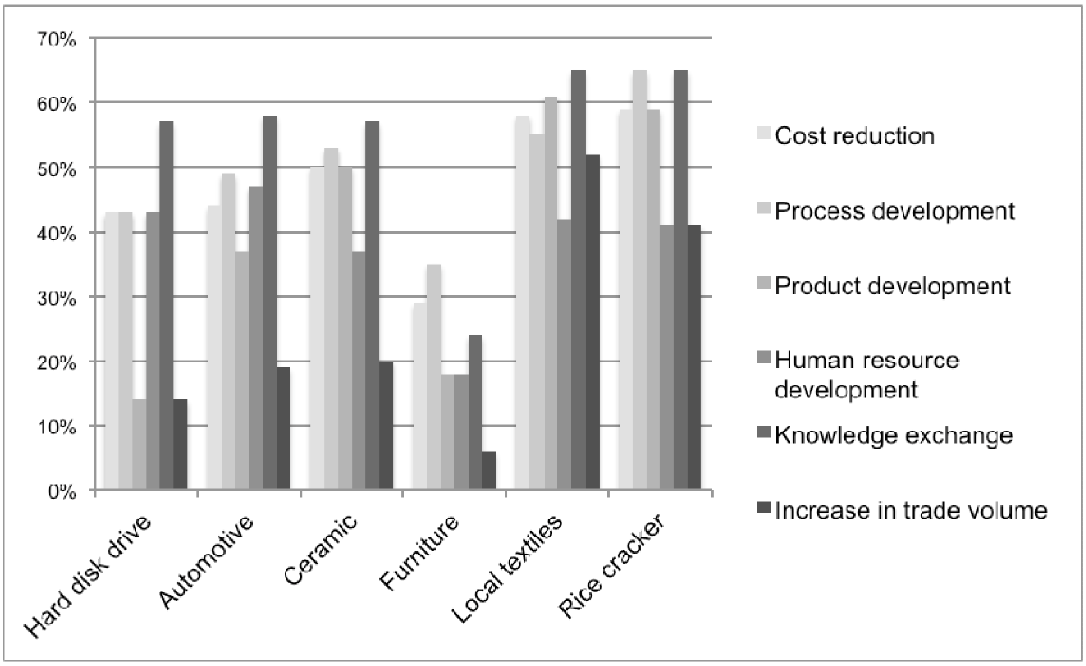



Figure 7.8 Benefits from linking with intermediaries

Table 7.3 Quality of services provided by innovation intermediaries as rated by firms having linkages with such intermediaries

| Average qualities / Roles of intermediaries | HDD | | Automotive | | Ceramic | | Furniture | | Local textile | | Rice cracker | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| **1. Sponsoring role** | | | | | | | | | | | | |
| Provision of financial supports | 2.33 | 1.155 | 2.50 | 1.291 | 3.17 | 1.329 | - | - | 3.60 | 0.894 | 3.17 | 0.408 |
| IPR management | 3.00 | 0 | 2.75 | 1.500 | 3.20 | 0.837 | - | - | 3.67 | 1.528 | 3.50 | 0.837 |
| **2. Brokering role** | | | | | | | | | | | | |
| Information sharing about potential partners | 4.00 | - | 3.32 | 0.646 | 3.56 | 0.512 | 3.14 | 0.378 | 4.13 | 0.915 | 3.83 | 0.753 |
| Provision of facilitations | 3.00 | - | 3.05 | 0.785 | 3.44 | 0.964 | 3.14 | 0.378 | 3.73 | 0.799 | 3.33 | 0.816 |
| Provision of access to external resources | 2.00 | - | 2.60 | 0.940 | 3.29 | 0.849 | 2.86 | 0.378 | 3.57 | 0.852 | 3.33 | 1.033 |
| **3. Boundary-spanning role** | | | | | | | | | | | | |
| Provision of technical services | 3.00 | 0 | 3.23 | 0.922 | 3.59 | 0.795 | 3.25 | 0.500 | 3.76 | 0.664 | 3.36 | 1.027 |
| Provision of assistance of external R&D utilization | 3.17 | 0.408 | 2.79 | 0.855 | 2.94 | 0.998 | 3.00 | 0.000 | 3.69 | 0.704 | 3.40 | 1.075 |
| Provision of assistance to in-house R&D | 3.33 | 0.516 | 2.72 | 1.018 | 2.93 | 0.829 | 3.00 | 0.000 | 3.78 | 0.667 | 3.44 | 1.014 |
| Knowledge circulation | 3.17 | 0.408 | 3.10 | 0.553 | 3.24 | 1.200 | 3.00 | 0.000 | 3.76 | 0.752 | 3.36 | 0.924 |

Figure 7.8 shows most firms in the MNC-dominated industries having similar perception of the benefits they could derive from interactions with intermediaries. However, firms in automotive industry perceive product development as a benefit much more than those in HDD industry. This is because firms in automotive industry have to mutually develop product innovation drawing support from their value chain networks and also from the government's protectionist policy, while product development of firms in HDD has to be conducted through in-house R&D due to global sourcing policy. HDD firms assessed assistance to in-house R&D to be the second most effective activity of intermediaries, while automotive firms assessed technical services to be the most effective intermediary activity (Table 7.3). This is because the automotive industry has been in operation for long, so that technical services are more readily available and effective. In the HDD industry, the government put much effort in stimulating backward linkage effects by upgrading the technological capability of MNC subsidiaries and local firms through the provision of assistance to in-house R&D efforts. Not surprisingly, the least effective intermediary role in the automotive industry is sponsoring. There is only one funding agency for the industry, namely, National Metal and Materials Technology Centre, which provides R&D funding for collaborative projects between universities and

firms in the automotive industry. According to this funding agency, however, finding universities that qualify for such funding was found to be difficult. In HDD industry, the least effective intermediary role is brokering to facilitate access to external resources. There is only the HDDI providing financial supports to HDD firms through I/UCRCs, the brokering intermediaries, who have their own resources to assist firms without any access to external resources.

In SME-based industries, the proportions of firms receiving benefits from intermediaries in the ceramic industry are slightly higher than those in the furniture industry. As seen in Figure 7.5b, the percentage of links firms have with intermediaries in the furniture industry is much lower than that in the ceramic industry. Thus, effectiveness of intermediaries is lower in the case of furniture firms than in the case ceramic firms, as can be seen in Table 7.3. In these two SME-based industries, the outstanding roles of intermediaries are provision of technical services by boundary-spanning intermediaries and information sharing by brokering intermediaries.

In the CE-based industries, increase in trade volume is perceived as a benefit higher than that in other industry groups. As seen in Figure 7.8, over 40 per cent of the firms in the CE-based industries obtained all benefits from their links with intermediaries. Apart from knowledge exchange, product and process development are the important benefits accruing to firms through intermediaries. The most outstanding role of intermediaries in these CE-based industries is information sharing by brokering intermediaries. In all activities, intermediaries in local textile industry perform slightly better than those in rice cracker industry.

Intermediaries were rated on the range bad to good (scale 2-4) for the various roles they play. Standard deviations of means of these rating vary from 0 to 1.528, showing broad similarity of views across firms regarding the various roles played by intermediaries. But ratings of some activities are largely different. For instance, firms facing problems with collaborative activities were likely to assign low rating scores to intermediaries. In such cases, the adequacy of support provided and the speed in which it is delivered were considered to be crucial for the effectiveness of these intermediaries.

### 7.2.6 Triple helix networks and innovation intermediaries

The engagement of universities in network development as boundary-spanners is significant for the development of the triple helix system in Thailand. Triple helix networks have evolved in Thailand since 2004 (involving the six industries considered in this study) on the back of the cluster development policy of government. And the success of cluster development has largely been influenced by the engagement of universities. For example, the HDDI convinced universities to establish I/UCRCs to interface with and provide technical services for firms in HDD industry. The ITAP uses experts in universities to provide technical assistance for furniture firms. The CMU established the KTC to assist local textile producers in the northern communities. The Thailand Research Fund provides R&D funding for universities to improve the quality of rice cracker products. On the other hand, the lack of qualified university researchers in automotive engineering appears to have constrained the engagement of the automotive industry in a triple helix network.

Sponsoring intermediaries are necessary to develop and maintain triple helix networks. Evidences obtained from the survey of the six industries considered in this study show some networks finding it difficult to get off the ground because of reduction in government supports and hence in the weakness of sponsoring intermediaries. For example, in the HDD and furniture industries, the number of collaborative projects involving the participation of universities and firms decreased dramatically, with only half-finished projects remaining with existing clients, after the sponsoring intermediaries, HDDI and ITAP, had their budgets cut. Both HDDI and ITAP are under the same organisation, NSTDA. In 2010, NSTDA changed its position by reducing the extent of its involvement in network development as a sponsoring intermediary and chose instead to strengthen its position in-house R&D.

Interestingly enough, some networks still operate after the budget withdrawal. For example, Ceracluster, a cluster in the ceramic industry, still survives and operates as an alliance company. Local textile networks use local experts and local knowledge centres to exchange information and knowledge. The case studies of these two networks as well as the network of HDD industry are presented in the next chapter.

From discussion in this section, the hypothesis H2(I) that the engagement of firms in triple helix networks depends on the availability of incentives for participation, including the availability of intermediaries can be duly confirmed. The data used for testing the hypothesis are extracted from documents and interviews (see section 7.1) and from a questionnaire-based survey (see section 7.2), which are summarised in Table 7.4.

As can be seen from Table 7.4, the development of triple helix networks depends largely on the engagement of universities as boundary-spanning intermediaries. In addition, brokering intermediaries are essential to convince universities to actively participate in trilateral projects and forge links between universities and firms. However, to maintain triple helix networks and trilateral projects, sponsoring intermediaries are essential, as seen from experiences of the HDD and furniture industries.

Table 7.4 Pre-existing networks, network status, roles and types of dominant intermediaries establishing triple helix networks

| Industries | | Pre-existing networks | Availability of intermediaries | | | Types of dominant intermediaries | | | Network status |
|---|---|---|---|---|---|---|---|---|---|
| | | | Sponsoring | Brokering | Boundary spanning | University-based | Government-oriented | Market-led | |
| **MNC** | Hard disk drive | Vertical | HDDI | HDDI, I/UCRCs | I/UCRCs, Universities | ✓ | | | Decline of triple helix network (after budget cut) |
| | Automotive | Vertical & horizontal | | TAI, Trade associations | Gov labs, TAI | | ✓ | ✓ | No established network (after government withdrawal) |
| **SME** | Ceramic | Vertical & horizontal | MOI | CIDC | CIDC, RIs, Universities | | ✓ | ✓ | Self-managed triple helix network (after government withdrawal) |
| | Furniture | Vertical & horizontal | ITAP | ITAP | Universities | | ✓ | ✓ | Decline of triple helix network (after budget cut) |
| **CBE** | Local textile | Vertical & horizontal | DEQP, TRF | KTC | CMU, experts | | ✓ | ✓ | Self-managed triple helix network (after budget cut) |
| | Rice cracker | Vertical | Local Gov, TRF | PIO | RTOs, Gov departments, universities | | ✓ | | Early development of triple helix network |

## 7.3 Statistical analysis

### 7.3.1 Access to external resources

The first hypothesis – that firms respond to triple helix initiatives prompted by intermediaries in order to build relational capital, and so to be able to access resources, including technological and financial resources – can be tested using multiple regression analysis, which will be carried out in this section. The regression model is represented by equation 6.1, which is:

$$IILINK_{ij} = \alpha_i + \beta_{1i} TECHEM_{ij} + \beta_{2i} TECHEQ_{ij} + \beta_{3i} INFO_{ij} + \beta_{4i} RDBUD_{ij} + \mu$$

where $IILINK_{ij}$ – the dependent variable – is the number of links firm j in industry i has with intermediaries (i = 1…6; and j = 1…n);

$TECHEM_{ij}$ is the number of employees qualified and engaged in technology development activities in firm j, industry i;

$TECHEQ_{ij}$ is the relevance and adequacy of equipment in firm j, industry i, has at its disposal for the purpose of technology development;

$INFO_{ij}$ is the frequency of access to information for in firm j, industry i;

$RDBUD_{ij}$ is the amount in firm j in industry i allocates for R&D activities;

$\alpha_i$ is the constant term;

$\beta_{1, 2, 3, 4}$ are the regression coefficients; and

$\mu$ is the error term.

The aim of the model is to determine in terms of statistical significance the factors that attract firms in each of the six industries to make themselves open for interaction with innovation intermediaries. The argument underlying this aim is: the more the interaction firms have with innovation intermediaries, the more the likelihood that they would be engaged in triple helix relationships, since the mission of innovation intermediaries is to act as a catalyst in network development by playing sponsoring, brokering and boundary-spanning roles.

The first task in the statistical exercise is to test the viability of the model. Viability in this case would require not only the existence of significant correlation between the dependent and independent variables, but also the absence of such correlations between the independent variables, lest the collinearity problem prevails. This task is performed using the Pearson correlation matrix.

The matrix for the Pearson correlations between the regression variables is presented in Table 7.5 for all six industries. It is found that only some independent variables are correlated with dependent variables; and some independent variables are correlated with other independent variables. Linearity of these variables was checked through scatter plots relating the dependent variable and each independent variable, as can be seen in Figure 7.9.

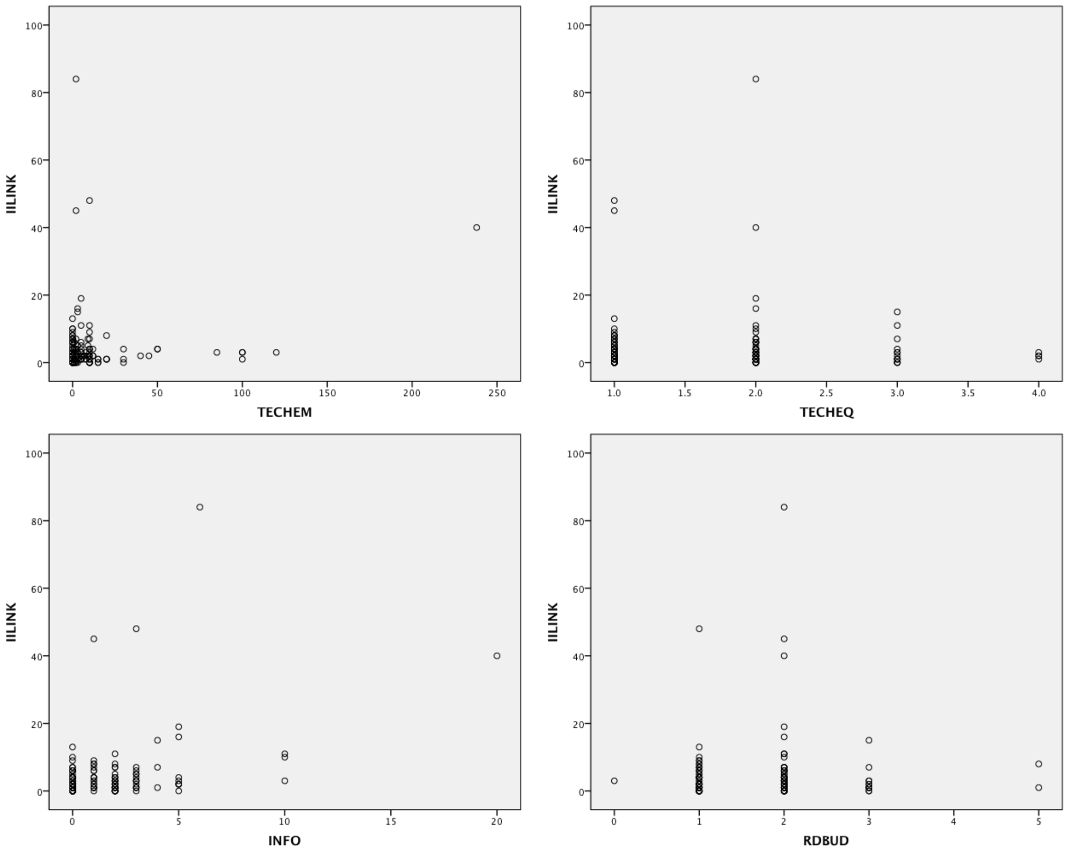



Figure 7.9 Scatter plots relating the dependent variable to the independent variables

Table 7.5 The Pearson correlation matrix for testing Hypothesis H1

| Pearson correlation | | II links | TECHEMP | TECHEQ | INFO | RDBUD |
|---|---|---|---|---|---|---|
| Hard disk drive | II links | 1.000 | | | | |
| | TECHEMP | .993** | 1.000 | | | |
| | TECHEQ | .288 | .307 | 1.000 | | |
| | INFO | .981** | .987** | .397 | 1.000 | |
| | RDBUD | .288 | .307 | 1.000** | .397 | 1.000 |
| Automotive | IILINK | 1.000 | | | | |
| | TECHEM | -.100 | 1.000 | | | |
| | TECHEQ | -.024 | .324 | 1.000 | | |
| | INFO | .284* | .469** | .339* | 1.000 | |
| | RDBUD | .042 | .248 | .591** | .272* | 1.000 |
| Ceramic | IILINK | 1.000 | | | | |
| | TECHEM | -.200 | 1.000 | | | |
| | TECHEQ | .084 | .473** | 1.000 | | |
| | INFO | .480** | .116 | .313* | 1.000 | |
| | RDBUD | .200 | .224 | .271 | .140 | 1.000 |
| Furniture | IILINK | 1.000 | | | | |
| | TECHEM | .441* | 1.000 | | | |
| | TECHEQ | .238 | .468* | 1.000 | | |
| | INFO | .193 | .754** | .614** | 1.000 | |
| | RDBUD | .126 | .458* | .867** | .668** | 1.000 |
| Local textile | IILINK | 1.000 | | | | |
| | TECHEM | .092** | 1.000 | | | |
| | TECHEQ | .072 | .304* | 1.000 | | |
| | INFO | .684 | .475** | .559** | 1.000 | |
| | RDBUD | .180 | .254 | .623** | .492** | 1.000 |
| Rice cracker | IILINK | 1.000 | | | | |
| | TECHEM | -.103 | 1.000 | | | |
| | TECHEQ | .229 | .202 | 1.000 | | |
| | INFO | .559** | .081 | .341 | 1.000 | |
| | RDBUD | .428* | .100 | .920** | .419* | 1.000 |
| All industries | IILINK | 1.000 | | | | |
| | TECHEM | .178* | 1.000 | | | |
| | TECHEQ | -.026 | .269** | 1.000 | | |
| | INFO | .399** | .639** | .346** | 1.000 | |
| | RDBUD | .035 | .177** | .600** | .291* | 1.000 |

Note: * Correlation is significant at 0.05 level.

** Correlation is significant at 0.01 level.

Table 7.6 Regression models for the relationship between firms' links with intermediaries and their access to resources

| Coefficients (t value) | Hard disk drive | Automotive | Ceramic | Furniture | Local textile | Rice cracker | All industries |
|---|---|---|---|---|---|---|---|
| Constant (α) | | 2.962* | 1.152 | 0.428 | 19.809*** | 1.337 | 5.559*** |
| | | (1.883) | (0.666) | (0.687) | (2.795) | (0.587) | (2.784) |
| Tech dev. employees | 0.147 | -0.033 | -0.137 | 0.055 | -1.008** | -0.074 | -0.040 |
| | (1.704) | (-1.649) | (-1.678) | (1.726) | (-2.181) | (-0.295) | (-1.169) |
| Tech dev. equipment | - | -0.504 | 0.143 | 0.455 | -16.956*** | -4.577 | -2.398* |
| | | (-0.615) | (0.149) | (0.773) | (-2.816) | (-1.646) | (-1.916) |
| Access to information | 0.266 | 0.789** | 0.753*** | -0.172 | 14.282*** | 0.661* | 2.053*** |
| | (1.102) | (2.539) | (2.787) | (-0.796) | (7.045) | (1.816) | (5.240) |
| R&D budget | -0.967 | 0.323 | 0.627 | -0.318 | 0.059 | 6.551* | 0.147 |
| | (-0.361) | (0.335) | (1.142) | (-0.506) | (0.011) | (1.950) | (0.122) |
| Adjusted $R^2$ | 0.974 | 0.070 | 0.228 | 0.037 | 0.619 | 0.331 | 0.175 |

Note: * Coefficient is significant at 0.1 level.
** Coefficient is significant at 0.05 level.
*** Coefficient is significant at 0.01 level.

Linear regressions were run for each industry and for all six industries; and the results of the regression analyses are shown in Table 7.6 (see details in Appendix 7).

In the estimation of multiple regression, there are several assumptions, i.e. normal distribution of errors, constant variance of residuals, independence of residuals and no multicollinearity (Morgan et al., 2007). First, to check the condition of normal distribution of errors, the Kolmogorov-Smirnov Test was used. Standardised residuals were calculated from the linear regressions. Then, Kolmogorov-Smirnov statistics was estimated. As seen in Table 7.7, the levels of significance of the Kolmogorov-Smirnov statistics for the six linear regressions are found to be higher than 0.05. This means that errors of the six linear regressions are normally distributed. However, when data of all industries are combined, errors of the linear regression are not normally distributed.

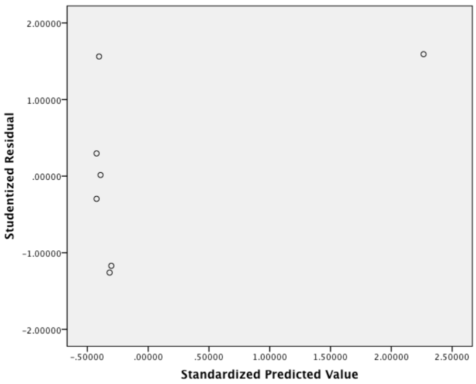
Table 7.7 Tests of assumptions of linear regression

| Tests | Hard disk drive | Auto-motive | Ceramic | Furniture | Local textile | Rice cracker | All industries |
|---|---|---|---|---|---|---|---|
| Kolmogorov-Smirnov statistic | 0.636 | 1.199 | 1.176 | 0.789 | 0.933 | 0.616 | 2.717 |
| Sig. | 0.813 | 0.113 | 0.126 | 0.563 | 0.349 | 0.842 | 0.000 |
| Durbin-Watson | 2.367 | 2.463 | 2.555 (-) | 2.483 | 1.574 | 1.171 (+) | 2.062 |
| Eigenvalue | 0.006 | 0.060 | 0.045 | 0.017 | 0.041 | 0.011 | 0.062 |
| Condition index | 23.347 | 8.130 | 9.311 | 15.547 | 9.782 | 17.981 | 7.636 |

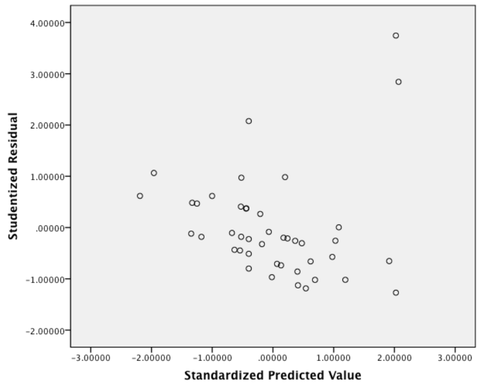
Second, the assumption of the independent residuals can be checked through Durbin-Watson. As seen in Table 7.7, Durbin-Watson statistics of most of the regressions range between 1.5 and 2.5, except those for ceramic and rice cracker industries. In most industries, errors are not associated with each other. However, in the ceramic industry, there is slightly negative autocorrelation because the Durbin-Watson statistic is over 2.5. In the rice cracker industry, errors are positively associated with each other because the Durbin-Watson statistic is less than 1.5.

Third, the eigenvalue and condition index can be used to see collinearity of independent variables. As seen in Table 7.7, the condition indexes for the HDD, furniture and rice cracker industries are high – over 10. This means the independent variables are correlated in each industry case. In the HDD, there is perfect collinearity between technological development equipment and R&D budget, so technological development equipment was excluded in the regression estimation. However, the condition index of the HDD industry is still very high. Apart from these three industries, the condition indexes for the other industries are at moderate level. Therefore, linear regressions for testing the hypothesis H1 cannot be simply estimated due to the multicollinearity of the independent variables. As seen in Table 7.6, the linear regression for the HDD industry has a very high $R^2$ but the coefficients are not significant (Gujarati, 2003). With multicollinearity, linear regression cannot be precisely estimated (Gujarati, 2003; Norušis, 2006).

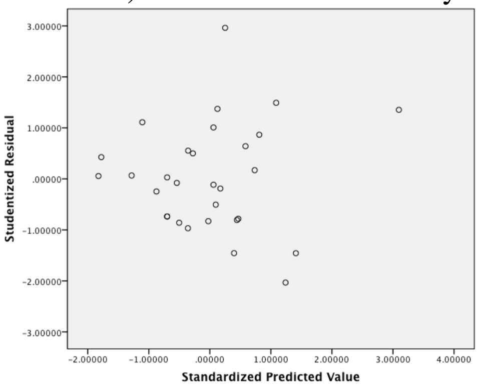
Fourth, to test constant variance of residuals, plots between 'studentised residuals' and predicted values were used to see the association of residuals and dependent variables (Norušis, 2006). As seen in Figure 7.10, the residuals of the six regressions are scattered around zero without any pattern i.e. funnel shape. This means the variances of residuals of regressions are constant (Norušis, 2006).



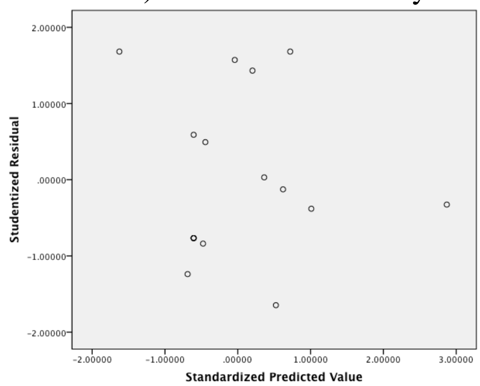

a) Hard disk drive industry



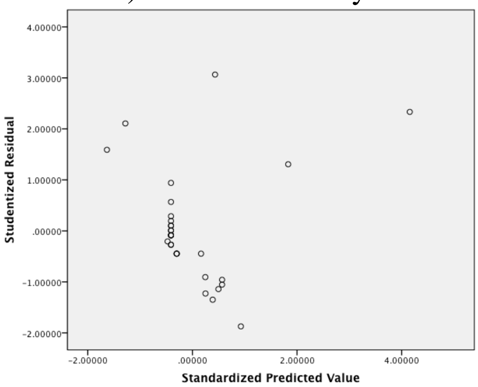

b) Automotive industry



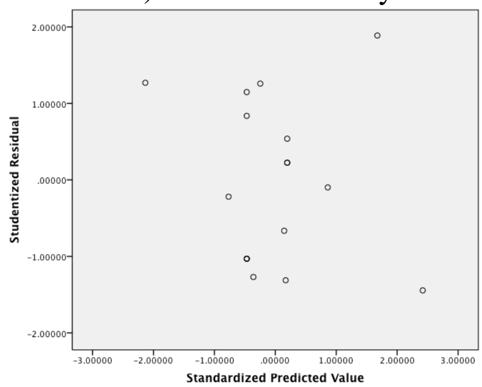

c) Ceramic industry



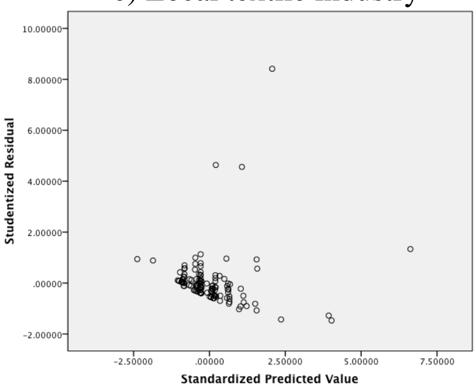

d) Furniture industry




e) Local textile industry




f) rice cracker industry




g) All industries

Figure 7.10 Scatter plots of the ‘studentised residual’ and predicted values

Table 7.8 Regression models estimated through stepwise and backward selection

| Coefficients (t value) | Hard disk drive | Automotive | Ceramic | Furniture | Local textile | Rice cracker | All industries |
|---|---|---|---|---|---|---|---|
| Constant (α) | 0.135<br>(0.171) | 2.638<br>(3.544)*** | 1.869<br>(2.711)** | 0.591<br>(2.700)** | 19.843<br>(3.201)*** | 3.603<br>(3.710)*** | 5.804<br>(3.183)*** |
| Tech dev. employees | 0.167<br>(19.004)*** | -0.034<br>(-1.812)* | - | 0.037<br>(1.904)* | -1.008<br>(-2.222)*** | - | - |
| Tech dev. equipment | - | - | - | - | -16.925<br>(-3.267)*** | - | -2.396<br>(-2.317)** |
| Access to information | - | 0.760<br>(2.570)** | 0.753<br>(2.896)*** | - | 14.286<br>(7.337)*** | 0.893<br>(2.610)** | 1.783<br>(5.764)*** |
| R&D budget | - | - | - | - | - | - | - |
| Adjusted $R^2$ | 0.984 | 0.108 | 0.203 | 0.141 | 0.633 | 0.267 | 0.179 |
| Selection method | stepwise | backward | stepwise | backward | stepwise | stepwise | stepwise |

Note: * Coefficient is significant at 0.1 level.
** Coefficient is significant at 0.05 level.
*** Coefficient is significant at 0.01 level.

From the assumption tests, it was found that multicollinearity is the main problem of the estimation by means of regression analysis. As seen in Table 7.5, the correlations between some independent variables – e.g. between technological employees and information access; and between technological equipment and R&D budget – are significant. To solve this problem, some variables have to be excluded by using backward and stepwise methods in variable selection (Norušis, 2006). The regression models for each industry and all industries are shown in Table 7.8 (see details in Appendix 7).

In the HDD industry, the evidence suggests that firms have links with intermediaries as they have adequate human resources. From the estimation made through stepwise selection, the number of technological development employees is the only variable resulting in the change of $R^2$. The coefficient of this variable is significant at one per cent level. This means linkages with intermediaries would be higher if the number of technological development employees increased. Change in the number of technological development employees explains 98.4 per cent of change in firms' linkages with intermediaries. This finding is in line with Rothwell and Dodgson (1991), which concludes that firms create external linkages when they have adequate qualified manpower. However, the finding of Rothwell and Dodgson are based on data relating to SMEs.

In the automotive industry, forging links with intermediaries is associated with human resources and access to information. The number of technological development employees is negatively associated with the links firms have established with intermediaries. This statistical finding, which is significant at 10 per cent level, means automotive firms have established links with intermediaries because of the problem of lack of internal human resources. This is contrary to the situation in the HDD industry where the establishment of links with intermediaries is leveraged by the availability of the relevant human resources. In addition, information access in the automotive industry is positively associated with firms' links with intermediaries. So the more frequent firms' access to information sources, the higher the likelihood for them to establish links with intermediaries. By the same token, it can also be expected that lack of information access would result in the need of firms to establish links with intermediaries. However, firms may establish links with intermediaries to access information sources because intermediaries provide information for firms. This statistical finding, which is observed to be significant at one per cent level, is at odds with the hypothesis that firms establish links with intermediaries in order to access external information with the aim to make up for the shortfall in internal supply of information. But it is difficult to determine the direction of causality from this cross-sectional data.

In the ceramic industries, firms' access to information is positively associated with their links with intermediaries. The association is found to be statistically significant at the one per cent level of significance. As in the case of firms in the automotive industry, ceramic firms with more sources of information access are likely to have more links with intermediaries. As seen from the section 7.2, both automotive and ceramic industries have their respective trade associations as their principal information sources.

Similar to firms in the HDD industry, the number of technological development employees for firms in the furniture industry is positively associated with the number of links they have established with intermediaries. This finding is significant at 10 per cent level. However, the adjusted $R^2$ of the regression model is very low at 0.141. This means change in number of employees can slightly explain change in number of links with intermediaries. Moreover, none of the coefficients of the independent variables is significant when the stepwise selection is used. Therefore, the backward selection method is applied to identify the last variable, which should be removed to get the $R^2$ improved.

In the regression corresponding to the local textile industry, the independent variables, except R&D budget of firms, have coefficients that are significant at one per cent level. Changes in these variables can together explain 63.3 per cent of changes that may occur in the extent of links with intermediaries. The evidence borne out by the regression analysis also shows that the number of links firms have with intermediaries depends on the state of their technological development employees (inversely); the facility of their access to information (directly); and the extent to which they are furnished with technological development equipment (inversely). This means firms in this industry establish links with intermediaries not merely because they have the facility of access to information, but also because they lack the human and physical resources that would be badly required for technological development. Thus, on the basis of this evidence, we would accept the hypothesis that firms build linkage with intermediaries because of lack of internal manpower and equipment. This is very much in line with expectation since in the local textile industry most CBEs do not have adequate resources for technology development, and they would, in the circumstances, be keen to establish links with intermediaries to exploit external resources.

In the case of the rice cracker industry, only the factor relating to information access is positively associated significantly (at 5 per cent level) with the state of firms' links with intermediaries. The adjusted $R^2$ is, however, low at 0.267, meaning that change in the frequency of access to information can explain 26.7 per cent of changes that may occur in the frequency of interactions with intermediaries.

In the regression run for all firms in the six industries, the factors relating to technology development equipment and information access are significantly associated with the dependent variable, but they can explain only 17.9 per cent of change in links with intermediaries. However, besides access to external resources, Knorringa (1999) points out access to market channels to be an important factor influencing firms to cooperate with other institutional actors. This is broadly consistent with our finding since the point about market access is well covered in this study insofar as access to information bears on innovation through its influence on developments in both the market and technology frontiers of business and industry.

The empirical analysis carried out in this section shows that for the firms in the six industries considered in this study, there are three factors affecting the establishment of links with intermediaries. These include factors relating to the availability of technological development expertise; adequacy and relevancy of firms' stock of equipment for research in technological development; and facility of access to information. The number of technological development employees is associated with number of links with intermediaries in four industries, including HDD, automotive, furniture and local textile industries. The direction of association is not, however, the same for all four industries. In the case of the HDD and furniture industries, the possession of adequate qualified human resources is found to be crucial for firms to forge links with intermediaries. In the case of the automotive and textile industries, it is the lack of human resources that is crucial. The number of information sources firms access is positively associated with the number of links firms have with intermediaries in four industries, including the automotive, ceramic, local textile and rice cracker industries. Firms in these industries establish links with intermediaries because of the facility of their access to information. In addition, there is statistically significant evidence showing the existence of a functional relationship between the links firms have with intermediaries and their stock of equipment geared for technological development in local textile industry. On the other hand, the factor relating to R&D budget was excluded from regression model of every industry. This is because the R&D budget is highly correlated with technological development equipment in all industry cases and weakly correlated with firms' links with intermediaries.

### 7.3.2 Effectiveness of intermediaries

Effectiveness of intermediary services is reflected by the way industries rate the intermediaries they are liaising with. Firms were asked to rate the quality of intermediary services and the mean value of the ratings for each industry is given in

Table 7.3. From the means of the ratings of intermediary services across industries shown in Table 7.3, the mean values of the ratings are for the most part widely spread. The only clear pattern that emerges is that intermediaries were consistently more popular in local textile and rice cracker industries than in other industries in all activities; and that intermediaries in local textile industry were rated higher than those in rice cracker industry in every activity. For the other industries, the mean values of intermediary rating are widely distributed. For example, intermediaries in HDD industry have higher qualities than those in the automotive industry in IPR management, information sharing, assistance of external R&D utilisation and assistance of in-house R&D. Intermediaries in ceramic industry have higher qualities than those of furniture industry in information sharing, provision of facilitations, access to external resources and technical services.

Comparing between industry groups, intermediaries in CE-based industry group performed best, (see Table 7.9). In every activity, intermediaries in SME-based industry groups were rated higher than those in the MNC-dominated industry group. This implies that CBEs are likely to rate their satisfaction for intermediaries highest, followed by SMEs and MNCs including large local firms.

Table 7.9 Quality of services provided by innovation intermediaries as rated by firms having linkages with such intermediaries

| Average qualities | MNC-dominated industry group | | | SME-based industry group | | | CE-based industry group | | |
|---|---|---|---|---|---|---|---|---|---|
| **Roles of intermediaries** | **Mean** | **Cases** | **SD** | **Mean** | **Cases** | **SD** | **Mean** | **Case** | **SD** |
| **1. Sponsoring role** | | | | | | | | | |
| Provision of financial supports | 2.4 | 7 | 1.134 | 3.17 | 6 | 1.329 | 3.36 | 11 | 0.674 |
| IP management | 2.86 | 7 | 1.069 | 3.20 | 5 | 0.837 | 3.56 | 9 | 1.014 |
| **2. Brokering role** | | | | | | | | | |
| Information sharing about potential partners | 3.35 | 23 | 0.647 | 3.43 | 23 | 0.507 | 4.05 | 21 | 0.865 |
| Provision of facilitations | 3.04 | 23 | 0.767 | 3.35 | 23 | 0.832 | 3.62 | 21 | 0.805 |
| Provision of access to external resources | 2.57 | 21 | 0.926 | 3.17 | 24 | 0.761 | 3.50 | 20 | 0.889 |
| **3. Boundary-spanning role** | | | | | | | | | |
| Provision of technical services | 3.18 | 28 | 0.819 | 3.52 | 21 | 0.750 | 3.61 | 28 | 0.832 |
| Provision of assistance of external R&D utilization | 2.88 | 25 | 0.781 | 2.95 | 20 | 0.887 | 3.58 | 26 | 0.857 |
| Provision of assistance to in-house R&D | 2.88 | 24 | 0.947 | 2.94 | 17 | 0.748 | 3.61 | 18 | 0.850 |
| Knowledge circulation | 3.12 | 26 | 0.516 | 3.20 | 20 | 1.105 | 3.61 | 28 | 0.832 |

Analysis of Variance (ANOVA) is used to test the statistical significance of any differences in the effectiveness of intermediaries within and between industry groups. These results, which are presented in Table 7.12, are based on the distillation of data for use in ANOVA through tests for normality (see Table 7.10) and homogeneity (Table 7.11) (Norušis, 2006).

*The normality test:* The Kolmogorov-Smirnov can be used to test whether or not the data is normally distributed. The Kolmogorov-Smirnov test is presented in Table 7.10 (see details in Appendix 8). In each industry case, most of the Kolmogorov-Smirnov statistics are not significant at the five per cent level. This means the null hypothesis that the data are normally distributed cannot be rejected outright. Although some of data are not normally distributed, because the significance levels are less than 0.05, this is acceptable as they are not extremely non-normal (Norušis, 2006).

Table 7.10 Kolmogorov-Smirnov Test of 5-Likert scale effectiveness

| Kolmogorov-Smirnov Z (2-tailed sig.) | Hard disk drive | Auto-motive | Ceramic | Furniture | Local textile | Rice cracker | All industries |
|---|---|---|---|---|---|---|---|
| **1. Sponsoring role** | | | | | | | |
| Financial supports | 0.667 | 0.301 | 0.694 | - | 0.780 | 1.205 | 1.555* |
| | (0.766) | (1.000) | (0.721) | | (0.577) | (0.110) | (0.016) |
| IP management | - | 0.595 | 0.515 | - | 0.438 | 0.959 | 0.985 |
| | | (0.870) | (0.953) | | (0.991) | (0.316) | (0.286) |
| **2. Brokering role** | | | | | | | |
| Information sharing | - | 1.313 | 1.464* | 1.335 | 0.938 | 0.623 | 2.070** |
| | | (0.064) | (0.028) | (0.057) | (0.343) | (0.833) | (0.000) |
| Facilitations | - | 1.384* | 1.131 | 1.335 | 1.152 | 0.717 | 1.847** |
| | | (0.043) | (0.155) | (0.057) | (0.141) | (0.682) | (0.002) |
| Access to external resources | - | 1.631** | 0.923 | 1.335 | 0.931 | 0.718 | 2.151** |
| | | (0.010) | (0.362) | (0.057) | (0.351) | (0.681) | (0.000) |
| **3. Boundary-spanning role** | | | | | | | |
| Technical services | - | 1.036 | 0.993 | 0.883 | 1.662** | 0.911 | 2.038** |
| | | (0.233) | (0.278) | (0.417) | (0.008) | (0.377) | (0.000) |
| External R&D utilization | 1.205 | 1.456* | 0.900 | - | 1.092 | 0.775 | 2.304** |
| | (0.110) | (0.029) | (0.278) | | (0.184) | (0.585) | (0.000) |
| Assistance of in-house R&D | 0.998 | 1.163 | 1.198 | - | 0.892 | 1.008 | 2.141** |
| | (0.272) | (0.133) | (0.114) | | (0.404) | (0.261) | (0.000) |
| Knowledge circulation | 1.205 | 1.663** | 1.102 | - | 1.355 | 1.261 | 2.214** |
| | (0.110) | (0.008) | (0.176) | | (0.051) | (0.083) | (0.000) |

Note: * Kolmogorov-Smirnov Z is significant at 0.05 level.
** Kolmogorov-Smirnov Z is significant at 0.01 level.

Table 7.11 Levene Statistic for testing homogeneity of variance

| Roles of intermediaries | Levene statistic | Sig. |
|---|---|---|
| **1. Sponsoring role** | | |
| Financial supports | - | - |
| IP management | 4.623 | 0.069 |
| **2. Brokering role** | | |
| Information sharing | 1.937 | 0.116 |
| Facilitations | 1.375 | 0.253 |
| Access to external resources | 1.753 | 0.150 |
| **3. Boundary-spanning role** | | |
| Technical services | 1.383 | 0.249 |
| External R&D utilization | 1.320 | 0.273 |
| Assistance of in-house R&D | 1.186 | 0.328 |
| Knowledge circulation | 5.928 | 0.000 |

*The homogeneity test:* Levene's Test is used to test homogeneity, in which variances of populations are equal. In this test, variances based on the mean of effectiveness of intermediaries in the six industries are compared against Levene statistics. Levene statistics based on the mean effectiveness of intermediaries is shown in Table 7.11 (see details in Appendix 8). As seen in Table 7.11, Levene statistics corresponding to most intermediary roles are not significant at the five per cent level, apart from the knowledge circulation role. This means variances for most of the mean values of effectiveness are equal.

In the exercise to compare the means of different populations in each industry group, three ANOVAs between two industries in three industry groups were estimated. The normality and homogeneity tests confirm that the ANOVA assumptions are not violated, which means that ANOVA can be used to compare means of effectiveness of intermediaries. The results are shown in Table 7.12 (see details in Appendix 9).

Table 7.12 Results from ANOVA of effectiveness of intermediaries between and within industry groups

| Roles of intermediaries / Average qualities | Within industry groups | | | | | | Between 3 industry groups | |
|---|---|---|---|---|---|---|---|---|
| | MNC-dominated | | SME-based | | CE-based | | | |
| | F | Sig | F | Sig | F | Sig | F | Sig |
| **1. Sponsoring role** | | | | | | | | |
| Financial supports | 0.031 | 0.867 | - | - | 1.143 | 0.313 | 1.924 | 0.171 |
| IP management | 0.079 | 0.789 | - | - | 0.048 | 0.833 | 0.972 | 0.397 |
| **2. Brokering role** | | | | | | | | |
| Information sharing | 1.064 | 0.314 | 3.756 | 0.066 | 0.503 | 0.487 | 6.757 | 0.002 |
| Facilitations | 0.003 | 0.995 | 0.600 | 0.447 | 1.062 | 0.316 | 2.840 | 0.066 |
| Access to external resources | 0.388 | 0.541 | 1.682 | 0.208 | 0.290 | 0.597 | 6.230 | 0.003 |
| **3. Boundary-spanning role** | | | | | | | | |
| Technical services | 0.354 | 0.557 | 0.648 | 0.431 | 1.587 | 0.219 | 2.183 | 0.120 |
| External R&D utilization | 1.067 | 0.312 | 0.015 | 0.904 | 0.684 | 0.416 | 5.220 | 0.008 |
| Assistance of in-house R&D | 1.952 | 0.176 | 0.021 | 0.886 | 0.679 | 0.422 | 4.233 | 0.019 |
| Knowledge circulation | 0.074 | 0.788 | 0.110 | 0.744 | 1.587 | 0.219 | 2.695 | 0.074 |

The ANOVA results show that effectiveness of intermediaries is not significantly different within industry groups, with the F-ratios too low across the board to be significant at even the 10 per cent level, with the only exception of SME-based firms where some degree of variation is apparent with respect to the intermediary role of brokering in information sharing. On the other hand, there is some evidence of statistically significant difference between industry groups in the effectiveness of intermediaries across most of the brokering and boundary spanning activities. As can be seen in Table 7.12, the F-ratios are not significant even at the 10 per cent level for all sponsoring activities and for the boundary-spanning role in the area of technical services. On the basis of this evidence, the hypothesis that there is no difference in the effectiveness in the performance of intermediaries across the three industry groups can be sustained only for sponsoring activities. Across industry groups, the performances of intermediaries in some activities in brokering and boundary-spanning roles are significantly different at the five per cent level. These activities include information sharing, provision of access to external resources, assistance in external R&D utilisation and in-house R&D.

On the basis of the evidence discussed earlier, the hypothesis H2(II) that firms' participation in triple helix activities is conditional on the effectiveness of intermediaries providing resources and services can be rejected. The analysis in sections 7.2.2 and 7.2.3 indicates that within industry groups, firms in the HDD industry are more active in triple helix interactions than those in the automotive industry; those in the ceramic industry are more active than those in furniture industry; and those in the local textile industry are more active than those in the rice cracker industry. However, there is no statistically significant evidence to show that intermediaries within industry groups perform differently in different activities. This implies that effectiveness of intermediaries do not influence activeness of firms in participating triple helix activities.

Interestingly, there is significant difference in the performance of intermediaries between industry groups. This could possibly be attributed to firms' expectations for intermediary services being different in different industry groups. Service quality is judged by comparing clients' expectation and perceived performance. The gap between the two is known as 'disconfirmation'. If the expectation of clients is high, the 'disconfirmation' is likely to be high, thus lowering satisfaction. In business services, including technical services, clients use their existing knowledge to evaluate performance of service providers if clients have inadequate technical skills (Patterson et al., 1997). In this case, the larger industries and firms are, the higher the expectation they have because larger firms with more advanced knowledge base, like MNCs, might need advanced services in which intermediaries may not be able to serve and satisfy them, leading to low satisfaction. Small firms with low knowledge base, like CBEs, might have lower expectation, thus rating higher satisfaction.

### 7.3.3 Technological capability development

The hypothesis H2(III) that the extent of firms' participation in triple helix networks depends on the degree of their technological capability development can be tested using the Spearman's Rank Order Correlation (Spearman Correlation). The Spearman Correlation is a nonparametric test of association between scale variable and ordinal variable (Bryman, 2008; Carver and Nash, 2009). The number of links with all actors is given in terms of scale data, which is a quantitative variable, while the level of technological capability is ordinal data, which is a qualitative variable. The results are shown in Table 7.13 (see details in Appendix 10).

Table 7.13 Spearman Correlation between the number of links with all actors and level of technological capability

| | Hard disk drive | Automotive | Ceramic | Furniture | Local textile | Rice cracker | All industries |
|---|---|---|---|---|---|---|---|
| Spearman's Rho | 0.553 | 0.150 | 0.239 | 0.226 | 0.254 | 0.207 | 0.194 |
| Approx. T | 1.484 | 0.968 | 1.302 | 0.897 | 1.417 | 0.818 | 2.366 |
| Approx. Sig. | 0.198 | 0.339 | 0.203 | 0.384 | 0.167 | 0.426 | 0.019 |
| No. of valid cases | 7 | 43 | 30 | 17 | 31 | 17 | 145 |

As seen in Table 7.13, the degree of associations between the number of links with all actors and the level of technological capability are positive, albeit moderate to low. Moreover, none of the Spearman correlation index for each of the six industries is significant. The correlation for all the six industries, however low at 0.194, is significant at the five per cent level. Thus, on the basis of the survey data, it can be concluded that there is no significant evidence to accept the hypothesis that the level of firms' technological capability explains their inclination to engage in networking to establish external links.

## 7.4 Conclusion

Triple helix networks could evolve from pre-existing inter-firm networks upon intervention by innovation intermediaries. The pre-existing inter-firm networks in the six sample industries covered in this study occur in the form of vertical value chain and horizontal/industrial networks. An attempt has been made in this chapter to explore evidence about the role intermediaries play in transforming inter-firm networks into triple helix networks using descriptive and statistical analyses. The hypothesis H2(I) that availability of intermediaries influences establishment of triple helix networks is confirmed through narrative and descriptive analyses. To establish triple helix networks, the boundary-spanning role played by universities is necessary. The absence of such intermediary service by universities could be a setback in the development of the triple helix system, as seen in the case of the automotive industry. But for triple helix networks to continue to be functional, the sponsoring role of intermediaries played by government-based agencies is crucial. Without the provision of financial supports, trilateral projects could not continue, as seen in the cases of HDD and furniture industries.

It is found that there is no empirical basis to uphold the hypothesis that firms are responsive to triple helix intermediaries in order to exploit access to external resources, including technological and financial resources. The evidence at hand suggests the main reason for most firms to establish links with intermediaries to be security for better information access. Firms could have better information access as they connect with intermediaries. In some industries, like HDD and furniture manufacturing, firms forge links with intermediaries mainly because they have adequate human resources that would enable them to exploit access to information resources for purposes of conducting technology development activities. On the other hand, firms in the automotive and local textile industries have established links with intermediaries in spite of the lack of technologically-oriented human resources. Interestingly enough, it was found that firms in local textile industry established links with intermediaries mainly to exploit external human and physical resources, suited for technological development.

The hypothesis H2(II) that firms would engage in triple helix network activities depending on the effectiveness of intermediaries providing resources and services is rejected because the satisfaction of firms for intermediaries within industry groups are not significantly different across firms, although the descriptive analysis indicates that some industries are more active than others within industry groups. However, expressions of satisfaction for intermediary services are significantly different across industry groups in some activities relating to the brokering and boundary spanning roles of intermediaries. This implies that the size of firms may influence the profile of expectation for services provided by intermediaries, thus yielding different satisfaction profiles across industry groups. Similarly, the hypothesis H2(III) that firms would engage in triple helix network activities depending on their level of technological capability is not supported by evidence in all industries.

Issues discussed in this chapter using the narrative and descriptive methods were put to the statistical test and most of these fell short of being significant. This may be due to the smallness of the sample size and the quality of the data used in the statistical analyses, failing to satisfy the robustness test. The results of the statistical analysis are nonetheless tentative, at best. It would therefore be useful to verify the validity of these findings using alternative methods, as is done in the next chapter, where the hypothesis H2(I) and H2(IV) that firms engage in triple helix activities depending on: the availability of intermediaries; and the degree of development of their pre-existing network, is investigated using the case study method.

# CHAPTER 8

# Case Studies of Cluster and Triple Helix Networks and Innovation Intermediaries

This chapter uses the multi-case study method to analyse the role of intermediaries in the transformation of pre-existing networks into triple helix network and put to the test the proposition that the engagement of firms in triple helix relationships depends on (a) the availability of intermediaries (H2(I)); and (b) the experiences of firms in pre-existing networks (H2(IV)). Multiple case studies are used to allow generalisability of the results insofar as comparison of multiple case studies can establish external validity because of the replication of logic and theoretical frameworks (Yin, 2002). The three case studies discussed in this chapter show the modalities of learning across firms in the dynamic process of knowledge creation.

The case studies involve a network of firms in each industry group considered in this study. In the multinational corporation (MNC)-dominated industry, TH Alliance, a group of small companies in hard disk drive (HDD) industry, was selected as one of the companies for case study. In the small and medium enterprise (SME)-based industry, Ceracluster Company, established from the development of cluster, was selected. In the community enterprise (CE)-based industry, Toobkeawma Knowledge Centre, founded by a community-based enterprise (CBE), was selected. Because these firms and group of firms were established for different purposes, they have thrived on different network systems, ranging from the tightest network – i.e. integration of production lines, as in TH Alliance – to loosest networks – i.e. informal knowledge exchange network, as in Toobkeawma Knowledge Centre.

The data analysed in this chapter derived from the interviews with five people from the HDD industry; three from the ceramic industry; and four from the local textile industry. Figure 8.1 shows the locations of these networks. Ceracluster (for ceramic industry) and Toobkeawma Knowledge Centre (for local textile industry) were established due to their geographical proximity to their respective industries. In the case of TH Alliance which is located in Bangkok area, it is knowledge and cognitive proximity that is crucial. Most leading universities in Thailand are located in Bangkok, the capital city.


Figure 8.1 Locations of three case studies

Source: www.bangkoksite.com

In this chapter, the roles of intermediaries, classification of innovation networks, processes of knowledge creation and technological learning, which were discussed in Chapter 3 are further explored through the three case studies. The chapter is organised in six sections. In the first section, the three case studies are introduced and set in context as triple helix networks to see if there is any evidence to show that the networks are kept active as a result of the involvement of intermediaries. In the second section, the nature of the links intermediaries make with enterprises and the specific roles they play within the link framework are discussed. In the third section, the salient features of the dynamics underlying the three triple helix networks are outlined. In the fourth section, learning processes corresponding to the three triple helix networks are compared and discussed. In the fifth section, the major problems constraining the triple helix dynamics from being played out in full are discussed. The conclusion to the Chapter is presented in the sixth section.

## 8.1 Establishment of triple helix networks and availability of intermediaries

Generally speaking, intermediaries are essential in the early stages of network formation to make up for deficiencies in communication and interaction that often arise because of differences in culture, motivation and technological capability of the principal triple helix actors. The aim of network building is to minimise the area of differences and maximise the area of common understanding, so that anyone of the institutional actors that has a better understanding of the others is, at least in principle, better positioned to lead the evolutionary process in the development of the network system. In the triple helix system, universities are often assigned this responsibility (Wright et al., 2008).

In the case of Thailand, the centralising bureaucratic system of governance has not enabled universities to develop the culture and motivation to assist industry. For instance, the research questions university researchers had to work on did not arise from industry at the grassroots but rather from the centre of bureaucratic governance. However, after the financial crisis in 1997, Thai universities became autonomous and have had to work with and serve industry to gain more income. However, technological capability of universities often fell too short to cater for the needs of industry. Indeed, industry was relatively better positioned to cater for its needs. For example, universities cannot keep up with the demand for advanced technologies in some industries, such as the automotive industry. With respect to demand for technologies in some traditional industries, the focus of universities was on basic research rather than applied research. While universities are used to the practice of research they were far removed from the practice of commercialisation. This situation limited the scope for university-industry interaction, still less for universities to take the lead role in building the triple helix networks in all the three industry cases to be considered in this chapter. This would make the role of intermediaries absolutely necessary to create the mechanisms required for promoting interactions between universities, industry and government agencies, and develop the triple helix network in the process. As discussed in previous chapters, intermediaries intervene as sponsors, transmitting policy with resources; brokers, building mechanisms for interaction and linking actors; and boundary spanners, providing operational services for knowledge circulation. These roles are explored in the three case studies discussed in the remainder of this chapter.

### 8.1.1 Hard disk drive industry: TH Alliance

The role of intermediaries has been found to be crucial for MNC-dominated industries in Thailand to stimulate the backward linkage effects, thus increasing the value added to economy. In the past, this role was executed by government agencies based on the so-called ‘local content requirement policy’, a protectionist policy aimed at promoting use of locally produced materials instead of imported ones. This policy of import substitution is now abandoned and replaced with a strategy for global sourcing. While this strategy may appeal to inward foreign direct investment (FDI), the government’s insistence to generate the maximum possible value added sets a challenge that local producers have to contend with. However, in this change of policy direction, the government’s position is based on the belief that for sustained increase in value added due to FDIs, MNCs would need to make substantial contributions to the technological capability development of local firms. In other words, growth in value added should be based not merely on the employment of more and more of primary resources (capital, labour, land and land-based resources), but more importantly on technological progress. According to an interviewee representing HDDI, the government agency supports the HDD industry:

> “MNCs in the HDD industry hardly connect with their competitors and local firms. They have their own global supply chains. If we did not develop clusters and establish the Hard Disk Drive Institute to provide supports to improve quality of manpower, they (the MNCs) would move to other countries offering better incentives.”

For the HDD industry, although Thailand has long been the manufacturing base for most global HDD makers, the value added created in the country has been known to be only a small fraction of sale, accounting for about 1.12 per cent of export value (Kohpaiboon, 2009). Most HDD makers and first tier suppliers are MNCs taking advantage of the low wage labour regime in Thailand. Local firms do not have the capability to produce parts due to the lack of infrastructure for high precision technology. In supporting value added creation, the government has focused on supporting industries, such as jig fixture, automation and indirect materials.

Cluster development policy has been pursued since 2006 to promote the HDD industry. Although clusters are dominated by MNCs, the government has sought to promote MNC-dominated clusters by encouraging them to select SMEs to enter the supply chain system and help the SMEs achieve the quality requirements of their MNC customers. Network brokers and incentives are necessary to build trust and cooperation between MNCs and SMEs (Altenburg and Meyer-Stamer, 1999).

TH alliance is a pilot project involving the horizontal integration of four SMEs in automation products. It was initiated as a cluster of local firms by the Hard Disk Drive Institute (HDDI) as supporting industries for HDD industry, such as machinery and equipment, thus accounting for the backward linkage effect of the HDD industry. To implement cluster development of local firms to support the activities of the HDD industry, the HDDI created Industry/University Cooperative Research Centres (I/UCRCs) as brokering intermediaries in three universities.

The Institute of Field Robotics (FIBO) in King Mongkut's University of Technology Thonburi (KMUTT), one of the three I/UCRCs, identified a list of potential local firms with the basic capability to manufacture automation products. It provided the list to an HDD maker to select potential suppliers to establish an alliance company by integrating production lines of local firms to realise economies of scale in the process of specialisation. Four SMEs were selected to establish TH Alliance to provide automation products for an HDD maker – some of the SMEs with comparative advantage in manufacturing capability and others in design capability. Each firm in TH Alliance had to invest in machines and resources for some production and testing lines in which it has comparative advantage, so that its outputs can be effectively integrated into the whole automation production system. These four SMEs set out their machines in particular lines to form a joint station at a site near an HDD maker. Then, as a boundary-spanning intermediary, the FIBO facilitated knowledge circulation between MNCs and local SMEs, by providing research support to local firms, thus offering them access to opportunities for reverse engineering and the acquisition of knowledge that would enable them to replicate some imported machines and develop their technological capabilities in the process. An interviewee representing a member of TH Alliance emphasised the importance of assistance offered by boundary-spanning intermediaries in the following words:

> "FIBO provided training in design engineering for our engineers and technicians. After training, we can do better jobs because we have more knowledge on how to select good quality machines. So, we can invest in good quality machines in the joint project. Without this training, we could not have won the bid for this project from the MNC."

Although the government research support offered through the HDDI accounts for a very small fraction of the total R&D investment of MNCs, it nonetheless helped to show MNCs that government policy was committed to growing SMEs and making them trustworthy as partners in production. Before the intervention of the HDDI, MNCs did not trust local SMEs because they are too small with low registered capital. They lacked quality assurance, inspection equipment and the ability to produce very high precision products. The HDDI support enhanced the credibility of SMEs, now that they have the skill and capability to work on larger projects with confidence. The HDDI helps SMEs to engage in business not only with HDD makers but also other industries requiring automation process.

An important outcome of the establishment of TH Alliance is the upgrading of the design capability of local firms, so that they would be able to serve MNCs and possibly learn and accumulate knowledge in the course of their interactions with the MNCs. As a sponsoring intermediary, the HDDI supported human resource development in the local SMEs. At the same time, FIBO, a boundary-spanning intermediary, provided training and technical assistance, such as finite element and structure, to the four SMEs. For example, an SME in TH Alliance had seven engineers (five electrical and two mechanical engineers) trained in design engineering and this had enabled the SME to work in joint a projects with MNCs[4]. FIBO also assisted with documents for quality certification that would enable local firms to gain the trust of MNCs and qualify them to enter the supply chain of MNCs.

[4] Based on information elicited from interview in the course of fieldwork.

In addition, the HDDI also provided financial support for prototype development at TH Alliance, with the aim that at the end of the project, the HDD maker would choose to buy machines from the TH alliance with their intellectual property rights (IPR). SMEs in TH Alliance can see the benefit of integration into the TH Alliance, as this integration qualifies them to bid for larger projects tendered by MNCs. The aim in the long run is to develop local design capability that would enable SMEs to cooperate with each other to engage – even without government support – in the import substitution of machines used by MNCs.

The process during the short term to the medium term period, however, proved to be rather complex and daunting. It was realised, for example, that the supports offered by the government was not enough to secure sustained MNC investment and purchasing that would allow the incorporation of SMEs into the MNC supply chain system. It was also noticed that strategy adopted by western HDD makers were different from that of Japanese automotive assemblers operating in Thailand. Western HDD makers – particularly those steeped in the Anglo-Saxon business tradition – followed global sourcing strategy, selecting the best and the cheapest sources without any consideration of the magnitude of contributions to local value added. On the other hand, Japanese automotive assemblers focused on the aim of upgrading the technological capabilities of local firms, so that they can engage as subcontractors with the Japanese assemblers on a long term basis. More importantly, when it comes to building a relationship of trust with local SMEs, technology secrecy is a main concern of HDD makers as there are only few of them in the world market at present. HDD makers facing an oligopolistic market would therefore find it strategic to require local SMEs in their supply chain system to sell to them their IPR together with their products as a condition for working together. MNCs thus exercise an upper hand over SMEs, as the latter do not have adequate negotiating power or market power to refuse to surrender their IPR obtained on the back of government support to the MNCs. This unfair outcome appears to have dissuaded the Thai Government from offering further support to the SMEs.

### 8.1.2 Ceramic industry: Ceracluster Company

Similar to TH Alliance, Ceracluster was founded as an alliance company on the back of the cluster development policy of the Thai Government. The Department of Industry Promotion (DIP) implemented the cluster policy of the Ministry of Industry by developing industrial clusters in different parts of Thailand. In the ceramic industry, it assigned the Ceramic Industry Development Centre (CIDC), a specialised centre under the DIP, to develop ceramic cluster in Lampang Province. As a sponsoring intermediary, DIP also provided a 5-year budget for cluster development. And as a brokering intermediary, the CIDC invited ceramic firms interested in participating in the cluster to formulate a 5-year plan.

In the first year of the plan, the CIDC worked as a brokering intermediary mediating among interested firms to build trust through the provision of training seminars. Although there is a concentration of ceramic firms in Lampang Province, these firms occur loosely connected, even as members of the Lampang Ceramic Association, whose task it is to organise exhibitions and trade fairs in Lampang.

The CIDC seminars and training programmes helped the firms to understand the concept of cluster, trust and mutual benefits arising from networking. After the establishment of Ceracluster, a private network broker, or an industrial cluster development agent (ICDA), was appointed to manage Ceracluster. This broker sought to draw links between members of Ceracluster and between members and government agencies. The ICDA was educated in Japan and had a background social work in community development in the border area of Thailand. His motivation for participation in the cluster was to demonstrate the possibility of network development among firms in the private sector through the market mechanism and with little or no government financial support. It was consequently felt that a strategy of joint investment among firms could be pursued as an alternative for cluster development. This, it was thought, would solve the lack of commitment of the private sector, which frustrated cluster initiatives during the first phase of cluster development in Lampang Province (see Chapter 7, section 7.1.2.1). An interviewee representing a member of the Ceracluster pointed out the main lessons that

Ceracluster can learn from the first phase of ceramic cluster development in Lampang as follows:

> "Firms' commitment is the most important factor for collaboration of networks. In addition, sacrifice is also essential because it is in the nature of SMEs that they lack division of labour. Owners have to do most of the administration job. They will not sacrifice their time and resources to participate in networks if they do not have mutual commitment. Therefore, joint investment of firms can warrant the commitment to the network."

The main agenda of the cluster development plan was to establish an alliance company, jointly invested by member firms, to coordinate and manage the cluster business. Initially, there were 20 members, most of them, small enterprises. The alliance developed a website as a market channel. It also jointly designed products for trade exhibitions, but these designs did not at the start attract much attention. However, with time more and more customers have come to recognise the name of the alliance, with the result that members of Ceracluster were able to obtain more calls for their products. For its role as a facilitator or intermediary, Ceracluster would charge three per cent of the sales of member firms as a commission. In addition, members have to pay ten per cent of their sales income to the manager of the Ceracluster as a management commission.

Unlike the TH alliance, knowledge producers facilitating knowledge circulation in Ceracluster include not only universities, but also government research units. As a boundary-spanning intermediary, CIDC, the research unit, provides R&D services to firms in Ceracluster. Thus, for instance, CIDC is reported to have engaged in an R&D project to test the viability of alternative compositions of local clay varieties to substitute for clays imported from other locations with the aim to reduce costs. In the event, the R&D experiment showed import substitution with local clay varieties to be too costly an innovation to be worthy of commercialisation.

In addition, the Support Arts and Crafts International Centre of Thailand (SACICT) provided technical assistance for some members in Ceracluster. The SACICT also offered financial support to Chulalongkorn University (CU) and Metal and Material Technology Center (MTEC) to encourage them to provide technical assistance to firms in Ceracluster. However, it was found that not all firms could adopt the technical recommendations of the consultants partly for lack of manpower and financial resources, and partly because technological development does not feature prominently as a matter of business priority in the firms' perception.

At the time of the fieldwork, Ceracluster was in the process of seeking R&D fund from National Innovation Agency for a project looking into the use of chemical reaction as a substitute for heating in the production of advanced ceramic, thus reducing energy costs. Ceracluster members can thus make use of R&D funds to hire Japanese experts to work on R&D projects in the CIDC. However, it was noticed from follow-up interviews a year later that no progress was made in this regard. This is not surprising considering that most of the Ceracluster activities are shallow and somewhat remote from the culture of technological development, and growth of activities in the Ceracluster, involving joint purchasing of raw materials and energy and joint marketing through exhibitions in trade fairs, has been rather slow (Martin and Sunley, 2003). In fact, the only remaining activity of the cluster is marketing in exhibition trade fairs; and some members, who did not benefit from cooperation in the cluster, are no longer participating in the cluster.

Most of these members are small enterprises, and without any scope for division of labour, owners have to do all most of the works themselves. This means that they cannot afford to sacrifice time to attend meetings with other cluster members. As at August 2012, there were only ten active members in the Ceracluster.

The Ceracluster case shows that clustering of small firms with shallow cooperation may not be sustainable as long as it stands outside the triple helix network detached from the mainstream of knowledge circulation. The role of knowledge producers is hardly apparent in the Ceracluster. Large and medium firms with strong marketing capabilities were not interested in participating in the cluster either for fear of losing their advanced technologies and market shares. For a cluster of small firms with low technology base, technological development is not the main concern. By the end of the 5-year plan in 2010, there was no evidence of a triple helix network associated with Ceracluster despite the intervention of CIDC as a sponsoring intermediary. Universities did not play any significant role in the activities of Ceracluster. In the event, government supports like training, seminars and R&D services, which the

CIDC delivered to Ceracluster, were discontinued. Deprived of the access to new knowledge sources and with no evidence of a triple helix network in it, Ceracluster lacked the dynamics that could have spurted its growth. Government support may prop it for a period, but all factors remaining the same, the cluster remains subject to the risk of failure through fragmentation.

### 8.1.3 Local textile industry: the Toobkeawma Knowledge Centre

The initiative of cluster development in local textile industry is different from the top-down policy in other industries. The links between the Knowledge and Technology Centre for Northern Textile (KTC), formerly known as 'Cotton and Silk' Programme, and the 182 enterprises in local textile industry in the Northern region has long been developed before the adoption of the cluster approach in 2004. The Cotton and Silk Programme, established as a project under a university, initially aimed to develop a supply chain for a local textile industry. Following the success of supply chain development, the Cotton and Silk programme morphed into a permanent Knowledge and Technology Centre in 2000 to be administered under the authority of the Science and Technology Institute of Chiang Mai University (CMU). The Centre's main aims have been to transfer scientific knowledge and technology to local communities and to build a network of local experts to facilitate the spread of knowledge to communities in the northern region of Thailand.

Several textile knowledge centres were established as hybrid organisations to disseminate knowledge and technology obtained from KTC. As a support agency or intermediary, KTC covers 182 community-based enterprises (CBEs) in 17 northern provinces. Some of the 182 enterprises are based on traditional knowledge; others have just started their businesses from scratch. KTC selected some enterprises based on traditional knowledge and exposed them to scientific knowledge. The KTC also trained individuals extracted from these selected enterprises to be trainers or local experts who would diffuse scientific knowledge integrating it into the underlying traditional knowledge as a new basis for enterprise development.

As KTC is constrained to cater for all 182 CBEs, it encouraged some of the strong CBEs to establish knowledge centres as sites of learning by doing for their CBEs and neighboring CBEs. Knowledge centres contain a feature of hybrid organisations, resulting from interactions between university, government and industry.

The Toobkeawma Knowledge Centre was established by a CBE, namely Nadao Dyeing and Weaving Community Enterprise, to be a knowledge centre at Lampang Province. It functions as a brokering and boundary-spanning intermediary, linking entrepreneurs and facilitating knowledge circulation between them. This knowledge centre is located in a production site and run by the CBE. A leader of this CBE, who was trained to be a local expert, had donated her land to found the knowledge centre. The CBE was financially supported by local government and agricultural-based government agencies and had loans from the Bank of Agriculture and Agricultural Co-operatives, a specialised government bank. These agencies providing financial supports served as sponsoring intermediary to the knowledge centre. This knowledge centre is used as a central site of management and some production processes, such as spinning and dyeing. It is also used as a learning site for members of the CBE and other CBEs in community. An interviewee representing member of Toobkeawma Knowledge Centre emphasised the role of sponsors as follows:

> "The mechanism of learning in knowledge centres was created by the KTC. In the establishment of the Toobkeawma Knowledge Centre, we have only land, but we lacked fund to develop the learning site and equipment. We received funding and loans from many sources, including local government and agricultural bank, because of the assistance of the KTC. If we were not supported by these organisations, the production of our community enterprise would have been based in our own houses without the central site for learning and socialising."

The Toobkeawma Knowledge Centre stands as a model of knowledge exchange between communities. It demonstrates, as Hongladarom (2002) had argued, that communities can build networks with other communities to pool and share knowledge and resources in order to overcome inadequate resource for large-scale technological development. In addition to being a knowledge centre for neighbouring communities, the Toobkeawma Knowledge Centre also facilitates knowledge exchange with other CBEs from different provinces. The CBE involves the entire process of textile production, including growing cotton and organic colours, spinning cotton thread, extracting natural colours, dyeing and weaving. The Knowledge

Centre can be a site to socialise and share knowledge. Moreover, the leader always conducts experiments on new organic plants and extraction, which can be shared to other CBEs. The important boundary spanner facilitating knowledge circulation is the leader of the Nadao CBE.

The KTC developed local experts and knowledge centres to be brokers after government supports were reduced. The KTC itself was reduced to play its traditional role as a knowledge producer, transferring knowledge to communities through its networked communities and local experts, who function as brokers and boundary spanners facilitating knowledge transfer. At present, government agencies play both their traditional and boundary-spanning roles by providing experts to train CBEs and certifying CBEs. A few government agencies regulate these CBEs through the provision of environmental certifications. They also hire experts to provide training and technical assistance for the CBEs. CBEs can apply for partial funding and soft loans from sponsoring intermediaries, such as Industrial Technical Assistance Program (ITAP) and the Northern Science Park, to engage in activities that would help them improve their technology base of production and meet certification requirements. The case of the local textile cluster shows the triple helix mechanism can take root and be sustained even without support from the main sponsor, CMU.

The three case studies discussed earlier appear to give credence to the hypothesis that firms would engage in triple helix networks depending on the availability of incentives for participation, including the availability of intermediaries. In the case of the HDD cluster, the TH Alliance which involved four SMEs in the HDD industry, was formed through the support systems provided by HDDI and FIBO. In the case of Ceracluster, the company was established by 20 SMEs in the ceramic industry because of government initiated intervention through the CIDC. In the case of the Toobkeawma Knowledge Centre, the centre was founded by a CBE through the initiative of KTC as an intermediary. Without these intermediaries, these three organisations could not have been founded.

However, as can be seen from the three cases discussed, the existence of intermediaries, whilst a necessary condition for the existence of networking, in general, and triple helix networks, in particular, does not guarantee the sustainability of the network systems intermediaries have helped to create, in the first place. In both the HDD and Ceracluster cases, network development was essentially a top-down initiative, so that it was not so much the effort of intermediaries that mattered for the evolution of the network systems, but rather the availability of government funding, which affected the sponsoring role of intermediaries. In the case of the local textile cluster, strategic decisions regarding networking production, knowledge and governance actors are locally rather centrally made, and the intermediary roles are played by actors of largely grassroots orientation. The conclusion that emerges from the case studies is that triple helix network development is effective when initiated and driven by grassroots actors rather than by top-down decisions.

Success in triple helix network development also depends on the interactions intermediary organisations engage in with industry and with each other. The system of interactions intermediaries engage in is discussed in the next section.

## 8.2 Transformation of pre-existing networks into triple helix networks: linkages and roles of intermediaries

Intermediaries play important roles in the establishment and the operation of business alliances, leading to the development of triple helix systems. In each of the three cases discussed earlier, intermediaries are seen playing three roles as sponsors, brokers and boundary spanners. These intermediaries work to promote interactions between knowledge, production and governance actors in ways that would ultimately transform inter-firm networks into triple helix networks.

Based on the principles underlying the principal-agent theory, brokering intermediaries were assigned by sponsors or policy makers to forge links between practitioners acting as boundary spanners and firms through the provision of resources in form of budget allocation. These brokering intermediaries allocated resources to boundary spanners acting as agents providing operational services to firms. For example, in the case of HDD industry, it can be seen in Figure 8.1 that the HDDI as a sponsoring intermediary assigned FIBO, to propose the establishment of TH Alliance as a brokering intermediary, and then provided funding for FIBO to play as a boundary-spanning role, providing technical assistance for the Alliance. Similarly, in the case of ceramic industry in Figure 8.2, the DIP as a sponsor assigned the CIDC to form Ceracluster as a broker and to provide R&D for Ceracluster as a boundary spanner. In the case of Toobkeawma Knowledge Centre as seen in Figure 8.3, the CMU, the sponsor, allocated annual budget for KTC, the broker, to help CBEs, the boundary spanners, to establish knowledge centres and arrange seminars and trainings for communities to transfer knowledge from the CMU research units and government agencies to industry.

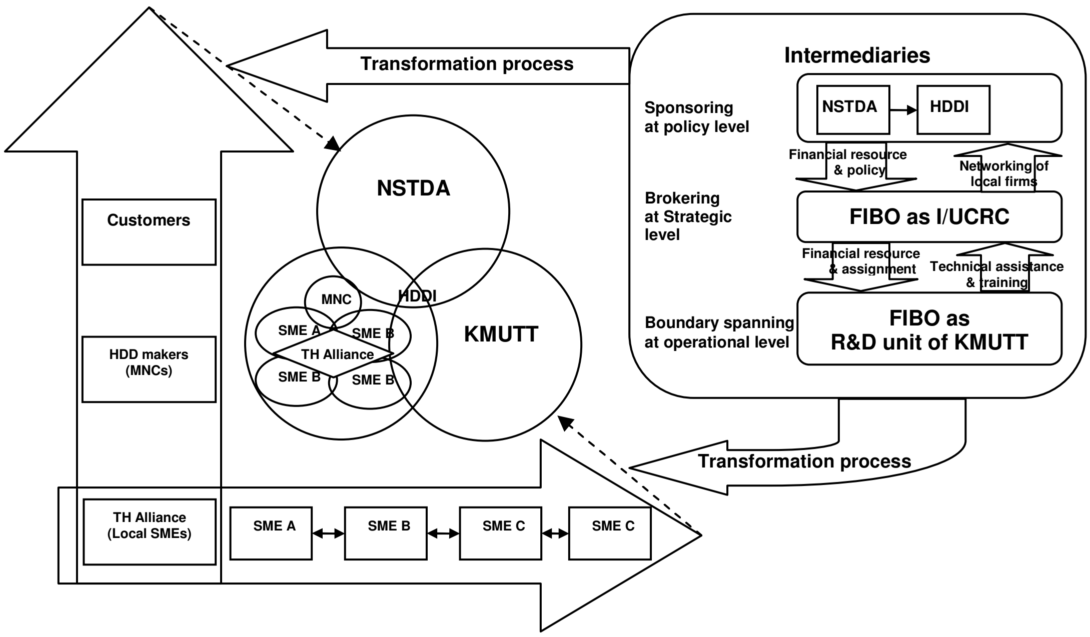



Figure 8.1 Triple helix system and intermediaries of hard disk drive industry

Source: Based on discussion in sections 8.1 and 8.2

Note:

| | |
|---|---|
| FIBO | Institute of Field Robotics |
| HDDI | Hard Disk Drive Institute |
| I/UCRC | Industry/University Cooperative Research Centre |
| KMUTT | King Mongkut's University of Technology Thonburi |
| NSTDA | National Science and Technology Development Agency |
| TH Alliance | Company established by SMEs in the Hard disk drive (HDD) industry |

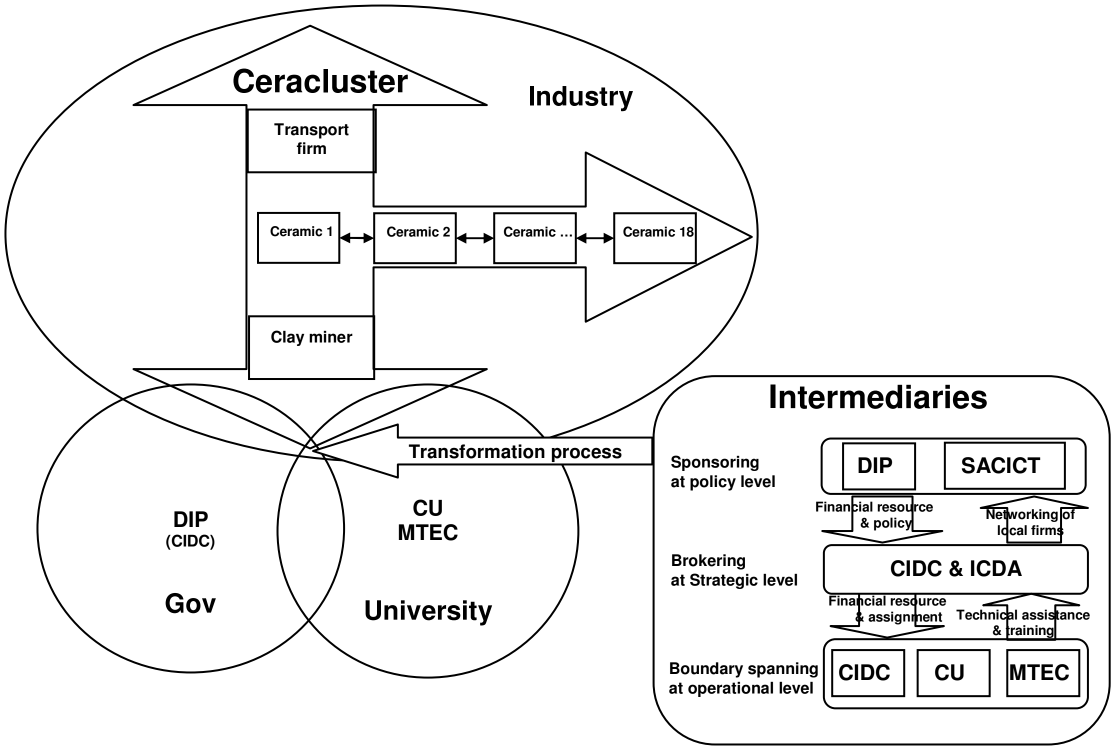



Figure 8.2 Triple helix system and intermediaries of ceramic industry

Source: Based on discussion in sections 8.1 and 8.2

Note:

| | |
|---|---|
| Ceracluster | Company established by 20 firms in ceramic industry |
| CIDC | Ceramic Industries Development Centre |
| CU | Chulalongkorn University |
| DIP | Department of Industry Promotion |
| ICDA | Industrial cluster development agent |
| MTEC | Metal and Material Technology Center |
| SACICT | Support Arts and Craft International Centre of Thailand |

It can be seen from these three case studies that intermediaries operating at policy, strategic and operational levels are linked through brokering. In these three cases, sponsoring intermediaries have linkages with brokering intermediaries in the form of delegation. Sponsors provide policy direction and budget for brokers to form clusters or triple helix networks. For example, as can be seen in Figures 8.1 – 8.3, the HDDI, the DIP and the CMU provide annual budgets to FIBO, CIDC and KTC to form the TH Alliance, the Ceracluster and the Knowledge Centre, respectively. Brokering intermediaries have linkages with boundary-spanning intermediaries through technical activities and resource allocation.

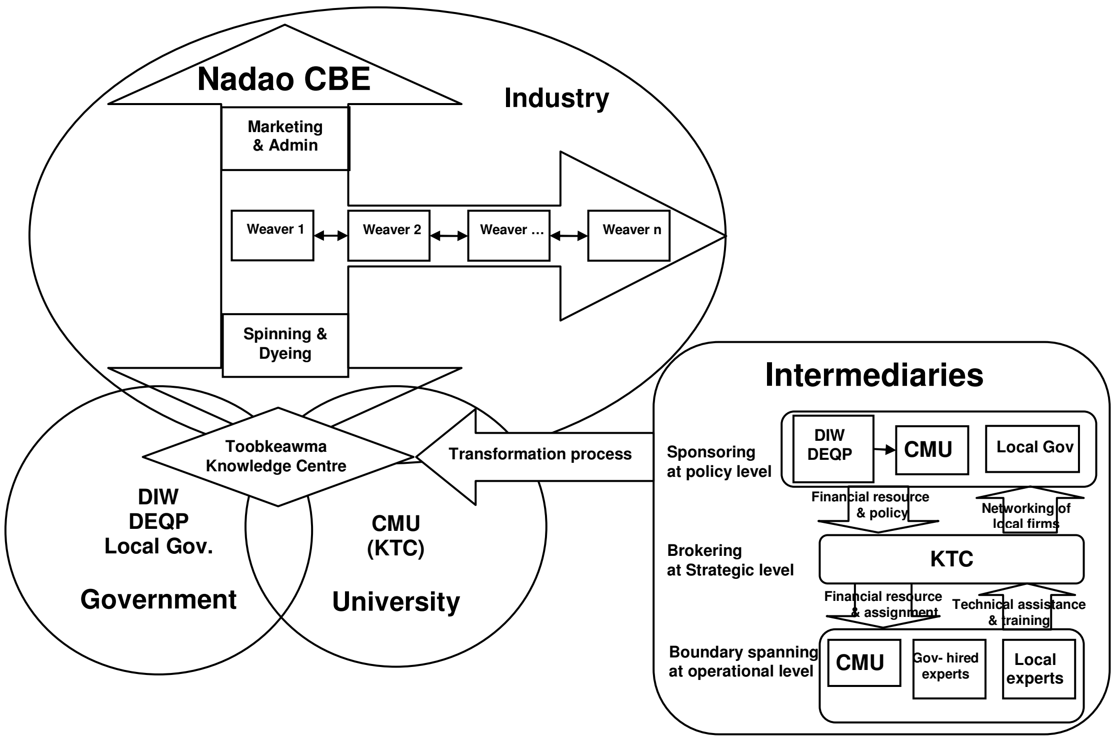



Figure 8.3 Triple helix system and intermediaries of local textile industry

Source: Based on discussion in sections 8.1 and 8.2

Note:

| | |
|---|---|
| CBE | Community-based enterprise |
| CMU | Chiang Mai University |
| DEQP | Department of Environmental Quality Promotion |
| DIW | Department of Industrial Works |
| KTC | Knowledge and Technology Centre for Northern Textile |

In the formation of clusters or triple helix networks, issues common to all members are issues relating to technological and managerial improvement. Some technological improvement activities could be done through cooperation because of economies of scale. Actors with high technological capability were attracted to serve technological improvement activities for the clusters. These technological improvement activities include provision of seminars, training programmes, technical assistance and R&D services. In the operation of technological improvement activities, boundary-spanning intermediaries providing operational services obtain financial supports and resources to conduct these activities via brokers.

It can be noted from the case studies that in some cases brokers and boundary spanners can be the same as government agencies due to policy delegation. For example, in the cases of Ceracluster and TH Alliance, the brokering intermediaries, CIDC and FIBO, also play a role as boundary-spanning intermediaries. This is because the Government had assigned relevant specialised government agencies or specialized centres to develop clusters or triple helix networks. These government agencies and research centres providing operational services for industry could be brokers establishing clusters in related industries because they have pre-existing linkages with industry.

The linkages between intermediaries operating at three levels can be generalised as in Figure 8.4 drawing on the discussion in section 4.1. Intermediaries at three levels can be linked through brokering intermediaries, which normally are specialised government agencies in related industries. Sponsoring intermediaries provide policy with resources to brokering intermediaries. Brokering intermediaries allocate resources to boundary-spanning intermediaries. Network activities, including knowledge creation and circulation, are promoted mainly by boundary-spanning intermediaries.

As seen in Figure 8.4, intermediaries could be universities, government agencies, firms and hybrid organisations arising from the development of triple helix networks. In the case of TH Alliance, there are three types of organisations playing the roles as intermediaries. The sponsors include a government agency, namely NSTDA, and a hybrid organisation, HDDI, which is supported by NSTDA. The broker, FIBO, is a research centre operating under a local university. The boundary spanner is also the university. Similar to TH Alliance, the sponsors in the Ceracluster case are also government agencies. However, the brokers include a government agency, namely CIDC and a business owner acting as ICDA. The boundary spanners are a government research institute and a university, which are MTEC and CU, respectively. In contrast to the first two cases, the sponsors in the case of Toobkeawma Knowledge Centre include a university, local governments and a financial institution. The brokers are a specialised centre in a university, namely KTC, and local experts, including entrepreneurs with traditional knowledge. The boundary spanners include a university, government-hired experts and local experts.

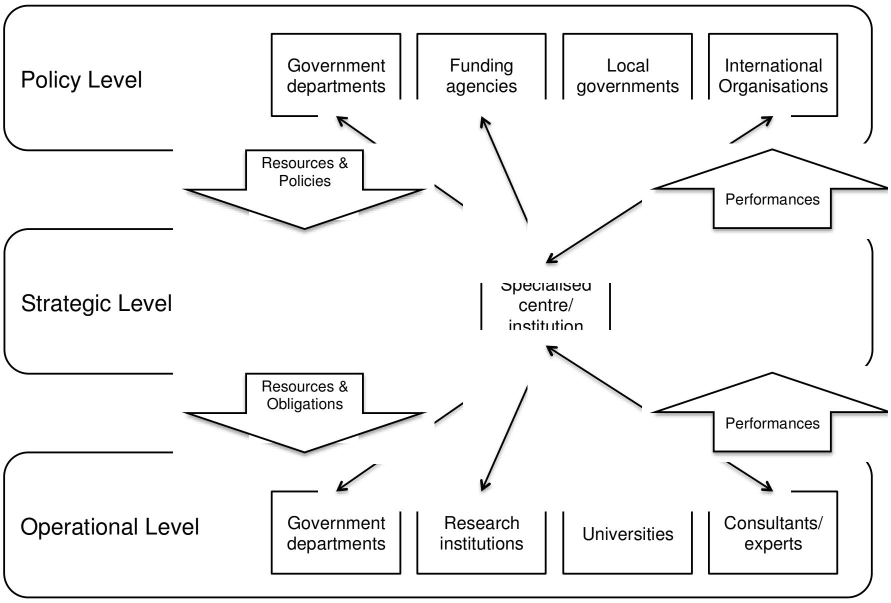



Figure 8.4 Linkages between intermediaries at three levels

Brokering can be considered as an additional structure of government network to help implement policies in developing countries (Kickert et al., 1997). In most cases, the main sponsors are government agencies, including government departments, government funding agencies and local government. Often, the government would play the role of a sponsoring in order to provide policies and resources for practitioners to put policy into action. However, practitioners could be boundary spanners, who provide operational services to industry. Practitioners can be seen in forms of government department, government research institutes and universities. Normally, sponsors can directly link with boundary spanners if there are mechanisms of delegation and collaboration between different organisations as well as linkages between boundary spanners and industry. However, these mechanisms and linkages may be absent in developing countries. Therefore, brokers, who translate, implement policies and allocate resources to practitioners, may be necessary to connect sponsors and boundary spanners.

A broker can perform several functions at the same time. In the three cases discussed, brokers are seen as representatives, liaisons, gatekeepers and cosmopolitans. In technological improvement activities, brokers enable knowledge circulation by linking boundary spanners and firms. Knowledge flows corresponding to these functions are shown in Figure 8.5. In the case of TH Alliance, FIBO functioned as a representative by linking and enabling knowledge flow from FIBO's researchers to firms in TH Alliance. At the same time, FIBO also functioned as a cosmopolitan by linking the four firms in TH Alliance and creating collaboration mechanisms for them to share knowledge. In the case of Ceracluster, CIDC functioned as a representative to flow knowledge from the CIDC's R&D unit to firms; and as a liaison connecting experts from a government research institute and a university with firms in the cluster. Moreover, a private broker, ICDA, who is the manager of Ceracluster, works as a gatekeeper searching for outside partners to supply knowledge to Ceracluster members through mechanisms of knowledge transfer. In the case of the Toobkeawma Knowledge Centre, KTC functioned as a representative creating a knowledge transfer mechanism through the creation of local experts; as a liaison linking government agencies and CBEs; and as a cosmopolitan establishing links among CBEs.

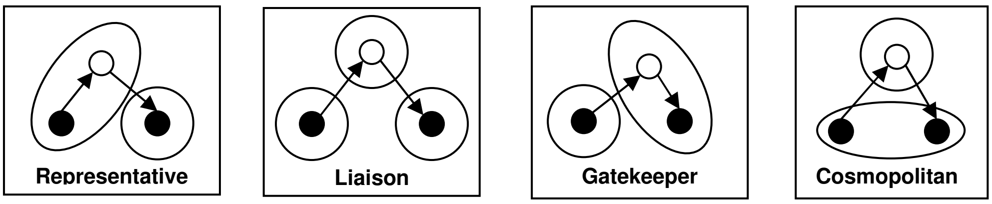



Figure 8.5 Functions of brokers and flows of knowledge

Two types of dominant intermediary organisations can be seen in these three case studies: university-based and government-oriented intermediaries. These dominant intermediaries play both brokering and boundary-spanning roles in the three cases. In the HDD industry, FIBO, a research centre of a university, is a university-based intermediary playing two roles as a broker and boundary spanner. Similarly, in the local textile industry, KTC, a centre working with R&D units in a university, is also a university-based intermediary. However, in the ceramic industry, CIDC is a government-oriented intermediary.

Comparing these three cases, it was found that the firms in TH Alliance and Toobkeawma Knowledge Centre had deeper cooperated in technological development activities than Ceracluster. Interestingly, university-based intermediaries are dominant in these two cases. A lesson learned from these case studies is that universities can effectively contribute to industrial and economic development. This is at odds with the widely maintained view that Thai universities are not strong enough to serve industry. These cases provide evidence that a few universities have transformed themselves to be entrepreneurial universities to create triple helix systems through the adoption of intermediary roles.

From these three case studies, it can also be concluded that triple helix networks can be created because of availability of intermediaries playing three roles as sponsors, brokers and boundary spanners. Moreover, another necessary condition is that these intermediaries have to connect each other through brokering intermediaries to assign tasks and allocate resources. However, when the three triple helix institutional actors – government, university, industry – can transform themselves to become supportive government agencies, entrepreneurial universities and knowledge-based firms, intermediation of brokers may not be needed. In developed countries, supportive government agencies can take the role of a sponsor, and entrepreneurial universities, the role of a boundary spanner. In developing countries, intermediaries are still necessary not only to create triple helix networks, but also to create the dynamics in the network system, thus creating the condition for sustainable economic development.

## 8.3 Evolution of network dynamics in triple helix relationships

In this study, networks dynamics is presumed to derive from the heterogeneity of actors, knowledge sets, competencies and resources that constitute the basis for the generation of new ideas and innovation in the context of triple helix relationships. As discussed in Chapter 3, innovation can be seen as a product of interaction of firms with different technology paths. The interaction process creates new technological opportunities; and network dynamics are apparent when new institutional actors bring into the network new sets of knowledge. But for network dynamics to occur, network players would need to evolve their learning processes from the simple single loop mode to the more complex double loop and triple loop modes. There is no evidence, however, that the relational experiences in the three cases have succeeded in developing the capability for complex learning, and so in creating network dynamics.

According to Nonaka and Takeuchi (1995), network dynamics would occur when knowledge is created through four knowledge conversion modes. In the first mode, firms can learn through socialisation between actors. For example, learning in TH Alliance occurred through provision of the operational services of a boundary spanner. FIBO as a boundary spanner provided training to the four SMEs in technical areas of engineering science, such as finite element and structures. The four firms in the cluster socialised through this learning process before working together in the next stage. The socialisation mode involves processes that can help upgrade the design capability of engineers of local firms enabling them to serve MNCs.

Like in TH Alliance, Ceracluster members were also trained by CIDC to build trust through collective actions. The training in Ceracluster encompassed technical and managerial areas to strengthen the capability of firms. MTEC and CU also provided technical assistance for members of Ceracluster. Socialisation between the firms and these boundary spanners created opportunities for learning. Similarly, learning in Toobkeawma Knowledge Centre also occurred through socialisation between local experts and firms. KTC provided training for entrepreneurs already steeped in traditional knowledge to become local experts. Socialisation thus enabled local experts to benefit from the process of knowledge exchange and to learn from the experiences of others. In addition, other CBEs could learn from the trainings provided by local experts arranged in the Toobkeawma Knowledge Centre after the local experts themselves are trained by the KTC. From these three case studies, it can be seen that low-risk activities with short-term visible outcome (i.e. training) can be used in network development to create trust before moving to more comprehensive and complex stages of coordination (Ceglie and Dini, 1999).

In the externalisation process, boundary spanners assist networks to codify their tacit knowledge into explicit knowledge through the mechanism of IPR. For example, FIBO helped firms to conduct reverse engineering and claim IPR on it. FIBO researchers conducted the reverse engineering of imported machines used by an HDD maker and transferred this knowledge and blueprints to the four firms in TH Alliance. The firms designed their own blueprints and built prototypes through replication. In building prototypes, HDDI provided financial support to the SMEs through FIBO to cover some of the costs of prototype development. After building prototypes, firms codified and filed them in the form of patents. In this process, downloading and redesigning occurred as firms learned blueprints from reverse engineering and adjusted their production to build prototypes. Thus the technological capability of engineers of SMEs could be upgraded from basic to intermediate level. In the case of the local textile industry, KTC encouraged local experts to produce best practices in the form of books to codify their scientific and traditional knowledge following learning from the knowledge exchange in the socialisation process. These books were distributed to all members of KTC. Once other firms follow the best practices, they can download and redesign their production to solve production problems. In contrast, codification of tacit knowledge did not take place in the case of Ceracluster because of lack of externalisation after training and technical assistance. Some firms applied the knowledge they acquired from training and technical assistance to their production, but other firms did not do so for lack of motivation and lack of resources to acquire and apply such knowledge.

Networking enabled firms to combine their knowledge and production. After training, the four firms in TH Alliance integrated their production lines to produce automation machines for HDD production in a site near the HDD maker. They claimed that they could select better machines for this joint project since they have upgraded their design capability with the assistance of FIBO. In this process, the four firms combined their existing explicit knowledge in machine production, in which they have specialisation, to create new knowledge or new production lines, also referred to as 'combination mode of knowledge conversion' (Nonaka and Takeuchi, 1995).

In the local textile industry, combination of knowledge occurred before the externalisation process. The knowledge acquired by local experts upon training and the knowledge of CMU researchers were shared and combined to create new knowledge, codified in form of best practices. However, combination of knowledge within Toobkeawma has not yet occurred because it was a one-way knowledge flow, as the other members of the CBE and neighbouring CBEs did not have the knowledge to impart to others. Interestingly, the leaders of Toobkeawma claimed that other knowledge centres located in other provinces visited and shared knowledge with the Toobkeawma Knowledge Centre, and that there might therefore be opportunity for combination of their knowledge in the future.

In the case of Ceracluster, members of the cluster jointly designed ceramic products for exhibition fairs; but this was not a result of technological development and knowledge combination. During the combination process, firms reframe their positions and relationships within the system in ways that would facilitate creative learning.

Innovation occurs where new combination knowledge can be commercialised. For example, the operation of new production lines in TH Alliance generates product innovation in the form of newly designed machines, substituting for imported machines. After integrating production lines, TH Alliance produced 10 machines to supply to the HDD maker. In addition, FIBO also provided and assisted in the production of documents for quality certification, as such certification is essential for local firms to enter into the supply chains of MNCs. During the course of the survey for this study, it was found that the HDD maker had purchased seven specialised machines patented by TH Alliance. In this process, new combined knowledge was appropriated into the production process, creating innovation in the form of new machines substituting for imported machines.

In the case of the Toobkeawma Knowledge Centre, the best practices obtained from KTC were integrated into the production process. Innovation in this case took the form of process improvement, reducing costs and improving the production process to be environmental friendly. This CBE is environmentally certified, and this helped it gain more orders from developed countries.

However, the internalisation mode did not occur in the case of Ceracluster due to the absence of newly combined knowledge. The commercialisation process in the externalisation mode is a process of transforming knowledge into innovation.

New combination of knowledge occurs as firms and networks transform and reconfigure by starting learning from the outcomes of the internalisation process through socialisation. However, it is too early to see from the three case studies the transformation and reconfiguration of triple helix networks. In other words, triple loop learning has not yet occurred in all three cases; and for lack of this, the dynamic driving force behind evolutionary process in the three triple helix networks is weak. So, while knowledge creation would in general call for completion of the four modes of knowledge conversion (i.e. socialisation, externalisation, combination and internalisation), a new loop of knowledge creation cannot begin in the absence of mechanisms for triple loop learning. This explains the weakness of network dynamics in the three cases discussed in this chapter.

Network dynamics arise consequent upon the progression of learning from the simple to the complex mode as projects evolve through the four modes of knowledge conversion and knowledge creation. According to Nonaka and Takeuchi (1995), the process of knowledge conversion and creation would involve socialisation between firms of new alliances, leading to externalisation in which tacit knowledge is transformed into explicit or codified knowledge, and then to combination between knowledge codified in existing patents and knowledge obtained from the reverse engineering of other patents. This new combined knowledge is then internalised into routine operations of new alliances, resulting in innovation. This process creates a new loop of knowledge creation driven by network dynamics. But for lack of network dynamics, there is no evidence of continuity in the knowledge conversion and creation cycle in the three cases discussed in this chapter.

For instance, after selling its patents to the HDD maker, TH Alliance was unable to sustain the innovation loop, as it was unable to reproduce and sell those seven machines to other HDD makers and other manufacturers in other industries. This means they had to bid for new projects and develop new machines to maintain the operation of the Alliance. However, some members of the Alliance felt that they did not obtain any benefits from the business of the alliance and were reluctant to continue their operation as members. Other members of the Alliance saw the opportunity of new cooperation, and two of them started a new alliance to bid for new projects from the same HDD maker. Another member would partner with an overseas company to establish a joint venture as a basis for technology transfer.

Similar to the case of TH Alliance, the leader of the Toobkeawma Knowledge Centre sought to acquire knowledge about new organic colours through engagement in research. This would produce combination of knowledge between CBEs and enable internalisation of new combination knowledge to happen.

The cases of TH Alliance and Toobkeawma Knowledge Centre show that tacit knowledge can be circulated from knowledge producers to knowledge users through socialisation in trainings and seminars. For example, in the case of Toobkeawma, after training by government-hired experts, local experts assimilated and disseminated new knowledge in their knowledge centres through learning by doing. In the case of TH Alliance, FIBO's researchers conducted reverse engineering and helped firms design machines.

Engineers acquire knowledge and upgrade their design capability through learning by doing and socialising with the researchers. However, in the case of Ceracluster, although firms recognised their weaknesses, they did not pay attention to technological improvement activities on grounds that they do not have adequate human and financial resources to improve their technological capability.

Although the evolution of network dynamics has so far been too patchy in these three triple helix networks to be of any significance, the scope for this appears promising in the cases of TH Alliance and Toobkeawma, where there is evidence of practices aimed at human resource development to upgrade technological capability.

## 8.4 Transformation of pre-existing networks and triple helix networks

Although the mode of learning in the three cases studies exhibits some characteristics of triple loop learning[5], the underlying trait of the learning process in all cases corresponds to an amalgam of single loop and double loop learning. In the case of TH Alliance, changes in network boundary and network links occurred when the Alliance was established. Actually, the four members of TH Alliance knew each other even before the formation of TH Alliance. Their previous relationships were based on personal contacts in a horizontal network within the same (automation) industry. This pre-existing network has been transformed into a triple helix network through the creation of a vertical value chain of the HDD industry. In the creation of vertical value chain, universities were attracted to the inter-firm network to upgrade the technological capability of the four members. Thus, the boundary of the former loose horizontal network was expanded through the formalization of relationships and the roles of actors. The Alliance is as such a new kind of strong network with new power structures. It formalised the cooperation and knowledge exchange practices of horizontal firms; and this gives TH Alliance the basic characteristics that would enable it to benefit from triple loop learning.

As at present, organisational learning in TH Alliance is of the double loop type, which limits it at best to incremental innovation. Although there was transformation and reconfiguration of the structural context, the organisation's environment and direction, the network has not yet produced radical innovation. The learning that SMEs obtained from training in design and engineering with FIBO has improved their absorptive capability. These firms reframed their activities in accord with the new network system to engage in alternative actions. For example, they developed

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[5] Triple loop learning occurs when there are changes in network boundary and connection, occurrence of new groups and roles, change in power structure, formalisation of participation and establishment of practices of knowledge exchange, leading to radical innovation. This is significantly different from single loop learning which involves following existing rules or respecting set boundaries rather than challenging them or redesigning them while learning by correcting problems. It is also different from double loop learning which is about breaking existing rules or changing the boundaries of activity to ensure problems do not recur (Pahl-Wostl, 2009). Triple loop learning involves 'out of the box' thinking and hence systemic changes and often results in the generation of innovative ideas. Where triple helix networks have partly or fully evolved, triple loop learning and its consequences are likely to be in evidence.

technologies and improved their production processes by using newly acquired knowledge following engagement in new network relationships. In addition, they obtained knowledge on quality improvement, which helped them select better machines with higher performance standard to produce more complex machines and tooling.

According to Savory (2006), SMEs can attain the ability to combine and configure resources without any gains in dynamic capability. The latter is crucial for radical innovation to emerge. But learning takes time; and in the early phase of the cycle, learning is related to technology transfer from universities to SMEs. Moreover, knowledge sharing among SMEs has not yet occurred in the TH Alliance project because jobs were allocated to each of the four Alliance members according to their respective areas of comparative advantage. The TH Alliance project is a top-down process in which Pahl-Wostl (2009) argued that formal networks would far from enable triple loop learning, unlike informal networks with bottom-up process, which are more open to the conditions of triple loop learning. However, with increased collaboration between firms in both horizontal and vertical value chain, the cross-fertilisation between firms in different production lines may lead to new technology opportunity and radical innovation. In addition, collaboration without government support will not be as formal and as rigid as would be the case with the TH Alliance project.

Similar to TH Alliance, Ceracluster is a new form of organisation establishing from the networking of firms in both the horizontal and vertical value chains. Prior to the integration, these horizontal firms had loose linkages in the form of Lampang Ceramic Association without, however, any close cooperation. Vertically networked firms have normal trading relationships of the supply chain type. In such cases, the integration process changes the pattern of relationships and boundaries of the member firms in the network; and triple loop learning is likely to occur in this new organisation. However, as it happens, actual learning in the Ceracluster is limited to the single loop mode. The operation of Ceracluster did not focus on technological improvement activities. Although the CU and the MTEC provided technical assistance to improve the productivity of some members, they adopted some adjustments to solve problems, albeit without any change in policy direction. Moreover, they are not willing to invest in human resource development because of time and resource constraints.

Toobkeawma Knowledge Centre is the product of knowledge exchange practices and the formalisation of participation of actors. These are practices, which are characteristically associated with the triple loop learning mode (Pahl-Wostl, 2009). Prior to the establishment of the knowledge centre, CBEs worked on their own without cooperation and knowledge exchange, as there were no mechanisms for collaboration. Instead, firms would learn through traditional training mechanisms from government departments and local governments. On the other hand, development of local experts and establishment of knowledge centres involved knowledge exchange mechanisms that are capable of enhancing opportunities for network dynamics to evolve through triple loop learning. However, to the extent that innovation at Toobkeawma Knowledge Centre is limited to incremental innovation, learning there could have been nothing more than of double loop mode at best. This is partly evidenced by the fact that the leader of the CBE had established links with local experts and that there was consequently knowledge exchange between them. There is, therefore, good reason to believe that the Toobkeawma Knowledge Centre and its networking CBEs have not yet developed the network system that is capable of generating profound changes.

There is some evidence suggesting that some triple loop learning had occurred in some CBEs involving cross-fertilisation of ideas. For instance, researchers at Payap University (PU) received social research fund from the Commission of Higher Education to study the local identity of business communities. The researchers selected a few CBEs to investigate, using the participatory approach, evidence of triple loop learning in terms of the development of new products. It was found that these CBEs would develop higher value added products if they had knowledge on organic dyeing to use with local organic fibres. The researchers contacted the KTC to ask for experts. The KTC provided a local expert from a CBE with knowledge and experience of dyeing with organic colours. Following establishment of the network involving interactions between university researchers, selected CBEs, KTC and the local expert, thanks to the social research fund, opportunities were created for the tacit knowledge of local experts to be transferred to entrepreneurs in the selected CBEs and to the researchers through socialisation via seminars, demonstration projects and learning by doing exercises. To do these activities, the local expert and the researchers had to stay with the selected CBEs for about a month to ensure that transfer of dyeing and weaving knowledge occurred.

The combination mode of knowledge conversion occurred when PU's researchers asked researchers in another university to develop fibre mixer to produce paper from unwanted plant. Through socialisation, PU's researchers could gain knowledge on fibres and dyeing from the local experts of two CBEs from different regions. However, they still lacked knowledge for designing and developing machines for production, even though they were on the lookout for those with the requisite knowledge and/or were conducting research in this field. The tacit and codified knowledge of the two groups of researchers were combined through this social R&D project, but the developed machine was not internalised as a component of the operation routine of the selected CBEs because of budget constraint to apply this on industrial scale.

After the success in organic colour dyeing with alternative fibres, the PU's researchers received funding for another project on the application of new fibres to existing products, such as mat, as in the case of some communities in the eastern region. The researchers had to stay with the new communities to transfer knowledge about new fibres and organic dyeing and, in return, to learn the existing production methods of communities through socialisation, which, according to Nonaka and Takeuchi (1995), is a mode of knowledge creation. After socialisation, the researchers had to write a report to be submitted to the funding agency. This process is considered as the externalisation mode of knowledge creation ((Nonaka and Takeuchi, 1995). In this project, the knowledge needed is beyond the capability of the researchers. Combination and internalisation have not occurred due to the government's preference for short-term outcomes. To adapt and test the application of new fibres, cooperation between the communities and combination between different knowledge sources are important. The researchers just introduced the alternative fibre to the communities. However, application of the knowledge and production of new fibres was contingent upon the needs of the communities. Without the latter, the researchers' effort would be an exercise in technology push unmatched with demand pull from the communities. For this reason, a lot of research outcomes have not been utilised. This was observed to be at the heart of the problem of lack of continuity in R&D funding, which is discussed in the next section.

In this section, it is shown that the experiences in pre-existing networks are not associated with the extent to which firms are engaged in triple helix networks. Before the establishment of triple helix networks, firms considered in the three case studies had loose linkages without any evidence of cooperation. The establishment of triple helix networks encouraged them to collaborate. However, learning, which is the important outcome of cooperation, is at different levels across firms, depending partly on whether collaborative mechanisms are deep or shallow with respect to technological development, and partly on who developed such collaborative mechanisms. TH Alliance and Toobkeawma Knowledge Centre appear to have reached the double loop leaning stage, while Ceracluster appears limited to the single loop learning stage. The former two cases were created as a result of the initiatives of university-based intermediaries. The latter case was a result of industry initiatives. This observation appears to give credence to the view that firms do not pay as much attention to knowledge development and exchange as universities do. Thus, development of technological capability in firms was constrained by shallow cooperation. From discussion in this section, there is no evidence to support the hypothesis H2(IV) that firms' engagement in triple helix networks would follow on their experiences in pre-existing networks can be rejected. Rather, the evidence based on the case of PU's researchers suggests that the occurrence of network dynamics and triple loop learning of networks depends on: cross-fertilisation between firms in different industries with different technology paths; access to new and diverse knowledge of universities; and bottom-up processes in network participation.

## 8.5 Shortfalls in R&D funding and the state of network dynamics

From the three cases discussed in this section, it is apparent that network dynamics could not occur in triple helix relationships despite government supports and the operation of intermediaries. This is because the full cycle of the four modes of knowledge creation specified by Nonaka and Takeuchi (1995) – i.e. socialisation, externalisation, combination and internalisation – could not be completed in the short term period to which government support is limited. Most government projects focus only on short-term outcomes, whereas, as discussed earlier, network dynamics can evolve through human resource development as a long-term outcome. Government support limited to the short-term period could at best produce shallow cooperation in which the learning process, if not limited to the single loop mode, cannot be expected to go beyond the double loop mode.

The Thai Government stopped its R&D supports long before the four modes of knowledge conversion were fully played out. For example, financial supports for HDDI, including TH Alliance, were reduced when government changed in 2010. Although TH Alliance could sell some qualified machines to the HDD maker, it no longer sought to bid for new projects, thus precluding options for the evolution of a new loop of knowledge creation. However, some firms decided to forge new alliance instead of continuing with TH Alliance. The implementation of this project even without government support is expected to provide the scope for a new loop to begin and for network dynamics to start evolving.

In the case of Ceracluster, too, the absence of network dynamics is a result of the short-term nature of government supports covering a 5-year period. Aware of this and its implications, members of Ceracluster did not factor in human resource development and technological improvement as part and parcel of their business agenda. So whatever socialisation they engaged in was reflective of shallow cooperation devoid of opportunities for learning, human resource development and technological improvement. In the same was the case with Toobkeawma Knowledge Centre where lack of government support constrained progression in the technological learning process.

The involvement of PU's researchers in the network process would appear to suggest possibilities for learning progression and knowledge creation, but internalisation of new combined knowledge requires huge investment from the government, which, however, never occurred. After knowledge creation, economic value can be generated through the internalisation of R&D results into operational routines. In Thailand, R&D results were hardly utilised in the manufacturing sector due to lack of efforts to push technology and lack of investment to scale up application of knowledge from lab-scale to commercial scale. Internalisation involves a process of commercialisation, which government may not, however, take into account. To take maximum advantage of R&D, it is imperative that government expanded its supports to encompass the commercialisation process. This process can be supported through financial incentives, such as partial grants and soft loans. Intermediaries are still necessary in this process, especially market-led intermediaries, such as venture capitalists and specialised government banks, to play sponsoring and brokering roles.

## 8.6 Conclusion

This chapter has shown that the significance of intermediaries as sponsors, brokers and boundary spanners for the transformation of pre-existing networks into triple helix networks. It was found that triple helix networks could significantly enhance learning when cooperation along the network is deep, leading to technological improvements. The collaborative mechanism offered by triple helix networks is essential for learning of the triple loop type, which is not afforded by pre-existing networks where cooperation is shallow.

On the basis of the evidence arising from the three case studies, the hypothesis H2(I) that the intervention of intermediaries is crucial for triple helix networks to evolve can be accepted, while the hypothesis H2(IV), that firms' engagement in triple helix networks would for the most part derive from their experiences in pre-existing networks, cannot be empirically sustained.

As discussed in this chapter, TH Alliance and Toobkeawma Knowledge Centre are comparatively more active than the Ceracluster. These two networks can be associated with learning of the double loop type. On the other hand, Ceracluster appears limited to single loop type learning. The key factor enabling learning, knowledge creation and the evolution of network dynamics is human resource development which requires the exploitation of tacit knowledge as a major contribution of knowledge creation. Most SMEs in traditional industries neglect human resource development activities due to resource and time constraints, thus denying themselves of opportunities for multi-loop learning and the evolution of network dynamics.

Active networks in the cases studied involved university-based intermediaries. For example, FIBO and KTC, which are under the administration of universities, are the main brokers to establish triple helix networks in the case of HDD and local textile. They have direct links with sources of knowledge. This can be understood to mean that the knowledge creation process in firms and the evolution of network dynamics directly or indirectly involves knowledge producers in a triple helix system. Unlike TH Alliance and Toobkeawma Knowledge Centre, Ceracluster does not have established links with universities. With shortfalls in the flow of knowledge into the Ceracluster network, there is the potential risk that Ceracluster may epitomize the case of a network in decline.

The common lesson learned from these three cases is that network dynamics has not occurred in any of these networks at least due to discontinuities in the provision of government supports. This lack of support prevents all four mode of knowledge conversion from being fully played out paving the way for the evolution of network dynamics. Insofar as the intermediaries considered are totally dependent on government funding, it can be argued that the way forward would be for the government to support instead market-led intermediaries, such as venture capitalists and specialised government banks, to do the business, especially in the commercialisation process. This way, the government's burden can be alleviated, as intermediaries would anyway continue to operate with or without government support as long as there is a viable market for the services of intermediaries.

# CHAPTER 9

# Conclusions and Recommendations

This chapter summarises key findings deriving from the qualitative and quantitative analyses. It was found that the major factor affecting network formation is the availability of intermediaries; and the major factor impeding the creation of network dynamics in a triple helix system is the lack of capability of human resources and the triple loop learning mode to combine knowledge. These findings lead to policy prescriptions to eliminate hindering factors and strengthen supportive ones, i.e. upgrading the technological capabilities of intermediaries to help create network dynamics and supporting market-led intermediaries to substitute for government-sponsored intermediaries. These findings and the analytical framework of the study constitute the essence in the contribution of the study. However, the study has several limitations that could be taken into account and improved upon in future research projects as will be discussed later in this chapter.

The chapter is organised into five sections. The first section summarises the key findings of this study. The second section proposes policy recommendations. The third section identifies contribution to knowledge of this study. The fourth section highlights limitations of this study and proposes suggestions for future research. The fifth section concludes the chapter.

## 9.1 Summary of key findings

The Thai manufacturing sector consists of firms that can be broadly categorised into three main groups: multinational corporation (MNC)-dominated firms, small and medium enterprise (SME)-based firms and community enterprise (CE)-based firms. Typically, high technology industries are concentrated within MNC category; conventional industries, within the SME category; and crafts and traditional products, within the CE category. Because firms in these industry groups have different levels of technological capability, cluster policy was designed and implemented as a way forward for promoting organisational and technological learning and creating network dynamics. However, for the cluster-based networks to be effective as a basis for innovation, competitiveness and sustainable growth, it is important that they are underpinned by the process of intermediation between knowledge users (industry) and knowledge producers (universities, research institutes). Innovation intermediaries thus play an important role in the formation and operation of networks as sponsors, brokers and boundary spanners, transforming cluster networks into triple helix networks in which industry, university and government feature as the major players.

This study has shown evidence of triple helix networks in some industries, like the hard disk drive (HDD), ceramic, furniture and local textile industries. Some of these triple helix networks are still active and dynamic. Others have declined following reduction in government supports. The findings suggest the formation of triple helix networks to be contingent upon the availability of financial support from sponsors or the availability of sponsoring intermediaries. The findings also suggest the creation of network dynamics in triple helix relationships to be largely influenced by the engagement of universities in network activities not only as knowledge producing players, but also as boundary-spanning intermediaries.

### 9.1.1 Motivations for building linkages with innovation intermediaries

From the regression analysis conducted in this study, 'access to information' was found to be the key motivating factor for firms to establish links with innovation intermediaries. In most of the industries surveyed, information access is significantly associated with the number of links between firms and intermediaries. The majority of firms in most industries perceived knowledge exchange to be the best they could derive in terms of network benefits as a result of establishing liaison with intermediaries. Not surprisingly, effectiveness of intermediaries providing access to information sharing featured as the most important concern for firms in most industries. What makes intermediaries so important in the eyes of firms is that in the role they play as sponsors, brokers and boundary-spanners, they can close information gaps arising from information asymmetry (Klerkx and Leeuwis, 2009) as well as creating forum for information exchange (Anderson and Jack, 2002) and providing access to information from a heterogeneous set of actors through brokerage (Burt, 2004). This finding is consistent with that of Kreiner and Schultz

(1993) who found access to current information arising from different sources, such as gossips, insight information and unpublishable tacit knowledge, to be the principal factor for firm's motivation to engage in network formation. .

Firms also forge links with innovation intermediaries to be able to exploit complementary external resources. The findings also show that employment of S&T qualified personnel by firms is associated with the links they establish with intermediaries. In the HDD and furniture industries, for example, firms establish links with intermediaries as they have adequate supply qualified manpower that would enable them to make the most of network benefits by learning from or absorbing external knowledge and knowhow (Rothwell and Dodgson, 1991). In the automotive and local textile industries, firms would establish links with intermediaries apparently in order to make up for their deficiencies in their in-house stock of S&T qualified manpower. Interestingly enough, this situation is observed in MNC-dominated and CE-based industries, where, it can be argued, local firms are almost invariably forced to enter into global supply chains as they do not usually have the required human resources in-house. They would therefore need to resort to external sources of supply in short term to mitigate their resource and capability deficits (Freel, 2000).

Another reason motivating firms to link up with intermediaries is to be able to have access to external sources of specialised equipment that would underpin their initiatives for technological development. This is especially true of the local textile industry. This CE-based industry was motivated to improve its production technology to meet the requirement for environmental certification, so that it would be in a position to obtain overseas orders. Firms in this industry are keen to link up with intermediaries to gain external supports due to lack of internal financial resources to invest in specialised equipment.

### 9.1.2 Factors affecting activeness of triple helix networks

The availability of incentives for participation, especially the availability of intermediaries, was found to be a key factor affecting the activeness of triple helix networks in terms of the depth of interaction between the major players. However, the hypothesis (H2) tests conducted based on statistical analysis did not show the effectiveness of intermediaries, the degree of technological capability development, and the experiences in pre-existing networks to be significantly associated with the depth of triple helix networks (Table 9.1). From the narrative analysis and the case study, it was found that apart from brokers, permanent sponsors are necessary for the provision of resources for supporting collaborative mechanisms. In addition, engagement of universities as knowledge producers is necessary to deepen collaboration for innovation and technology development.

Although availability of intermediaries affects activeness of triple helix networks, effectiveness of these intermediaries does not appear to add significantly to the depth of the network. Comparing the status of network status between two industries within an industry group, the industries with active networks were found to be the HDD, ceramic and local textile industries. However, the ANOVA test showed that there is no significant difference between the effectiveness of intermediaries of two industries within industry groups. Interestingly, effectiveness of intermediaries between industry groups is significantly different. This may be because of the threshold level for the satisfaction of firms with respect to network benefits. Smaller firms with fewer internal resources expect government supports at shallow level, such as basic training and financial supports. These supports may easily satisfy their needs. On the other hand, larger firms with more internal resources expect government supports at deeper level, such as advanced training and expensive testing equipment.

Table 9.1 Summary of the hypotheses, test procedures and results

| Hypothesis H2 | | Analysis method | Factors affecting activeness of networks |
|---|---|---|---|
| H2(I) | Availability of intermediaries | Narrative analysis and case studies | Availability of permanent sponsors and universities as boundary spanners |
| H2(II) | Effectiveness of intermediaries | Descriptive analysis and ANOVA | No association with activeness |
| H2(III) | Degree of technological capability development | Spearman correlation | No association with activeness |
| H2(IV) | Experiences in pre-existing networks | Descriptive analysis and case studies | No association with activeness |

As seen in Table 9.1, there is no evidence of association between the technological capability of firms and activeness of firms as network players. This is because most firms in Thailand have technological capability at moderate to low level. According Arnold et al. (2000), the majority of MNC subsidiaries and local large firms in Thailand have capabilities for technology acquisition and assimilation, while most SMEs have the capabilities for technology use and operation. Therefore, on the basis of the evidence of this study, activeness of triple helix networks does not depend on degree of technological capability development of firms.

The results of analysis in this study have shown that the activeness or depth of triple helix networks does not depend on firms' experiences in pre-existing networks. It can be seen that some industries, like automotive and furniture industries, consists of both vertical and horizontal linkages. However, triple helix networks could not be built and sustained in these industries. This finding is in line with that of Wiesinger (2007), who argued that social capital of pre-existing networks, such as trade associations, does not guarantee the development of new networks. To solve this, Klerkx and Leeuwis (2009) suggested that the innovation broker can formalise the interactions of actors by destroying pre-existing networks. This suggestion is duly by the finding from the finding of furniture industry where ITAP attempted to build a triple helix network by entering into a trade association network. Unfortunately, most firms in the network were not keen on technology development, being locked instead into marketing activities to capture market share from competitors. Eventually, this ITAP driven triple helix network declined when ITAP reduced its supports.

### 9.1.3 Factors constraining evolution of dynamics in triple helix networks

Actually, in all selected industries, intermediaries playing a brokering role were found to be the prerequisite for the development of triple helix networks. Triple helix networks could be established as there were intermediaries playing the sponsoring, brokering and boundary-spanning roles; and the network dynamics in triple helix relationships could be created, as there was scope for combination of knowledge between heterogeneous actors. Lack of these factors leads to inability to establish and maintain triple helix networks. For example, it was found that the triple helix network of automotive industry could not be established due to lack of a permanent sponsor to support collaborative mechanisms, thus preventing the formation of the network in the industry. From case studies, it was found that the triple helix network could not generate the dynamics that would add to its depth and create opportunities for innovation mainly because of shortfalls in human resource development and the absence of new knowledge producer to combine knowledge. It can be seen from the case of TH Alliance and Toobkeawma Knowledge Centre that learning at both individual and organisation levels emerged, as collaborative mechanisms were deep into technological development, enabling human resource development. In this process, university-based intermediaries were essential to create and circulate knowledge. Payap University's researcher projects discussed in section 8.5 shows that network dynamics could be created as two groups of researchers working in different fields combine their knowledge. This finding gives credence to a widely discussed argument that lack of new knowledge that would be expected to derive from heterogeneous actors prevents networks from being dynamic and sustainable (DeBresson and Amesse, 1991; Bell and Albu, 1999; Breschi and Malerba, 2001; Knorringa and van Staveren, 2006; Capaldo, 2007; Giuliani, 2007; Lan and Zhangliu, 2011). The case studies also showed evidence of network dynamics where universities played a role as boundary-spanning intermediaries to combine and circulate knowledge across different networks. This combined knowledge can be radical innovation if the internalisation mode of knowledge conversion and creation involved the triple loop learning mode as well as the commercialisation of knowledge. However, neither triple loop learning nor commercialisation has not yet occurred in the industries considered in the study.

## 9.2 Policy implications

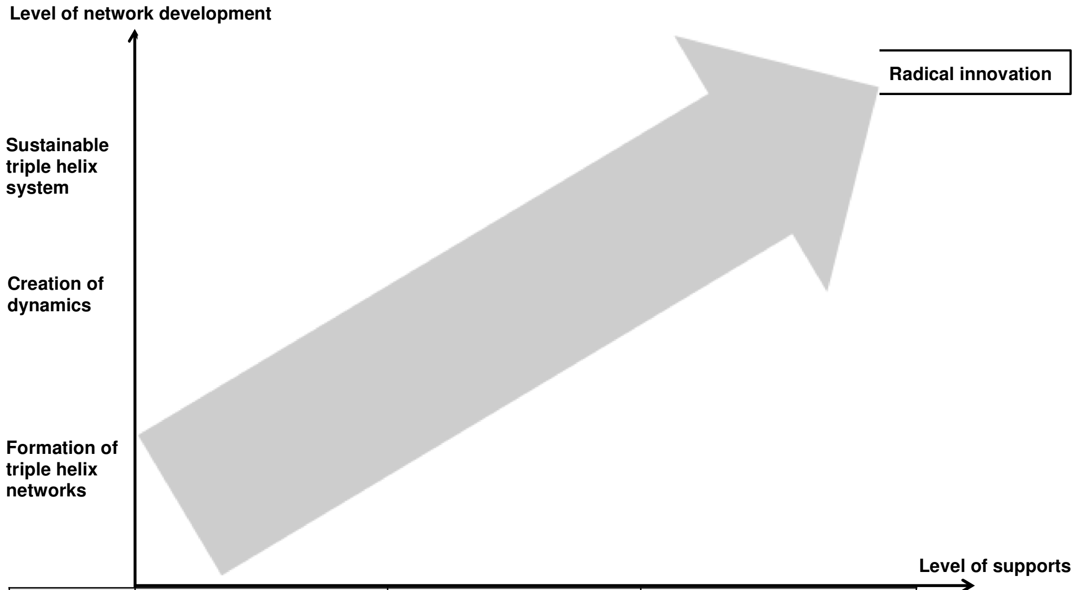
According to the key findings mentioned earlier, triple helix networks can be established depending on availability of intermediaries to facilitate the network development process as sponsors, brokers and boundary spanners. Policy recommendations for the formation and operation of triple helix networks should focus on systemic supports through these three roles of intermediaries as discussed below.

### 9.2.1 Provision of continual, long-term and systemic supports

To promote sustainable economic development through triple helix system, the government should provide systemic supports through sponsoring, brokering and boundary-spanning intermediaries. These supports should last until triple helix networks become sustainable because it was found that sudden budget cuts can not only hinder the creation of network dynamics, but can also ruin trust between triple helix actors that intermediaries have attempted to build. The long-term and continual government supports should be provided according to level of network development.

In the formation of triple helix networks, sponsors provide funding for collaborative projects to initially promote the triple helix culture of partnerships, collaboration and interdisciplinary R&D initiatives involving players from the knowledge, production and policy and governance spheres. Brokers attract triple helix actors to join networks by providing collaborative mechanisms as incentives. Boundary spanners with absorptive capability provide operational services to mitigate firms' shortfalls of internal resources and capabilities. Once triple helix networks are put in place, they would be expected to evolve cumulatively, becoming dynamic networks as these networks are connected to other networks through brokering. At this stage, sponsors' intervention to provide funds for multidisciplinary R&D would stimulate combination of knowledge between heterogeneous actors. This would call for upgrading of the technological capability of universities as knowledge producers, so that they would be able to conduct multidisciplinary R&D, and triple helix networks can grow creating radical innovation without recourse to government support. At this stage of triple helix network development, market-led intermediaries, driven by the prospect of profit making, could be encouraged to substitute for the supports provided by government-based intermediaries. Market-led intermediaries can occur in the forms of venture capital as sponsors, leading firms as private brokers, private and university consultants as boundary spanners (see Figure 9.1).

At present, the policy of the Thai government is limited to the first stage of network formation which does not, however, involve the creation of network dynamics. To promote the creation of network dynamics and hence the triple helix system, policy should focus on knowledge creation and combination through capability improvement of triple helix actors. It should also focus on the commercialisation process through the creation of market-led intermediaries.




| | | | |
|---|---|---|---|
| **Sponsoring** | Funding for collaborative projects | Funding for multidisciplinary R&D | Supporting market-led sponsors, e.g. venture capital |
| **Brokering** | Linking Triple Helix actors | Connecting to other brokers, | Establishing private brokers e.g. leading firms |
| **Boundary spanning** | Providing operational services through government research institutes and universities with absorptive capability | Upgrading technological capability of universities | Supporting private and university consultants to provide operational services |

Figure 9.1 Systemic supports of intermediaries playing three roles: sponsoring, brokering and boundary spanning in the transformation of triple helix networks into triple helix system

Source: Based on preceding discussion in section 9.2.1

### 9.2.2 Strengthening technological capability of intermediaries

To promote the creation of network dynamics, intermediaries, especially boundary spanners, would need to develop adaptive capability to combine their existing knowledge to create new knowledge. They also need to develop the capability to absorb knowledge from outside and transfer it to industry to solve common problems. Network dynamics can be created as intermediaries gain higher capability to create new knowledge through the combination of existing knowledge, thus producing incremental innovation. To progress the network beyond this stage, policy should focus on technological capability upgrading of knowledge producers and users – i.e. universities and firms. From the key findings of this study, it can be established that human resource development is a crucial factor for technological capability improvement. Human resource development initiatives can help upgrade the absorptive capabilities of triple helix actors and also equip them with adaptive and creative capabilities, thus enabling them to progress from single loop to double loop and then to triple loop modes of learning.

### 9.2.3 Promoting market-led intermediary organisations

The development of a triple helix system would call on policy to focus on the internalisation mode of knowledge conversion, which is related to the commercialisation process. It is at the internalisation stage that radical innovation can occur through cross-fertilisation of knowledge different networks and different fields and industries. For example, in the Silicon Valley, some new electronics technologies were created from a few different branches of technology development projects of venture capitalists (Robertson and Langlois, 1995). The lessons to be learned from this well-known case are that private sector players can assume the role of intermediaries to create radical innovation and continual network dynamics; and that government-based intermediaries can withdraw their support as all network actors have adequate capability to efficiently play their roles. Even so, the roles that intermediaries play remain essential for the sustainability of the triple helix system. The question is who should play that role. The burden of evidence borne by the Silicon Valley experience appears to suggest that before withdrawing its supports, the Thai government would need to promote market-led intermediaries to take up the role – venture capitalists as sponsors; leading firms as brokers; and private and university consultants as boundary-spanners.

## 9.3 Contribution to knowledge

This study contributes to knowledge in four ways. First, the study provides a robust conceptual framework to look into the systemic roles of intermediaries to create network dynamics and the basis for the generation of innovation sustainable economic growth. These intermediaries play three roles at three levels: sponsors, formulating and transmitting policy and allocating resources at policy level; brokers, linking actors at strategic level; and boundary spanners, providing technical services at operational level. The intermediaries themselves are inter-connected through brokers to stimulate knowledge creation, diffusion and utilisation, thus creating network dynamics.

Secondly, this study sheds light on the specifics underlying the evolution of the triple helix system, starting from pre-existing networks, which evolve into cluster and triple helix networks. Triple helix networks further evolve on the back of a complex system of learning that produces network dynamics, thereby ushering in the triple helix system of innovation. This is the first attempt to explain the evolutionary development of the triple helix system in these terms drawing on a synthesis of ideas relating to the evolution of learning modes (Flood and Romm, 1996; Romme and Wittleoostuijn, 1999); the evolution of knowledge creation and conversion (Nonaka and Takeuchi, 1995); and the heterogeneity of network actors in terms of resources, knowledge, experience and competencies (DeBresson and Amesse, 1991; Bell and Albu, 1999; Breschi and Malerba, 2001; Knorringa and van Staveren, 2006; Capaldo, 2007; Giuliani, 2007; Lan and Zhangliu, 2011).

Thirdly, the empirical findings of this study give credence to the widely maintained proposition that network dynamics of can be created from interaction of heterogeneous actors possessing diverse and complimentary competencies and resources.

Finally, this study provides a holistic view of intermediation in the whole innovation process and all industry groups across the manufacturing sector. Most empirical studies on intermediaries have used single case studies of an industry, or else two totally different industries. Not much has been done by way of comparison within and between industries in the three industry groups considered in this study. Therefore, the empirical results and recommendations of this study are expected to be of significance for policy aimed at promoting sustainable industrial development in Thailand based on innovation and competitiveness.

## 9.4 Suggestions for future research

For all its contributions, this study is not without limitations. First, the low response rate of the questionnaire survey has the effect of diminishing the robustness of the data used in the analysis by failing to reflect a good cross-section of whole population of firms. The survey had sought to cover the total population, but many failed to respond. To mitigate such limitations on the robustness of data, alternative methods of questionnaire administration should be used in the future, involving, for example, employment of personal delivery of questionnaires and the conduct of structured interview by telephone. However, such methods may too costly and could be time consuming.

Second, the six selected industries are at different stages of network development, because of the different path dependency of industrial development in each case. For future research, more industries could be included in each industry group to explore common patterns within these three industry groups. This would allow the formulation of specific policies that are appropriate to the circumstances of the different industry groups.

Third, the scope and unit of analysis can be broadened to cover discussion at the international level. As triple helix network is not limited to geographical proximity, the conceptual frameworks of development of the triple helix network and the systemic roles of intermediaries can be used to analyse knowledge networks with cognitive, technology, culture and social proximities at regional, national and international levels. The conceptual frameworks developed in this thesis can be adopted to analyse networks at all levels, and there is a possibility to use the framework to analyse network development in the South East Asian Region, including Thailand, Malaysia, Indonesia and Singapore.

## 9.5 Recommendations for future practice

From the main conceptual and empirical findings, human resource development features as the key factor to sustain network activities of learning and knowledge exchange. It is therefore suggested that human resource development should be considered as a main object of supportive government intervention.

Although network development may not constitute the main strategy for economic development in Thailand, the systemic roles of intermediaries can still be used in the process of institutional capacity building, as it provides a mechanism for the coordination of government agencies and the integration of policies and plans.

## 9.6 Conclusion

To date, innovation intermediaries in the six selected industries are at the first stage of network development, which is network formation; and activities in these networks are not deep enough to create network dynamics, ushering in the triple helix system of innovation. The evolutionary process of network dynamic creation would require intermediaries to pay more attention to the significance of the transformation of tacit knowledge to explicit knowledge through human resource development and the significance of combination of explicit knowledge categories through the networking of heterogeneous actors. In addition, to reach the sustainable position of the triple helix system, intermediation should be in the hands of private sector players. Therefore, the Thai government would in the long run do better in its effort of promoting innovation through network development by promoting market-driven intermediary organisations, like venture capitalists, and creating a market mechanism for private intermediation of triple helix network players.

This study has considered the case of Thailand. But the results of the analysis can have significant bearing not only for pointing the direction for future research on triple helix network and triple helix innovation system development in Thailand, but also as a lesson of experience in the evolution of the triple helix system of innovation for other developing countries.

# References

Afuah, A. (2003). *Innovation management: strategies, implementation and profits* (2 ed.). Oxford: Oxford University Press.

Ahuja, G. (2000). Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study. *Administrative Science Quarterly, 45*(3), 425-455.

Aldrich, H. and Herker, D. (1977). Boundary Spanning Roles and Organization Structure. *The Academy of Management Review, 2*(2), 217-230.

Altenburg, T. and Meyer-Stamer, J. R. (1999). How to Promote Clusters: Policy Experiences from Latin America. *World Development, 27*(9), 1693-1713.

Anderson, A. R. and Jack, S. L. (2002). The articulation of social capital in entrepreneurial networks: a glue or a lubricant? *Entrepreneurship & Regional Development, 14*(3), 193-210.

Argyris, C. (1990). *Overcoming organizational defenses : facilitating organizational learning*: Boston : Allyn and Bacon.

Argyris, C. (1992). *On organizational learning*: Oxford ; Malden, Mass. : Blackwell Business.

Argyris, C. (1994). Good Communication That Blocks Learning. *Harvard Business Review, 72*, 77-85.

Argyris, C. (1996). Unrecognized Defenses of Scholars: Impact on Theory and Research. *ORGANIZATION SCIENCE, 7*(1), 79-87.

Argyris, C. and Schön, D. A. (1978). *Organizational learning: a theory of action perspective*: Addison-Wesley Pub. Co.

Argyris, C. and Schön, D. A. (1996). *Organizational learning II : theory, method, and practice*: Reading, Mass. : Addison-Wesley Pub. Co.

Arnold, E., Bell, M., Bessant, J. et al. (2000). *Enhancing Policy and Institutional support for Industrial Technology Development in Thailand*: SPRU, CENTRIM, Technopolis.

Balthasar, A., Bättig, C., Thierstein, A. et al. (2000). "Developers": key actors of the innovation process. Types of developers and their contacts to institutions involved in research and development, continuing education and training, and the transfer of technology. *Technovation, 20*(10), 523-538.

Balzat, M. and Hanusch, H. (2004). Recent trends in the research on national innovation systems. *Journal of Evolutionary Economics, 14*(2), 197-210.

Bathelt, H., Malmberg, A. and Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography, 28*(1), 31-56.

Beckman, C. M. and Haunschild, P. R. (2002). Network Learning: The Effects of Partners' Heterogeneity of Experience on Corporate Acquisitions. *Administrative Science Quarterly, 47*(1), 92-124.

Beeby, M. and Booth, C. (2000). Networks and inter-orgnizational learning: a critical review. *The Learning Organization, 7*(2), 75-88.

Bell, M. and Albu, M. (1999). Knowledge Systems and Technological Dynamism in Industrial Clusters in Developing Countries. *World Development, 27*(9), 1715-1734.

Bendis, R. A., Seline, R. S. and Byler, E. J. (2008). A new direction for technology-based economic development: The role of innovation intermediaries. *Industry and Higher Education, 22*, 73-80.

Benner, M. and Sandström, U. (2000). Institutionalizing the triple helix: research funding and norms in the academic system. *Research Policy, 29*(2), 291-301.

Bessant, J. and Rush, H. (1995). Building bridges for innovation: the role of consultants in technology transfer. *Research Policy, 24*(1), 97-114.

BOT. (2013). Total value and quantity of exports classified by product group (Publication. Retrieved 18 March 2013, from Bank of Thailand: http://www.bot.or.th/Thai/Statistics/EconomicAndFinancial/ExternalSector/Pages/StatInternationalTrade.aspx#

Braczyk, H.-J., Cooke, P. and Heidenreich, M. (Eds.). (1998). *Regional innovation systems : the role of governances in a globalized world*: London ; Bristol, Pa., USA: UCL Press.

Braun, D. (1993). Who Governs Intermediary Agencies? Principal-Agent Relations in Research Policy-Making. *Journal of Public Policy, 13*(2), 135-162.

Braun, D. and Guston, D. H. (2003). Principal-agent theory and research policy: an introduction. *Science and Public Policy, 30*, 302-308.

Breschi, S. and Malerba, F. (2001). The Geography of Innovation and Economic Clustering: Some introductory notes. *Industrial and Corporation Change, 10*(4), 817-833.

Brimble, P. and Urata, S. (2006). *Behavior of Japanese, Western, and Asian MNCs in Thailand: Lessons for Japanese MNCs.* Paper presented at the Japan Center for Economic Research,June 1, 2006, Tokyo.

Bryman, A. (2008). *Social Research Methods* (3rd ed.). Oxford: Oxford University Press.

Burt, R. S. (1976). Positions in Networks. *Social Forces, 55*(1), 93-122.

Burt, R. S. (2000). The network structure of social capital. *Research in Organizational Behavior, 22*, 345-423.

Burt, R. S. (2001). Structural Holes versus Network Closure as Social Capital. In *Social Capital: Theory and Research* (pp. 31-56): Aldine de Gruyter.

Burt, R. S. (2004). Structural Holes and Good Ideas. *American Journal of Sociology, 110*(2), 349-399.

Capaldo, A. (2007). Network structure and innovation: The leveraging of a dual network as a distinctive relational capability. *Strategic Management Journal, 28*(6), 585-608.

Carayannis, E. G., Alexander, J. and Ioannidis, A. (2000). Leveraging knowledge, learning, and innovation in forming strategic government-university-industry (GUI) R&D partnerships in the US, Germany, and France. *Technovation, 20*(9), 477-488.

Carayannis, E. G. and Wang, V. (2008). The Role of the Firm in Innovation Networks and Knowledge Clusters. In E. G. Carayannis, D. Assimakopoulos and M. Kondo (Eds.), *Innovation Networks and Knowledge Culsters: Findings and Insights from the US, EU and Japan* (pp. 1-20). New York: Palgrave Macmillan.

Carver, R. H. and Nash, J. G. (2009). *Doing data analysis with SPSS version 16.* Belmont, CA: Brooks/Cole Cengage Learning.

Ceglie, G. and Dini, M. (1999). *SME Cluster and Network Development in Developing Countries: the Experience of UNIDO*. Paper presented at the International Conference on Building a Modern and Effective Development Service Industry for Small Enterprises,2-5 March 1999, Rio de Janeiro.

Chang, Y.-C. and Chen, M.-H. (2004). Comparing approaches to systems of innovation: the knowledge perspective. *Technology in Society, 26*(1), 17-37.

Chung, S. (2002). Building a national innovation system through regional innovation systems. *Technovation, 22*(8), 485-491.

Cooke, P., Gomez Uranga, M. and Etxebarria, G. (1997). Regional innovation systems: Institutional and organisational dimensions. *Research Policy, 26*(4-5), 475-491.

Cooke, P. and Wills, D. (1999). Small Firms, Social Capital and the Enhancement of Business Performance Through Innovation Programmes. *Small Business Economics, 13*(3), 219-234.

Crone, M. (2003). *Clustering and Cluster Development in Knowledge-intensive Industries: A 'Knowledge and Learning' Perspective on New Firm Formation and Firm-building/Firm Growth in Ireland's Indigenous Software Industry.* Paper presented at the Regional Science Association International,20-22 August 2003, St Andrews, Scotland.

DeBresson, C. and Amesse, F. (1991). Networks of innovators :A review and introduction to the issue. *Research Policy, 20*(5), 363-379.

Doloreux, D. and Parto, S. (2005). Regional innovation systems: Current discourse and unresolved issues. *Technology in Society, 27*(2), 133-153.

Dzisah, J. and Etzkowitz, H. (2008). Triple helix circulation: the heart of innovation and development. *International Journal of Technology Management and Sustainable Development, 7*(2), 101-115.

Edquist, C. and Hommen, L. (1999). Systems of innovation: theory and policy for the demand side. *Technology in Society, 21*(1), 63-79.

Eisingerich, A. B., Bell, S. J. and Tracey, P. (2010). How can clusters sustain performance? The role of network strength, network openness, and environmental uncertainty. *Research Policy, 39*(2), 239-253.

Etzkowitz, H. (2002). Incubation of incubators: innovation as a triple helix of university-industry-government networks. *Science and Public Policy, 29*, 115-128.

Etzkowitz, H. (2008). *The triple helix: university-industry-government innovation in action*. Oxon; New York: Routledge.

Etzkowitz, H. and Dzisah, J. (2008). Rethinking development: circulation in the triple helix. *Technology Analysis & Strategic Management, 20*(6), 653.

Etzkowitz, H. and Leydesdorff, L. (1995). The Triple Helix: University - Industry - Government Relations A Laboratory for Knowledge Based Economic Development. *EASST Review, 14*(1).

Etzkowitz, H. and Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy, 29*(2), 109-123.

Etzkowitz, H. and Zhou, C. (2007). *Regional Innovation Initiator: The Entrepreneurial University in Various Triple Helix Models* Paper presented at the Triple Helix VI Conference Singapore.

Fagerberg, J. and Srholec, M. (2008). National innovation systems, capabilities and economic development. *Research Policy, 37*(9), 1417-1435.
Fernandez, R. M. and Gould, R. V. (1994). A Dilemma of State Power: Brokerage and Influence in the National Health Policy Domain. *American Journal of Sociology, 99*(6), 1455-1491.
Fleming, L. and Waguespack, D. M. (2007). Brokerage, Boundary Spanning, and Leadership in Open Innovation Communities. *ORGANIZATION SCIENCE, 18*(2), 165-180.
Flood, R. L. and Romm, N. R. A. (1996). Coutours of diversity management and triple loop learning. *Kybernetes, 25*(7/8), 154-163.
Francois, P. (2002). *Social capital and economic development*: London ; New York : Routledge.
Freel, M. (2000). External linkages and product innovation in small manufacturing firms. *Entrepreneurship & Regional Development, 12*(3), 245-266.
Freeman, C. (1987). *Technology, policy, and economic performance : lessons from Japan*: London ; New York : Pinter Publishers.
Freeman, C. (1991). Networks of innovators: A synthesis of research issues. *Research Policy, 20*(5), 499-514.
Gemünden, H. G., Ritter, T. and Heydebreck, P. (1996). Network configuration and innovation success: An empirical analysis in German high-tech industries. *International Journal of Research in Marketing, 13*(5), 449-462.
Ghosal, V., Harrington, J. E. and Stennek, J. (2007). *The political economy of antitrust [internet resource]*: Bingley, U.K. : Emerald.
Gilsing, V. (2005). *The dynamics of innovation and interfirm networks : exploration, exploitation and co-evolution*: Cheltenham UK ; Northampton, Mass. : Edward Elgar Publishing.
Giuliani, E. (2007). The selective nature of knowledge networks in clusters: evidence from the wine industry. *Journal of Economic Geography, 7*(2), 139-168.
Goktepe, D. (2003). The Triple Helix as a model to analyze Israeli Magnet Program and lessons for late-developing countries like Turkey. *Scientometrics, 58*(2), 219-239.
Gordon, I. R. and McCann, P. (2000). Industrial Clusters: Complexes, Agglomeration and/or Social Networks? *Urban Studies, 37*(3), 513-532.
Gould, R. V. and Fernandez, R. M. (1989). Structures of Mediation: A Formal Approach to Brokerage in Transaction Networks. *Sociological Methodology, 19*, 89-126.
Gray, D. O. (2000). Government-sponsored industry-university cooperative research: an analysis of cooperative research center evaluation approaches. *Research Evaluation, 9*(1), 57-67.
Gujarati, D. N. (2003). *Basic econometrics*: Boston : McGraw Hill.
Guo, B. and Guo, J.-J. (2011). Patterns of technological learning within the knowledge systems of industrial clusters in emerging economies: Evidence from China. *Technovation, 31*(2-3), 87-104.
Hagedoorn, J. and Schakenraad, J. (1990). Strategic Partnering and Technological Co-operation. In B. D. e. al. (Ed.), *Perspectives in Industrial Organisation* (pp. 171-191). the Netherlands: Kluwer Academic Publishers.
Hargadon, A. B. (2002). Brokering knowledge: Linking learning and innovation. *Research in Organizational Behavior, 24*, 41-85.

Harryson, S. J., Dudkowski, R. and Stern, A. (2008). Transformation Networks in Innovation Alliances: The Development of Volvo C70. *Journal of Management Studies, 45*(4), 745-773.
Hobday, M. and Rush, H. (2007). Upgrading the technological capabilities of foreign transnational subsidiaries in developing countries: The case of electronics in Thailand. *Research Policy, 36*(9), 1335-1356.
Hongladarom, S. (2002). *Community-Based Science and Technology and Third World Development.* Paper presented at the International Conference on Science, Technology and Innovation: Emerging International Policy Issues,23-24 September 2002, Harvard University.
Hosein Rezazadeh Mehrizi, M. and Pakneiat, M. (2008). Comparative analysis of sectoral innovation system and diamond model (the case of telecom sector of Iran). *Journal of technology management & innovation, 3*, 78-90.
HowardPartners. (2007). *Study of the Role of Intermediaries in Support of Innovation*. Retrieved 1 November 2011. from http://www.innovation.gov.au/Innovation/ReportsandStudies/Documents/InnovationIntermediariesReport.pdf.
Howells, J. (2006). Intermediation and the role of intermediaries in innovation. *Research Policy, 35*(5), 715-728.
Huber, G. P. (1991). Organizational Learning: The Contributing Processes and the Literatures. *ORGANIZATION SCIENCE, 2*(1), 88-115.
IMD. (2012). World Competitiveness Online (Publication. Retrieved 1 November 2012: http://www.worldcompetitiveness.com/OnLine/App/Index.htm
Intarakumnerd, P. (2005). The Roles of Intermediaries in Clusters: The Thai Experiences in High-tech and Community-based Clusters. *Asian Journal of Technology Innovation, 13*(2), 23-43.
Intarakumnerd, P. (2007). FDI Strategies, Technological Upgrading, and Spillovers: Lessons of Thailand for Other Developing Countries. *The Japanese Society for Science Policy and Research Management, 22*(2), 103-115.
Intarakumnerd, P., Chairatana, P. and Tangchitpiboon, T. (2002). National innovation system in less successful developing countries: the case of Thailand. *Research Policy, 31*(8-9), 1445-1457.
Intarakumnerd, P. and Schiller, D. (2009). University-Industry Linkages in Thailand: Successes, Failures, and Lessons Learned for Other Developing Countries. *Seoul Journal of Economics, 22*(4), 551-589.
Isaksen, A. (2001). Building Regional Innovation Systems: Is Endogenous Industrial Development Possible in the Global Economy? *Canadian Journal of Regional Science, 24*(1), 101-120.
Johannissson, B. (1998). Personal networks in emerging knowledge-based firms: spatial and functional patterns. *Entrepreneurship & Regional Development: An International Journal, 10*(4), 297 - 312.
Johnson, B., Edquist, C. and Lundvall, B.-Å. (2003). *Economic Development and the National System of Innovation Approach.* Paper presented at the Globelics Conference,November 3-6, 2003, Rio de Janeiro.
Johnson, W. H. A. (2008). Roles, resources and benefits of intermediate organizations supporting triple helix collaborative R&D: The case of Precarn. *Technovation, 28*(8), 495-505.

Johnson, W. H. A. (2009). Intermediates in triple helix collaboration: the roles of 4th pillar organisations in public to private technology transfer. *International Journal of Technology Transfer and Commercialisation, 8*, 142-158.
Karlsson, R., Backman, M. and Djupenström, A. (2010). Sustainability Considerations and Triple-Helix Collaboration in Regional Innovation Systems. In *Facilitating Sustainable Innovation through Collaboration* (pp. 17-39).
Kaukonen, E. and Nieminen, M. (1999). Modeling the Triple Helix from a Small Country Perspective: The Case of Finland. *The Journal of Technology Transfer, 24*(2), 173-183.
Kickert, W. J. M., Klijn, E.-H. and Koppenjan, J. F. M. (1997). *Managing complex networks : strategies for the public sector*: London ; Thousand Oaks, Calif. : Sage.
Kim, K., Choi, Y., Choi, C. Y. et al. (2010). The role of intermediaries on technological risk management and business development performance in Korea. *Technological Forecasting and Social Change, 77*(6), 870-880.
Kim, Y., Kim, W. and Yang, T. (2012). The effect of the triple helix system and habitat on regional entrepreneurship: Empirical evidence from the U.S. *Research Policy, 41*(1), 154-166.
Kirby, A. J. (1988). Trade Associations as Information Exchange Mechanisms. *The RAND Journal of Economics, 19*(1), 138-146.
Kirkels, Y. and Duysters, G. (2010). Brokerage in SME networks. *Research Policy, 39*(3), 375-385.
Klerkx, L. and Leeuwis, C. (2008). Delegation of authority in research funding to networks: experiences with a multiple goal boundary organization. *Science and Public Policy, 35*, 183-196.
Klerkx, L. and Leeuwis, C. (2009). Establishment and embedding of innovation brokers at different innovation system levels: Insights from the Dutch agricultural sector. *Technological Forecasting and Social Change, 76*(6), 849-860.
Knorringa, P. (1999). Agra: An Old Cluster Facing the New Competition. *World Development, 27*(9), 1587-1604.
Knorringa, P. and van Staveren, I. (2005). *Social capital for industrial development: operationalizing the concept*. Vienna: United Nations Industrial Development Organization.
Knorringa, P. and van Staveren, I. (2006). *Social capital for industrial development: operationalizing the concept*. Vienna: United Nations Industrial Development Organization.
Kodama, T. (2008). The role of intermediation and absorptive capacity in facilitating university-industry linkages--An empirical study of TAMA in Japan. *Research Policy, 37*(8), 1224-1240.
Kohpaiboon, A. (2009). *Hard disk drive industry in Thailand: International Production Network versus Industrial Clusters.* Paper presented at the Singapore Economic Review ConferenceSingapore.
Krause, D. R., Handfield, R. B. and Tyler, B. B. (2007). The relationships between supplier development, commitment, social capital accumulation and performance improvement. *Journal of Operations Management, 25*(2), 528-545.

Kreiner, K. and Schultz, M. (1993). Informal Collaboration in R & D. The formation of Networks Across Organizations. *Organization Studies, 14*(2), 189-209.
Kumaresan, N. and Miyazaki, K. (1999). An integrated network approach to systems of innovation: the case of robotics in Japan. *Research Policy, 28*(6), 563-585.
Lall, S. (1992). Technological Capabilities and Industrialization. *World Development, 20*(2), 165-186.
Lan, W. and Zhangliu, W. (2011). Research on Innovation Mechanism and Risk of Industrial Cluster. *Energy Procedia, 13*(0), 10061-10067.
Landry, R., Amara, N. and Lamari, M. (2002). Does social capital determine innovation? To what extent? *Technological Forecasting and Social Change, 69*(7), 681-701.
Lazzarini, S., Chaddad, F. and Cook, M. (2001). Integrating supply chain and network analyses: The study of netchains. *Journal on Chain and Network Science, 1*(1), 7-22.
Lee, J., Árnason, A., Nightingale, A. et al. (2005). Networking: Social Capital and Identities in European Rural Development. *Sociologia Ruralis, 45*(4), 269-283.
Lee, S., Park, G., Yoon, B. et al. (2010). Open innovation in SMEs - An intermediated network model. *Research Policy, 39*(2), 290-300.
Leydesdorff, L. and Zawdie, G. (2010). The triple helix perspective of innovation systems. *Technology Analysis & Strategic Management, 22*(7), 789-804.
Liefner, I. and Schiller, D. (2008). Academic capabilities in developing countries--A conceptual framework with empirical illustrations from Thailand. *Research Policy, 37*(2), 276-293.
Lin, N. (1999). Building a Network Theory of Social Capital. *Connections, 22*(1), 28-51.
Lundvall, B.-Å. (1992). *National systems of innovation : towards a theory of innovation and interactive learning*: London ; New York : Pinter.
Lyons, T. S. (2002). Building social capital for rural enterprise development: Three case studies in the United States. *Journal of Developmental Entrepreneurship, 7*(2), 193-216.
Madill, J. J., Haines, G. H. and Riding, A. L. (2004). Networks and linkages among firms and organizations in the Ottawa-region technology cluster. *Entrepreneurship & Regional Development: An International Journal, 16*(5), 351 - 368.
Malerba, F. (2002). Sectoral systems of innovation and production. *Research Policy, 31*(2), 247-264.
Marques, J. P. C., Caraça, J. M. G. and Diz, H. (2006). How can university-industry-government interactions change the innovation scenario in Portugal?--the case of the University of Coimbra. *Technovation, 26*(4), 534-542.
Martin, R. and Sunley, P. (2003). Deconstructing clusters: chaotic concept or policy panacea? *Journal of Economic Geography, 3*(1), 5-35.
Mason, R. M. (Year). *Strategic information systems: use of information technology in a learning organization.* Paper presented at the System Sciences, 1993, Proceeding of the Twenty-Sixth Hawaii International Conference on,5-8 Jan 1993.

Menzel, M.-P. and Fornahl, D. (2007). Cluster Life Cycles - Dimensions and Rationales of Cluster Development [Electronic Version]. *Jena Economic Reseach Papers*.
MOI. (2012). *National Industrial Development Master Plan 2012-2031*. Retrieved 1 November 2012. from http://www.industry.go.th/5/Forms/AllItems.aspx.
Morgan, G. A. (2004). *SPSS for introductory statistics : use and interpretation* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum.
Morgan, G. A., Leech, N. L., Gloeckner, G. W. et al. (2007). *SPSS for introductory statistics [internet resource] use and interpretation*: Mahwah, N.J. ; London : Lawrence Erlbaum.
Morrison, A. (2008). Gatekeepers of Knowledge within Industrial Districts: Who They Are, How They Interact. *Regional Studies, 42*(6), 817 - 835.
Murdoch, J. (2000). Networks - a new paradigm of rural development? *Journal of Rural Studies, 16*(4), 407-419.
Nakwa, K., Zawdie, G. and Intarakumnerd, P. (2012). Role of Intermediaries in Accelerating the Transformation of Inter-Firm Networks into Triple Helix Networks: A Case Study of SME-based Industries in Thailand. *Procedia - Social and Behavioral Sciences, 52*(0), 52-61.
Nelson, R. R. and Rosenberg, N. (1993). Technical Innovation and National Systems
In R. R. Nelson (Ed.), *National innovation systems : a comparative analysis*. New York Oxford University Press.
Nelson, R. R. and Winter, S. G. (1974). Neoclassical vs. Evolutionary Theories of Economic Growth: Critique and Prospectus. *The Economic Journal, 84*(336), 886-905.
NESDB. (2006). *Cluster Mapping Project for Upgrading Competitiveness of Manufacturing and Service Sector* (Final Report). Bangkok: National Economic and Social Development Board.
NESDB. (2007). *10th National Economic and Social Development Plan 2007-2011*. Retrieved 1 November 2012. from http://eng.nesdb.go.th/Default.aspx?tabid=402.
NESDB. (2010). Gross Regional and Provincial Product (GPP) (Publication. Retrieved 1 November 2012: http://www.nesdb.go.th/Default.aspx?tabid=96
NESDB. (2012). *11th National Economic and Social Development Plan 2012-2016*. Retrieved 1 November 2012. from http://eng.nesdb.go.th/Default.aspx?tabid=402.
Nishimura, J. and Okamuro, H. (2011). Subsidy and networking: The effects of direct and indirect support programs of the cluster policy. *Research Policy, 40*(5), 714-727.
Nonaka, I. and Takeuchi, H. (1995). *The knowledge-creating company : how Japanese companies create the dynamics of innovation*: New York : Oxford University Press.
Norušis, M. J. (2006). *SPSS 15.0 guide to data analysis*: Upper Saddle River, N.J. : Prentice Hall.
NSTDA. (2004). *The National Science and Technology Strategic Plan (2004-2013)*. Bangkok: NSTDA.
NSTDA. (2008). *Guidance and Experiences: Development of Sub-sectoral Innovation Network*. Bangkok: National Science and Technology Development Agency.

NSTDA. (2011). Research and Development Committee (RDC). Unpublished Database. National Science and Technology Development Agency.
OECD. (1997). *National Innovation Systems*. Paris: OECD Publication.
OSMEP. (2009a). *Report on economic status of SMEs: Ceramic*. Bangkok: Office of Small and Medium Enterprises Promotion.
OSMEP. (2009b). *Report on economic status of SMEs: Wood furniture*. Bangkok: Office of Small and Medium Enterprises Promotion.
OSMEP. (2010). *SME Annual Report 2009*. Bangkok: Office of Small and Medium Enterprises Promotion.
OSMEP. (2012a). *3rd SME Promotion Plan (2012-2016)*. Retrieved 1 November 2012. from http://www.sme.go.th/Pages/promoteSMEs/art_14.aspx.
OSMEP. (2012b). *SME Annual Report 2011*. Bangkok: Office of Small and Medium Enterprises Promotion.
Owen-Smith, J. and Powell, W. W. (2004). Knowledge Networks as Channels and Conduits: The Effects of Spillovers in the Boston Biotechnology Community. *Organization Science, 15*(1), 5-21.
Pahl-Wostl, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change, 19*(3), 354-365.
Pananond, P. (2007). The changing dynamics of Thai multinationals after the Asian economic crisis. *Journal of International Management, 13*(3), 356-375.
Patterson, P. G., Johnson, L. W. and Spreng, R. A. (1997). Modeling the determinants of customer satisfaction for business-to-business professional services. *Academy of Marketing Science. Journal, 25*(1), 4-17.
Peschl, M. F. (2008). Triple-loop learning as foundation for profound change, individual cultivation, and radical innovation: Construction processes beyond scientific and rational knowledge. *Munich Personal RePEc Archive*.
PIO. (2007). *Report on development of and upgrading agro-industrial product: Lampang*: Provincial Industry Office, Ministry of Industry.
Porter, M. E. (2000). Location, Competition, and Economic Development: Local Clusters in a Global Economy. *Economic Development Quarterly, 14*(1), 15-34.
Pöyhönen, A. and Smedlund, A. (2004). Assessing intellectual capital creation in regional clusters. *Journal of Intellectual Capital, 5*(3), 351-365.
Promwong, K. (2001). *An analysis of the sources of productivity growth and competitiveness in Thailand's manufacturing sector.* University of Strathclyde.
Punyasavatsut, C. (2007). SMEs in The Thai Manufacturing Industry: Linking with MNEs. In H. Lim (Ed.), *ERIA Research Project Report 2007: ASEAN and SME and Globalization* (Vol. 2007).
Pyka, A. (2002). Innovation networks in economics: from the incentive-based to the knowledge-based approaches. *European Journal of Innovation Management, 5*(3), 152-163.
Robertson, P. L. and Langlois, R. N. (1995). Innovation, networks, and vertical integration. *Research Policy, 24*(4), 543-562.
Romme, A. G. L. and Wittleoostuijn, A. v. (1999). Circular organizing and triple loop learning. *Journal of Organizational Change Management, 12*(5), 439-454.

Rothwell, R. and Dodgson, M. (1991). External linkages and innovation in small and medium-sized enterprises. *R&D Management, 21*(2), 125-138.
Saad, M. and Zawdie, G. (2008). Triple helix in developing countries - issues and challenges. *Technology Analysis & Strategic Management, 20*(6), 649 - 652.
Savory, C. (2006). Translating knowledge to build technological competence. *Management Decision, 44*(8), 1052-1075.
SCEB. (2011). *Community-based enterprise registeration*. Bangkok: Secretariat Office of Community Enterprise Promotion Board.
Schmitz, H. and Nadvi, K. (1999). Clustering and Industrialization: Introduction. *World Development, 27*(9), 1503-1514.
Schumpeter, J. A. (1934). *The theory of economic development* Cambridge: Harvard University Press.
Senge, P. M. (1990). *The fifth discipline : the art and practice of the learning organization*: New York : Doubleday/Currency.
Smedlund, A. (2006). The roles of intermediaries in a regional knowledge system. *Journal of Intellectual Capital, 7*, 204-220.
Snell, R. and Chak, A. M.-K. (1998). The Learning Organization: Learning and Empowerment for Whom? *Management Learning, 29*(3), 337-364.
St. John, C. H. and Pouder, R. W. (2006). Technology Clusters versus Industry Clusters: Resources, Networks, and Regional Advantages. *Growth and Change, 37*(2), 141-171.
STI. (2012a). Analysis of Thailand's Competitiveness 2012. Unpublished internal report.
STI. (2012b). *National Science, Technology and Innovation Policy and Plan 1 (2012-2021)*. Retrieved 1 November 2012. from http://www.sti.or.th/th/index.php?option=com_content&view=article&id=169&Itemid=134.
Swann, G. M. P. (2009). *The Economics of Innovation: An Introduction*. Cheltenham: Edward Elgar Publishing.
TAI. (2007). *Automotive Industry Master Plan (2007-2011)*. Retrieved 30 June 2011. from http://www.oie.go.th/academic/industryplan.
Tallman, S., Jenkins, M., Henry, N. et al. (2004). Knowledge, Clusters, and Competitive Advantage. *The Academy of Management Review, 29*(2), 258-271.
TAPMA. (2011). About TAPMA. Retrieved 28 June, 2011, from http://www.thaiautoparts.or.th/abouttapma.php
Täube, V. G. (2004). Measuring the Social Capital of Brokerage Roles. *Connection, 26*(1), 29-52.
Taylor, S. (2004). Knowledge circulation: the 'triple helix' concept applied in South Africa. *Industry and Higher Education, 18*, 329-334.
Techakanont, K. and Terdudomtham, T. (2004). Evolution of Inter-firm Technology Transfer and Technological Capability Formation of Local Parts Firms in the Thai Automobile Industry. *Journal of Technology Innovation, 12*(2), 151-183.
Teubal, M., Yinnon, T. and Zuscovitch, E. (1991). Networks and market creation. *Research Policy, 20*(5), 381-392.
THE. (2012). Times Higher Education World University Rankings (Publication. Retrieved 1 November 2012, from Thomson Reuters:

http://www.timeshighereducation.co.uk/world-university-rankings/2012-13/world-ranking/region/asia

UNCTAD. (2005). *Transfer of Technology for Successful Integration into the Global Economy: A Case Study of the Electronics Industry in Thailand*. New York and Geneva: United Nations.

Van der Meulen, B. (1998). Science policies as principal-agent games: Institutionalization and path dependency in the relation between government and science. *Research Policy, 27*(4), 397-414.

Van der Meulen, B. (2003). New roles and strategies of a research council: intermediation of the principal-agent relationship. *Science and Public Policy, 30*(5), 323-336.

Van Lente, H., Hekkert, M., Smits, R. et al. (2003). Roles of systemic intermediaries in transition processes. *International Journal of Innovation Management, 7*(3), 1-33.

Walker, G., Kogut, B. and Shan, W. (1997). Social Capital, Structural Holes and the Formation of an Industry Network. *Organization Science, 8*(2), 109-125.

Wathne, K. H. and Heide, J. B. (2004). Relationship Governance in a Supply Chain Network. *The Journal of Marketing, 68*(1), 73-89.

White, L. and Christopoulos, D. C. (2011). The public sector as broker: an interim report. *Procedia - Social and Behavioral Sciences, 10*(0), 132-139.

Wiesinger, G. (2007). The importance of social capital in rural development, networking and decision-making in rural areas. *Revue de geographie alpine, 95*(7), 43-56.

Wongdeethai, A., Kamondetdacha, R. and Intarakumnerd, P. (2010). *Policy Challenges of FDI on R&D in Thailand: Case Studies of Food, Automotive and Electronics Sectors*. Bangkok: National Science Technology and Innovation Policy Office.

Woolcock, M. (1998). Social capital and economic development: Toward a theoretical synthesis and policy framework. *Theory and Society, 27*(2), 151-208.

Wright, M., Clarysse, B., Lockett, A. et al. (2008). Mid-range universities' linkages with industry: Knowledge types and the role of intermediaries. *Research Policy, 37*(8), 1205-1223.

Yang, C.-H., Chen, C.-J. and Shyu, J. Z. (2008). Innovation Intermediary for Creating Regional Knowledge Capabilities in Knowledge Cluster, *IEEE International Conference*.

Yin, R. (2002). *Case Study Research: Design and Methods, Third Edition, Applied Social Research Methods Series, Vol 5*: Sage Publications, Inc.

Yokakul, N. and Zawdie, G. (2010). Innovation network and technological capability development in the Thai SME sector: The case of the Thai dessert industry. *International Journal of Technology Management and Sustainable Development, 9*(2), 19-36.

Youtie, J. and Shapira, P. (2008). Building an innovation hub: A case study of the transformation of university roles in regional technological and economic development. *Research Policy, 37*(8), 1188-1204.

Yusuf, S. (2008). Intermediating knowledge exchange between universities and businesses. *Research Policy, 37*(8), 1167-1174.

# Appendix 1

## Ethics application form

**Please answer all questions**

| 1. Title of the investigation |
|---|
| Innovation intermediaries and triple helix networks in developing countries with particular reference to the case of Thailand |

| 2. Chief Investigator (Ordinance 16 member of staff only) |
|---|
| Name: Dr.Girma Zawdie<br>Status:<br>☐ Professor<br>☐ Reader<br>☒ Senior Lecturer<br>☐ Lecturer<br>Department: Civil and Environmental Engineering<br>Telephone: 01415484443<br>E-mail: g.zawdie@strath.ac.uk |

| 3. Other Strathclyde investigator(s) |
|---|
| Name:<br>Status (e.g. lecturer, post-/undergraduate):<br>Department:<br>Telephone:<br>E-mail: |

| 4. Non-Strathclyde collaborating investigator(s) |
|---|
| Name:<br>Status (e.g. lecturer, post-/undergraduate):<br>Department/Institution:<br>If student(s), name of supervisor:<br>Telephone:<br>E-mail:<br>Please provide details for all investigators involved in the study: |

| 5. Overseas Supervisor(s) |
|---|
| Name(s): Dr.Patarapong Intarakumnerd<br>Status: Lecturer<br>Department/Institution: College of Innovation, Thammasat University<br>Telephone:<br>Email: prpu6@hotmail.com<br>I can confirm that the local supervisor has obtained a copy of the Code of Practice: Yes ☒ No ☐<br>Please provide details for all supervisors involved in the study: Revising questionnaire and interview questions |

| 6. Where will the investigation be conducted |
|---|
| Thailand |

| 7. Duration of the investigation |
|---|
| Duration(years/months) : 1 year 9 months<br><br>Start date (expected): 01 / 12 / 2010 Completion date (expected):30 / 08 / 2012 |

| 8. Sponsor (please refer to Section C and Annex 3 of the Code of Practice): |
|---|
| |

| 9. Funding body (if applicable) |
|---|
| Name of funding body:<br>Status of proposal – if seeking funding (please click appropriate box):<br>☐ In preparation<br>☐ Submitted<br>☐ Accepted<br>Date of Submission of proposal: / /<br>Date of start of funding: / / |

| 10. Objectives of investigation (including the academic rationale and justification for the investigation) |
|---|
| Data collection for Ph.D. research |

| 11. Nature of the participants<br>Please note that investigations governed by the Code of Practice that involve any of the types of projects listed in B1(b) must be submitted to the University Ethics Committee for prior approval |
|---|
| Are any of the categories mentioned in Section B1(b) (participant considerations) applicable in this investigation?<br>☐ Yes<br>☒ No<br>Please detail nature of participants: Executives of firms and staff of government organisations<br>Number: 930 Age (range): 25-60<br>Please also include information on: recruitment methods (see section B4 of the Code of Practice); inclusion/exclusion criteria; and any further screening procedure to be used<br>Thai firms in selected industries, including hard disk drive, automotive, ceramic, furniture, local textile and rice cracker industries, and related government agencies in these industries |

| 12. What consents will be sought and how?<br>Please note that the information sheets and consent forms to be used should be attached to this form |
|---|
| Participants may need to provide consent to use their data for academic propose and research-related activities. Information sheet is in form of cover letter in Thai language, and the consent can be assumed in forms of responses of participants. |

| 13. Methodology<br>Investigations governed by the Code of Practice that involve any of the types of projects listed in B1(a) must be submitted to the University Ethics Committee for prior approval. Where an independent reviewer is not used, then the UEC/ DEC reserves the right to scrutinise the methodology. |
|---|
| Are any of the categories mentioned in the Code of Practice Section B1(a) (project considerations) applicable in this investigation?<br>☐ Yes<br>☒ No<br>If 'yes' please detail: |

Design: what kind of design/research method(s) is/are to be used in the investigation? questionnaire administration and interviews

Techniques: what specific techniques will be employed and what exactly is required of participants? interview 20 key persons from university, industry, government and intermediary organisation in each industry and send postal questionnaire to population of firms in each industry

Has this methodology been subject to independent scrutiny?
☐ Yes
☒ No
Please provide the name and contact details of the independent reviewer:

14. Data collection, storage and security

Explain how data are handled, specifying whether it will be fully anonymised, pseudo-anonymised, or just confidential, and whether it will be securely destroyed after use:
Data are analysed and presented in the analysis chapter of thesis and related articles without stating names of companies and interviewees
Explain how and where it will be stored, who has access to it, and how long it will be stored:
Data are stored in PC of the investigator and will be destroyed after PhD is awarded.
Will anyone other than the named investigators have access to the data? Yes ☐ No ☒
If 'yes' please explain:

15. Potential risks or hazards

Participants may be unwilling to provide their insight information

16. Ethical issues

17. Any payment to be made

none

18. What debriefing, if any, will be given to participants

Objectives and aims of study and required information

19. How will the outcomes of the study be disseminated (will you seek to publish the results)

PhD thesis and journal articles

20. Nominated person to whom participants' concerns/ questions should be directed before, during or after the investigation (please also provide contact details)

Karantarat Nakwa and Dr.Girma Zawdie

21. Previous experience of the investigator(s) with the procedures involved

The investigator used to work as a researcher in Thailand in relevant issues, so the investigator is quite familiar with questionnaire administration and interviews

| **Checklist** | **Enclosed** | **N/A** |
|---|---|---|
| Participant Information Sheet(s) | ☒ | ☐ |
| Consent Form(s) | ☐ | ☒ |
| Sample questionnaire(s) | ☒ | ☐ |
| Sample interview format(s) | ☒ | ☐ |
| Sample advertisement(s) | ☐ | ☒ |

| | | |
|---|---|---|
| Any other documents (please specify below) | ☐<br>☐<br>☐<br>☐<br>☐ | ☐<br>☐<br>☐<br>☐<br>☐ |

| |
|---|
| 22. Chief Investigator and Head of Department Declaration<br>Please note that unsigned applications will not be accepted and both signatures are required |
| I have read the University's Code of Practice on Investigations involving Human Beings and have completed this application accordingly.<br><br>Signature of Chief Investigator<br><br>Please also type name here: Dr.Girma Zawdie<br><br>I confirm I have read this application, I am happy that the study is consistent with departmental strategy, that the staff and/or students involved have the appropriate expertise to undertake the study, that the study makes appropriate use of available resources and facilities within the department and that there are no other departmental-specific issues relating to the study of which I am aware<br><br>Signature of Head of Department<br><br>Please also type name here<br><br>Date: / / |

23. Only for University sponsored projects under the remit of the DEC/SEC, with no external funding and no NHS involvement

**Head of Department statement on Sponsorship**

This application requires the University to sponsor the investigation. This is done by the Head of Department for all DEC applications with exception of those that are externally funded and those which are connected to the NHS (those exceptions should be submitted to R&KES). I am aware of the implications of University sponsorship of the investigation and have assessed this investigation with respect to sponsorship and management risk. As this particular investigation is within the remit of the DEC and has no external funding and no NHS involvement, I agree on behalf of the University that the University is the appropriate sponsor of the investigation and there are no management risks posed by the investigation.

If not applicable, click here ☐

| | |
|---|---|
| Signature of Head of Department | |
| Please also type name here | |
| Date: | / / |

For applications to the University Ethics Committee the completed form should be sent to ethics@strath.ac.uk with the relevant electronic signatures.

**Management Risk Assessment and Sponsorship**
You are required to complete this form when:

- Your application is going to University Ethics Committee (UEC). You should attach it with your application when you send the application to the ethics mailbox.
- Your application is going to Departmental Ethics Committee (DEC), or the School Ethics Committee (SEC) in the case of HASS, and there is no NHS involvement or external funding. The CI should complete and submit the form to the Head of Department/School General Application Forms.

The Code of Practice on Investigations involving Human Beings requires that all investigations involving humans as subjects should be subject to management risk assessment as well as ethical scrutiny. For those investigations that fall within the remit of the University Ethics Committee, and/or involve the NHS, and/or are externally funded then this form should be completed and submitted to Research & Knowledge Exchange Services. For those investigations that fall within the remit of the Departmental Ethics Committee, and do not involve the NHS, and are not externally funded then this form should be completed and submitted by the Chief Investigator to his/her Head of Department.

1. Title of investigation: Innovation intermediaries and triple helix networks in developing countries with particular reference to the case of Thailand

2. Chief Investigator : Dr.Girma Zawdie

3. Is it proposed the University will sponsor the investigation (i.e. have responsibility for overall management of the investigation)?
   Yes ☐ No ☒ If no, who is the Sponsor? none

4. Are you aware of any issues relevant to the University's insurance cover? For example is this a clinical trial and/or are you offering no-fault compensation to volunteers?
   Yes ☐ No ☒
   If yes, what are those issues? ………………

5. Are you aware of any issues relevant to the University's assessment of management risk of this project? Please see attached for examples of possible management risk issues.
   Yes ☐ No ☒
   If yes, what are those issues? …………

Signature of Chief Investigator: ………………………………..
Date: …………………………...
For investigations that fall within the remit of the University Ethics Committee, and/or involve the NHS, and/or are externally funded please send this completed form with the appropriate ethics application form to Helen Baigrie, Contracts Manager, Research and Knowledge Exchange Services.

**Management Risk Assessment Issues**
When considering management risk Research and Knowledge Exchange Services and Senior Officers will consider factors including, but not limited to, the following.

1. Risk to reputation of University and risk of litigation and/or insurance claims. This risk maybe caused by:
    - harm to volunteers and wider community
    - poor research strategy
    - breach of statutory framework or contractual obligations
    - project not being carried out according to protocol
    - inadequate or inappropriate insurance cover.
2. Risk to research completion. This risk maybe caused by:
    - failure to properly carry out research
    - failure to proper supervise students
    - inadequate resources and/or facilities
    - inexperienced staff.
3. Risk to dissemination and use of research results. This risk maybe caused by lack of resources or failure to identify and act upon intellectual property in results.
4. Risk to researchers – career and reputation. This risk maybe caused by misconduct or non-completion of research.

The management risk assessment will consider the University's context, in particular:

- Research and Development Strategy, including the objective of the University in general, and the objective of University research generally and within the relevant faulty/department.
- Research and Development Structure and Systems. In particular the support provided by the University's structure to reduce the risks posed by research and by this investigation, and the systems in place to monitor and respond to the risks.

# Appendix 2

## Formal letter for interviews

สวทช NSTDA

ที่ วท ๕๔๐๑/ ๑๓๕๒

๙ มีนาคม ๒๕๕๔

เรื่อง ขออนุญาตเข้าสัมภาษณ์

เรียน

สิ่งที่ส่งมาด้วย หัวข้อการสัมภาษณ์ เรื่อง "บทบาทของตัวกลางทางนวัตกรรมในการสร้างเครือข่ายความร่วมมือระหว่างภาครัฐ ภาคการศึกษา และภาคอุตสาหกรรม"

ด้วยนางสาวกรัณฑรัตน์ นาขวา ตำแหน่ง ผู้ช่วยนักวิจัย ฝ่ายกลยุทธ์ สำนักงานพัฒนาวิทยาศาสตร์และเทคโนโลยีแห่งชาติ (สวทช.) ได้รับทุนรัฐบาลกระทรวงวิทยาศาสตร์และเทคโนโลยี เพื่อศึกษาระดับปริญญาโท-เอก สาขา Science and Technology Policy เน้น University and Industry Linkage ขณะนี้กำลังศึกษาระดับปริญญาเอก ชั้นปีที่ ๒ ณ University of Strathclyde ประเทศสหราชอาณาจักร ได้ทำงานวิจัยเพื่อศึกษาบทบาทและประสิทธิภาพของตัวกลางทางนวัตกรรม (Innovation Intermediaries) ในการสร้างเครือข่ายความร่วมมือระหว่างภาครัฐ ภาคการศึกษา และภาคอุตสาหกรรม เพื่อการพัฒนาเทคโนโลยีในภาคอุตสาหกรรมไทย โดยจะศึกษาเปรียบเทียบ ๑๐ อุตสาหกรรมใน ๕ ลักษณะอุตสาหกรรม ได้แก่ ๑) อุตสาหกรรมที่มีบรรษัทต่างชาติเป็นผู้นำ ๒) อุตสาหกรรมที่ประกอบด้วยวิสาหกิจขนาดกลางและขนาดเล็ก ๓) อุตสาหกรรมระดับวิสาหกิจชุมชน ๔) อุตสาหกรรมในภาคบริการ และ ๕) อุตสาหกรรมฐานความรู้ ซึ่งงานวิจัยนี้จะเป็นประโยชน์อย่างยิ่งต่อการจัดทำนโยบายในการสร้างกลไกที่ดียิ่งขึ้นในการสนับสนุนภาคอุตสาหกรรม เพื่อตอบสนองกับความต้องการของกลุ่มอุตสาหกรรมแต่ละกลุ่ม และงานวิจัยนี้เป็นส่วนหนึ่งของวิทยานิพนธ์ระดับปริญญาเอก ซึ่งในการทำงานวิจัยดังกล่าว นางสาวกรัณฑรัตน์ฯ มีความประสงค์จะขอสัมภาษณ์บุคคลจากภาครัฐ ภาคการศึกษา และภาคอุตสาหกรรม เพื่อนำมาวิเคราะห์และสรุปผล

สวทช. พิจารณาแล้วเห็นว่าท่านเป็นผู้ที่มีความสำคัญและมีบทบาทเป็นอย่างมากต่อการพัฒนาเทคโนโลยีในภาคอุตสาหกรรมของประเทศ จึงใคร่ขออนุญาตเข้าสัมภาษณ์ท่านในหัวข้อเรื่อง "บทบาทของตัวกลางทางนวัตกรรมในการสร้างเครือข่ายความร่วมมือระหว่างภาครัฐ ภาคการศึกษา และภาคอุตสาหกรรม" (สิ่งที่ส่งมาด้วย) ***โดยข้อมูลที่ได้รับจะถูกเก็บเป็นความลับอย่างเคร่งครัด และการนำเสนอผลงานวิจัยจะนำเสนอในภาพรวมเท่านั้น***

จึงเรียนมาเพื่อโปรดพิจารณาอนุญาตให้นางสาวกรัณฑรัตน์ฯ เข้าสัมภาษณ์ท่านตามวันเวลาที่ท่านสะดวกด้วย จักขอบคุณยิ่ง

ขอแสดงความนับถือ

(นายณรงค์ ศิริเลิศวรกุล)
รองผู้อำนวยการ
ปฏิบัติการแทนผู้อำนวยการ
สำนักงานพัฒนาวิทยาศาสตร์และเทคโนโลยีแห่งชาติ

สำนักงานกลาง
ฝ่ายนักเรียนทุนรัฐบาลกระทรวงวิทยาศาสตร์ฯ
โทรศัพท์ ๐ ๒๕๖๔ ๗๐๐๐ ต่อ ๑๔๑๐ – ๑๔๑๖
โทรสาร ๐ ๒๕๖๔ ๗๑๒๕

สำนักงานพัฒนาวิทยาศาสตร์และเทคโนโลยีแห่งชาติ
111 อุทยานวิทยาศาสตร์ประเทศไทย ถนนพหลโยธิน ตำบลคลองหนึ่ง อำเภอคลองหลวง จังหวัดปทุมธานี 12120 โทรศัพท์ 0 2564 7000 โทรสาร 0 2564 7002-5

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# Appendix 3

## Interview Questions

1) How many networks do they belong to? For what reason?
2) For this project, what is the starting point? How could they participate in the networks and create interaction?
3) Who are important actors of the networks? (including university, firms and government agencies)
4) What are their functions and contribution to the networks? How much is the budget of projects aiming to form and manage the networks?
5) What are skills needed to develop and manage the interaction of the networks? How can they develop these skills?
6) Which stage are their networks in?
7) Do they realise who are innovation intermediaries of the networks?
8) Do they think whether innovation intermediaries play appropriate roles with adequate capabilities? Do they need anything else from innovation intermediaries?
9) Do they still need assistance from innovation intermediaries? For how long?
10) What is the future direction of the networks? What is needed to be done to reach the aim of the networks?
11) Can they provide the lists of members of their networks?

# Appendix 4

## Cover letter for questionnaire survey

สวทช
NSTDA

ที่ วท ๕๔๐๑ / ๑๓๕๓

๙ มีนาคม ๒๕๕๔

เรื่อง ขอความอนุเคราะห์ตอบแบบสอบถาม

เรียน ท่านผู้บริหารระดับสูงหรือท่านเจ้าของกิจการ

สิ่งที่ส่งมาด้วย แบบสอบถามเรื่อง “บทบาทของตัวกลางทางนวัตกรรมในการสร้างเครือข่ายความร่วมมือระหว่างภาครัฐ ภาคการศึกษา และภาคอุตสาหกรรม”

ด้วยนางสาวกรัณฑรัตน์ นาขวา ตำแหน่ง ผู้ช่วยนักวิจัย ฝ่ายกลยุทธ์ สำนักงานพัฒนาวิทยาศาสตร์และเทคโนโลยีแห่งชาติ (สวทช.) ได้รับทุนรัฐบาลกระทรวงวิทยาศาสตร์และเทคโนโลยี เพื่อศึกษาระดับปริญญาโท-เอก สาขา Science and Technology Policy เน้น University and Industry Linkage ขณะนี้กำลังศึกษาระดับปริญญาเอก ชั้นปีที่ ๒ ณ University of Strathclyde ประเทศสหราชอาณาจักร ได้ทำงานวิจัยเพื่อศึกษาบทบาทและประสิทธิภาพของตัวกลางทางนวัตกรรม (Innovation Intermediaries) ในการสร้างเครือข่ายความร่วมมือระหว่างภาครัฐ ภาคการศึกษา และภาคอุตสาหกรรม เพื่อการพัฒนาเทคโนโลยีในภาคอุตสาหกรรมไทย โดยจะศึกษาเปรียบเทียบ ๑๐ อุตสาหกรรมใน ๕ ลักษณะอุตสาหกรรม ได้แก่ ๑) อุตสาหกรรมที่มีบรรษัทต่างชาติเป็นผู้นำ ๒) อุตสาหกรรมที่ประกอบด้วยวิสาหกิจขนาดกลางและขนาดเล็ก ๓) อุตสาหกรรมระดับวิสาหกิจชุมชน ๔) อุตสาหกรรมในภาคบริการ และ ๕) อุตสาหกรรมฐานความรู้ ซึ่งงานวิจัยนี้จะเป็นประโยชน์อย่างยิ่งต่อการจัดทำนโยบายในการสร้างกลไกที่ดียิ่งขึ้นในการสนับสนุนภาคอุตสาหกรรม เพื่อตอบสนองกับความต้องการของกลุ่มอุตสาหกรรมแต่ละกลุ่ม และงานวิจัยนี้เป็นส่วนหนึ่งของวิทยานิพนธ์ระดับปริญญาเอก ซึ่งในการทำงานวิจัยดังกล่าว นางสาวกรัณฑรัตน์ฯ ได้ใช้แบบสอบถามเป็นเครื่องมือในการเก็บข้อมูลจากภาครัฐ ภาคการศึกษา และภาคอุตสาหกรรม เพื่อนำมาวิเคราะห์และสรุปผล

สวทช. พิจารณาแล้วเห็นว่าหน่วยงานของท่านมีความสำคัญและมีบทบาทเป็นอย่างมากต่อการพัฒนาเทคโนโลยีในภาคอุตสาหกรรมของประเทศ จึงใคร่ขอข้อมูลจากหน่วยงานของท่าน โดยโปรดพิจารณาให้ความอนุเคราะห์ตอบแบบสอบถาม (สิ่งที่ส่งมาด้วย) ทั้งนี้ ***ข้อมูลที่ได้รับจะถูกเก็บเป็นความลับอย่างเคร่งครัด และการนำเสนอผลงานวิจัยจะนำเสนอในภาพรวมเท่านั้น***

จึงเรียนมาเพื่อโปรดพิจารณาให้ความอนุเคราะห์ตอบแบบสอบถามของนางสาวกรัณฑรัตน์ฯด้วย จักขอบคุณยิ่ง

ขอแสดงความนับถือ

(นายณรงค์ ศิริเลิศวรกุล)
รองผู้อำนวยการ
ปฏิบัติการแทนผู้อำนวยการ
สำนักงานพัฒนาวิทยาศาสตร์และเทคโนโลยีแห่งชาติ

สำนักงานกลาง
ฝ่ายนักเรียนทุนรัฐบาลกระทรวงวิทยาศาสตร์ฯ
โทรศัพท์ ๐ ๒๕๖๔ ๗๐๐๐ ต่อ ๑๔๑๐ – ๑๔๑๖
โทรสาร ๐ ๒๕๖๔ ๗๑๒๕

**สำนักงานพัฒนาวิทยาศาสตร์และเทคโนโลยีแห่งชาติ**
111 อุทยานวิทยาศาสตร์ประเทศไทย ถนนพหลโยธิน ตำบลคลองหนึ่ง อำเภอคลองหลวง จังหวัดปทุมธานี 12120 โทรศัพท์ 0 2564 7000 โทรสาร 0 2564 7002–5

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# Appendix 5

# Questionnaire

**Part I Firm's Characteristics**

1. Company name…………………………………………………………….....
2. Age …. years
3. Sale (2010) ….. baht
4. Profit (2010) …. % of sale
5. Employees

   ☐ less than 50 persons ☐ from 50-200 persons ☐ more than 200 persons
6. Fixed assets

   ☐ less than 50 million baht ☐ from 50-200 million baht ☐ more than 200 million baht

**Part II Resources and Capabilities**

7. Number of employees for technology and innovation development ….. persons
8. Estimated R&D equipment as a percentage of fixed assets

   ☐ none ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ more than 50%
9. Number of database for technology and innovation development …. Sources
10. Budget for technology and innovation development as a percentage of sale

    ☐ none ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ more than 50%
11. Which level of technological capability do you have?

    ☐ Technology acquisition such as quality control, maintenance, adaption to local market

    ☐ Solving technology problems such as process adaption for cost saving, product improvement, adapting imported technology

    ☐ Developing new products and processes

**Part III Types of linkages in the Triple Helix Relationship**

12. Do you have linkages with universities? ☐ No because……………………

☐ Yes, please specify types of linkage and partners

☐ Joint research

….. projects with①[6] ….. projects with③

….. projects with② ….. projects with④

….. projects with others…………………

☐ Technology licensing

….. projects with① ….. projects with③

….. projects with② ….. projects with④

….. projects with others…………………

☐ Contract research

….. projects with① ….. projects with③

….. projects with② ….. projects with④

….. projects with others…………………

☐ Consultancy service

….. projects with① ….. projects with③

….. projects with② ….. projects with④

….. projects with others…………………

☐ Testing

….. projects with① ….. projects with③

….. projects with② ….. projects with④

….. projects with others…………………

☐ R&D equipment sharing

….. projects with① ….. projects with③

….. projects with② ….. projects with④

….. projects with others…………………

☐ Training, seminar and conference

….. projects with① ….. projects with③

….. projects with② ….. projects with④

….. projects with others…………………

☐ R&D personnel exchange

….. projects with① ….. projects with③

….. projects with② ….. projects with④

….. projects with others…………………

☐ Other ……………………………………………………………………………………

+

13. Do you have linkages with government agencies? ☐ No, because……………

☐ Yes, please specify types of linkage and partners

☐ Controlled by laws and regulations

….. projects with① ….. projects with③

….. projects with② ….. projects with④

….. projects with others…………………

☐ Funding for collaborative projects

….. projects with① ….. projects with③

….. projects with② ….. projects with④

….. projects with others…………………

☐ Setting preferential rules and regulation

….. projects with① ….. projects with③

….. projects with② ….. projects with④

….. projects with others…………………

☐ Technology brokerage

….. projects with① ….. projects with③

….. projects with② ….. projects with④

….. projects with others…………………

---

[6] Note: ①, ②, ③ and ④ refer to actor 1, 2, 3 and 4 respectively. Lists of actors were obtained from interviews.

☐ Financial supports for individual firms e.g. loans, grants
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ Training, seminar and conference
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ Other supports
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ Consultancy service
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ Testing and calibrating services
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ R&D equipment sharing
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ Other……………………………………………………………………………………

14. Do you have linkages with other firms? ☐ No, because……………………..

☐ Yes, please specify types of linkage and partners

☐ Trading relationship
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ Developing information sharing platform
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ Testing services
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ Developing new products and process with alliances
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ Participation in trade/industrial associations
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ Provision of consultancy service to solve technical problems
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ R&D equipment sharing
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ Acquistion of consultancy service
….. projects with① ….. projects with③
….. projects with② ….. projects with④
….. projects with others…………………

☐ Other……………………………………………………………………………………

## Part IV Benefits from innovation intermediaries

15. Do you gain any benefit from linking with innovation intermediaries (i.e. ….)

- ☐ Cost reduction
- ☐ Process improvement
- ☐ Product development
- ☐ Human resource development
- ☐ Information and knowledge exchange
- ☐ Increase in trading relationship

## Part V Effectiveness of innovation intermediaries

16. Do you have linkages with these intermediary organisations?

For example,

1. Financial supports i.e. ……
2. Linkage creation i.e. ……
3. Operational services i.e. ……

If yes, how do you evaluate their effectiveness in following aspects?

| Effectiveness | | Extremely poor | Below average | Average | Above average | Excellent |
|---|---|---|---|---|---|---|
| **1** | **Provision of financial supports** | | | | | |
| 1.1 | Management in financial supports | | | | | |
| 1.2 | Technology management | | | | | |
| **2** | **Linkage with other actors** | | | | | |
| 2.1 | Provision of information about and meeting with potential partners | | | | | |
| 2.2 | Provision of facilities for joint projects | | | | | |
| 2.3 | Provision of access to external resources e.g. financial and technical supports | | | | | |
| **3** | **Improvement of absorptive capacity** | | | | | |
| 3.1 | Provision of technical services | | | | | |
| 3.2 | Provision of assistance for utilising outside R&D | | | | | |
| 3.3 | Provision of assistance for in-house R&D | | | | | |
| 3.4 | Facilitation of knowledge circulation in networks | | | | | |

# Appendix 6

# Industry-specific questionnaires in Thai language

อุตสาหกรรมยานยนต์

**แบบสอบถาม**

**ส่วนที่ 1 ข้อมูลทั่วไปของบริษัท**

1. ชื่อบริษัท.......................................................................................................................
2. อายุบริษัท .................…. ปี
3. ยอดขาย ....................................….. บาท
4. กำไร ...........................................…. % ของยอดขาย
5. จำนวนพนักงาน

☐ น้อยกว่า 50 คน ☐ 50-200 คน ☐ มากกว่า 200 คน

6. จำนวนสินทรัพย์ถาวร

☐ น้อยกว่า 50 ล้านบาท ☐ 50-200 ล้านบาท ☐ มากกว่า 200 ล้านบาท

7. สัดส่วนการถือหุ้นโดยคนไทย

☐ ไม่มี ☐ 1-50% ☐ 51-99% ☐ 100%

**ส่วนที่ 2 ทรัพยากรและขีดความสามารถ**

8. จำนวนพนักงานที่ใช้ในการพัฒนาเทคโนโลยี ..........................….. คน
9. ประมาณการเครื่องมืออุปกรณ์ที่ใช้ในการทำวิจัยและพัฒนาคิดเป็นสัดส่วนกับสินทรัพย์ถาวร

☐ ไม่มี ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ มากกว่า 50%

10. จำนวนฐานข้อมูลหรือวารสารเกี่ยวกับการพัฒนาเทคโนโลยีและนวัตกรรมที่ติดตามและรับเป็นแหล่งข้อมูล.............แหล่ง
11. งบประมาณสำหรับการพัฒนาเทคโนโลยีและนวัตกรรมคิดเป็นสัดส่วนของยอดขาย

☐ ไม่มี ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ มากกว่า 50%

12. บริษัทท่านมีขีดความสามารถทางเทคโนโลยีอยู่ในระดับใด

☐ รับเทคโนโลยีจากภายนอกมาใช้ เช่น การควบคุมคุณภาพ การซ่อมบำรุง การปรับสินค้าให้ตรงการกับความต้องการของตลาดท้องถิ่น

☐ สามารถแก้ปัญหาเกี่ยวกับเทคโนโลยีได้เอง เช่น การปรับปรุงกระบวนการเพื่อลดต้นทุน การปรับปรุงผลิตภัณฑ์ การปรับเปลี่ยนเทคโนโลยีที่นำเข้า

☐ การพัฒนาผลิตภัณฑ์และกระบวนการใหม่

**ส่วนที่ 3 ความเชื่อมโยงภาครัฐ มหาวิทยาลัย และอุตสาหกรรม**

13. บริษัทท่านมีความเชื่อมโยงกับมหาวิทยาลัยหรือไม่

☐ ไม่มี เพราะ ..........................................................................................................................

☐ มี โปรดระบุลักษณะและจำนวนความเชื่อมโยง

| | |
|---|---|
| ☐ การร่วมวิจัย | ☐ การใช้สิทธิ์ทรัพย์สินทางปัญญา |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การจ้างวิจัย | ☐ การบริการที่ปรึกษา |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การวิเคราะห์ทดสอบ | ☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การประชุม สัมมนา อบรม | ☐ การแลกเปลี่ยนบุคลากร |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |

☐ อื่นๆ ..........................................................................................................................

14. บริษัทท่านมีความเชื่อมโยงกับหน่วยงานภาครัฐหรือไม่

☐ ไม่มี เพราะ ..........................................................................................................................

☐ มี โปรดระบุลักษณะและจำนวนความเชื่อมโยง

| | |
|---|---|
| ☐ ถูกควบคุมโดยกฎหมาย ระเบียบข้อบังคับ | ☐ การให้ทุนโครงการความร่วมมือ |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ MTEC |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ ช่วยภาครัฐจัดทำกฎระเบียบที่เอื้อประโยชน์ | ☐ การเชื่อมโยงกับหน่วยงานอื่น |
| ….. โครงการ กับ BOI | ….. โครงการ กับ สถาบันยานยนต์ |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การสนับสนุนทางการเงินรายบริษัท | ☐ การประชุม สัมมนา อบรม |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ สถาบันยานยนต์ |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |

☐ การวิเคราะห์ สอบเทียบ
….. โครงการ กับ สถาบันยานยนต์
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ การบริการที่ปรึกษา
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ อื่นๆ ……………………………...............................……………………………………………………………

15. บริษัทท่านมีความเชื่อมโยงกับบริษัทอื่นหรือไม่

☐ ไม่มี เพราะ .........................................................................................................………........

☐ มี โปรดระบุลักษณะและจำนวนความเชื่อมโยง

☐ ความสัมพันธ์ด้านการค้า
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ การพัฒนาระบบการแลกเปลี่ยนข้อมูล
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ การวิเคราะห์ทดสอบ
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ การพัฒนาผลิตภัณฑ์ และ/หรือกระบวนการในลักษณะเครือข่ายพันธมิตร
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ การเข้าร่วมสมาคมการค้า/อุตสาหกรรม
….. โครงการ กับ TAPMA
….. โครงการ กับ TAIA
….. โครงการ กับ.........................................................

☐ การรับบริการที่ปรึกษาเพื่อแก้ปัญหาทางเทคนิค
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ กาให้บริการที่ปรึกษา
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ อื่นๆ ……………..............................……………………………………………………………

**ส่วนที่ 4 ประโยชน์ที่ได้รับจากตัวกลางทางนวัตกรรม**

16. ท่านมีการพัฒนาทางด้านใดบ้างจากการเชื่อมโยงกับตัวกลางทางนวัตกรรม (สถาบันยานยนต์)

- ☐ การลดต้นทุน
- ☐ การพัฒนากระบวนการผลิต
- ☐ การพัฒนาผลิตภัณฑ์
- ☐ การพัฒนาขีดความสามารถของบุคลากร
- ☐ การแลกเปลี่ยนข้อมูล ข่าวสาร ความรู้
- ☐ การเพิ่มขึ้นของปริมาณการค้า

**ส่วนที่ 5 ประสิทธิภาพของหน่วยงานที่เป็นตัวกลางทางนวัตกรรม**

17. บริษัทท่านมีความเชื่อมโยงกับหน่วนงานที่เป็นตัวกลางทางนวัตกรรมเหล่านี้หรือไม่

ได้แก่ 1. การสนับสนุนทางการเงิน – MTEC

2. การเชื่อมโยงหน่วยงานต่างๆ – สถาบันยานยนต์

3. การพัฒนาขีดความสามารถ – สถาบันยานยนต์ มหาวิทยาลัยต่างๆ

ถ้ามี ท่านจะประเมินประสิทธิภาพของหน่วยงานเหล่านี้ในด้านต่างๆ เหล่านี้อย่างไร กรุณาใส่เครื่องหมาย ✓ ในช่องที่ท่านเห็นว่าเหมาะสม

| Effectiveness | | **แย่มาก** | **แย่** | **ปานกลาง** | **ดี** | **ดีมาก** |
|---|---|---|---|---|---|---|
| 1. **การสนับสนุนทางการเงิน** (โดย MTEC) | | | | | | |
| 1.1 | บริหารจัดการการสนับสนุนทางการเงิน | | | | | |
| 1.2 | การบริหารจัดการเทคโนโลยี เช่น ทรัพย์สินทางปัญญา | | | | | |
| 2. **การเชื่อมโยงหน่วยงานต่าง ๆ** (โดย สถาบันยานยนต์) | | | | | | |
| 2.1 | การให้ข้อมูลเกี่ยวกับการประชุมความร่วมมือ และผู้ร่วมมือที่มีศักยภาพ | | | | | |
| 2.2 | การจัดหาสิ่งอำนวยความสะดวกของโครงการความร่วมมือ | | | | | |
| 2.3 | การช่วยเหลือในการเข้าถึงแหล่งทรัพยากรจากภายนอก เช่น การสนับสนุนทางการเงิน และด้านเทคนิค | | | | | |
| 3. **การพัฒนาขีดความสามารถของอุตสาหกรรม** (โดย สถาบันยานยนต์ และมหาวิทยาลัยต่างๆ) | | | | | | |
| 3.1 | การให้บริการทางด้านเทคนิค เช่น วิเคราะห์ ทดสอบ สอบเทียบ ที่ปรึกษา | | | | | |
| 3.2 | การช่วยเหลือในการใช้ประโยชน์จากงานวิจัยภายนอก | | | | | |
| 3.3 | การช่วยเหลือในการทำวิจัยในบริษัท | | | | | |
| 3.4 | การอำนวยความสะดวกให้การไหลเวียนข้อมูล ข่าวสาร ความรู้ | | | | | |

อุตสาหกรรม Hard Disk Drive

**แบบสอบถาม**

**ส่วนที่ 1 ข้อมูลทั่วไปของบริษัท**

1. ชื่อบริษัท

   ..........................................................................................................................

2. อายุบริษัท ..................… ปี
3. ยอดขาย (ปี 2553)........................................….. บาท
4. กำไร (ปี 2553)..............................................…. % ของยอดขาย
5. จำนวนพนักงาน

   ☐ น้อยกว่า 50 คน ☐ 50-200 คน ☐ มากกว่า 200 คน

6. จำนวนสินทรัพย์ถาวร

   ☐ น้อยกว่า 50 ล้านบาท ☐ 50-200 ล้านบาท ☐ มากกว่า 200 ล้านบาท

7. บริษัทอยู่ในระดับใดใน Supply Chain

   ☐ HDD maker ☐ บริษัทใน tier-1 ☐ บริษัทใน tier-2

**ส่วนที่ 2 ทรัพยากรและขีดความสามารถ**

8. จำนวนพนักงานที่ใช้ในการพัฒนาเทคโนโลยี ............................….. คน
9. ประมาณการเครื่องมืออุปกรณ์ที่ใช้ในการทำวิจัยและพัฒนาคิดเป็นสัดส่วนกับสินทรัพย์ถาวร

   ☐ ไม่มี ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ มากกว่า 50%

10. จำนวนฐานข้อมูลหรือวารสารเกี่ยวกับการพัฒนาเทคโนโลยีและนวัตกรรมที่ติดตามและรับเป็นแหล่งข้อมูล.............แหล่ง
11. งบประมาณสำหรับการพัฒนาเทคโนโลยีและนวัตกรรมคิดเป็นสัดส่วนของยอดขาย

    ☐ ไม่มี ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ มากกว่า 50%

12. บริษัทท่านมีขีดความสามารถทางเทคโนโลยีอยู่ในระดับใด

    ☐ รับเทคโนโลยีจากภายนอกมาใช้ เช่น การควบคุมคุณภาพ การซ่อมบำรุง การปรับสินค้าให้ตรงการกับความต้องการของตลาดท้องถิ่น

    ☐ สามารถแก้ปัญหาเกี่ยวกับเทคโนโลยีได้เอง เช่น การปรับปรุงกระบวนการเพื่อลดต้นทุน การปรับปรุงผลิตภัณฑ์ การปรับเปลี่ยนเทคโนโลยีที่นำเข้า

    ☐ การพัฒนาผลิตภัณฑ์และกระบวนการใหม่ด้วยตัวเอง (จาก R&D)

**ส่วนที่ 3 ความเชื่อมโยงภาครัฐ มหาวิทยาลัย และอุตสาหกรรม**

13. บริษัทท่านมีความเชื่อมโยงกับมหาวิทยาลัยหรือไม่

☐ ไม่มี เพราะ ..........................................................................................................................

☐ มี โปรดระบุลักษณะ และจำนวนครั้งของความเชื่อมโยง

| | |
|---|---|
| ☐ การร่วมวิจัย | ☐ การใช้สิทธิ์ทรัพย์สินทางปัญญา |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ☐ การจ้างวิจัย | ☐ การบริการที่ปรึกษา |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ☐ การวิเคราะห์ทดสอบ | ☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ☐ การประชุม สัมมนา อบรม | ☐ การแลกเปลี่ยนบุคลากร |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |

☐ อื่นๆ ..........................................................................................................................

14. บริษัทท่านมีความเชื่อมโยงกับหน่วยงานภาครัฐหรือไม่

☐ ไม่มี เพราะ ..........................................................................................................................

☐ มี โปรดระบุลักษณะและจำนวนครั้งของความเชื่อมโยง

| | |
|---|---|
| ☐ ถูกควบคุมโดยกฎหมาย ระเบียบข้อบังคับ | ☐ การให้ทุนโครงการความร่วมมือ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ HDDI ภายใต้ NECTEC |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ☐ ช่วยภาครัฐจัดทำกฎระเบียบที่เอื้อประโยชน์ | ☐ การเชื่อมโยงกับหน่วยงานอื่น |
| ….. โครงการ กับ BOI | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ☐ การสนับสนุนทางการเงินรายบริษัท | ☐ การประชุม สัมมนา อบรม |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |
| ….. โครงการ กับ........................................................ | ….. โครงการ กับ........................................................ |

☐ การวิเคราะห์ สอบเทียบ

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

☐ การบริการที่ปรึกษา

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

☐ การขอยกเว้นภาษี

….. โครงการ กับ BOI

….. โครงการ กับ กรมสรรพากร

….. โครงการ กับ สวทช.

☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

☐ อื่นๆ ……………………………..............................…………………………………………………………

15. บริษัทท่านมีความเชื่อมโยงกับบริษัทอื่นหรือไม่

☐ ไม่มี เพราะ ..............................................................................................…………......

☐ มี โปรดระบุลักษณะและจำนวนครั้งของความเชื่อมโยง

☐ ความสัมพันธ์ด้านการค้า

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

☐ การพัฒนาระบบการแลกเปลี่ยนข้อมูล

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

☐ การวิเคราะห์ทดสอบ

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

☐ การพัฒนาผลิตภัณฑ์ และ/หรือกระบวนการในลักษณะเครือข่ายพันธมิตร

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

☐ การเข้าร่วมสมาคมการค้า/อุตสาหกรรม

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

☐ การบริการที่ปรึกษาเพื่อแก้ปัญหาทางเทคนิค

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

☐ การบริการที่ปรึกษา

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

….. โครงการ กับ.........................................................

☐ อื่นๆ ……………...............................……………………………………………………………

**ส่วนที่ 4 ประโยชน์ที่ได้รับจากตัวกลางทางนวัตกรรม**

16. ท่านมีการพัฒนาทางด้านใดบ้างจากการเชื่อมโยงกับตัวกลางทางนวัตกรรม (HDDI และ 3 I/UCRCs ในมหาวิทยาลัย ได้แก่ มจธ. ลาดกระบังฯ และขอนแก่น)

- ☐ การลดต้นทุน
- ☐ การพัฒนากระบวนการผลิต
- ☐ การพัฒนาผลิตภัณฑ์
- ☐ การพัฒนาขีดความสามารถของบุคลากร
- ☐ การแลกเปลี่ยนข้อมูล ข่าวสาร ความรู้
- ☐ การเพิ่มความสัมพันธ์ทางการค้า

**ส่วนที่ 5 ประสิทธิภาพของหน่วยงานที่เป็นตัวกลางทางนวัตกรรม**

17. บริษัทท่านมีความเชื่อมโยงกับหน่วนงานที่เป็นตัวกลางทางนวัตกรรมเหล่านี้หรือไม่

ได้แก่ 1. การสนับสนุนทางการเงิน – HDDI

2. การเชื่อมโยงหน่วยงานต่างๆ – HDDI และ 3 I/UCRCs ภายใต้ มจธ. สจล. และ ม.ขอนแก่น

3. การพัฒนาขีดความสามารถ – หน่วยวิจัยใน 3 มหาวิทยาลัยหลัก และมหาวิทยาลัยเครือข่าย และหน่วยงานภาครัฐที่ให้บริการอุตสาหกรรม

ถ้ามี ท่านจะประเมินประสิทธิภาพของหน่วยงานเหล่านี้ในด้านต่างๆ เหล่านี้อย่างไร

กรุณาใส่เครื่องหมาย ✓ ในช่องที่ท่านเห็นว่าเหมาะสม

| Effectiveness | | แย่มาก | แย่ | ปานกลาง | ดี | ดีมาก |
|---|---|---|---|---|---|---|
| 1. | **การสนับสนุนทางการเงิน** (โดย HDDI) | | | | | |
| 1.1 | บริหารจัดการการสนับสนุนทางการเงิน | | | | | |
| 1.2 | การบริหารจัดการเทคโนโลยี เช่น การเจรจา หรือการจัดทำหลักเกณฑ์เกี่ยวกับทรัพย์สินทางปัญญา | | | | | |
| 2. | **การเชื่อมโยงหน่วยงานต่าง ๆ** (โดย HDDI และ 3 I/UCRCs ภายใต้ มจธ. ลาดกระบังฯ และ ม.ขอนแก่น) | | | | | |
| 2.1 | การให้ข้อมูลเกี่ยวกับการประชุมความร่วมมือ และผู้ร่วมมือที่มีศักยภาพ | | | | | |
| 2.2 | การจัดหาสิ่งอำนวยความสะดวกของโครงการความร่วมมือ เช่น การเขียนโครงการ การติดตามความก้าวหน้าของโครงการ | | | | | |
| 2.3 | การช่วยเหลือในการเข้าถึงแหล่งทรัพยากรจากภายนอก เช่น การสนับสนุนทางการเงิน และด้านเทคนิคจากหน่วยงานอื่นๆ | | | | | |
| 3. | **การพัฒนาขีดความสามารถของอุตสาหกรรม** (โดย หน่วยวิจัยใน 3 มหาวิทยาลัยหลัก และมหาวิทยาลัยเครือข่าย และหน่วยงานภาครัฐที่เกี่ยวข้องในการให้บริการอุตสาหกรรม เช่น TMEC, NECTEC, MTEC, NANOTEC เป็นต้น) | | | | | |
| 3.1 | การให้บริการทางด้านเทคนิค เช่น วิเคราะห์ ทดสอบ สอบเทียบ ที่ปรึกษา | | | | | |
| 3.2 | การช่วยเหลือในการใช้ประโยชน์จากงานวิจัยภายนอก | | | | | |
| 3.3 | การช่วยเหลือในการทำวิจัยในบริษัท | | | | | |
| 3.4 | การอำนวยความสะดวกให้การไหลเวียนข้อมูล ข่าวสาร ความรู้ | | | | | |

อุตสาหกรรมเซรามิก

**แบบสอบถาม**

**ส่วนที่ 1 ข้อมูลทั่วไปของบริษัท**

1. ชื่อบริษัท......................................................................................................................
2. อายุบริษัท ..................… ปี
3. ยอดขาย (ปี 2553) ......................................….. บาท
4. กำไร (ปี 2553) ..............................................…. % ของยอดขาย
5. จำนวนพนักงาน

☐ น้อยกว่า 50 คน ☐ 50-200 คน ☐ มากกว่า 200 คน

6. จำนวนสินทรัพย์ถาวร

☐ น้อยกว่า 50 ล้านบาท ☐ 50-200 ล้านบาท ☐ มากกว่า 200 ล้านบาท

**ส่วนที่ 2 ทรัพยากรและขีดความสามารถ**

7. จำนวนพนักงานที่ใช้ในการพัฒนาเทคโนโลยี ............................….. คน
8. ประมาณการเครื่องมืออุปกรณ์ที่ใช้ในการทำวิจัยและพัฒนาคิดเป็นสัดส่วนกับสินทรัพย์ถาวร

☐ ไม่มี ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ มากกว่า 50%

9. จำนวนฐานข้อมูลหรือวารสารเกี่ยวกับการพัฒนาเทคโนโลยีและนวัตกรรมที่ติดตามและรับเป็นแหล่งข้อมูล.............แหล่ง
10. งบประมาณสำหรับการพัฒนาเทคโนโลยีและนวัตกรรมคิดเป็นสัดส่วนของยอดขาย

☐ ไม่มี ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ มากกว่า 50%

11. บริษัทท่านมีขีดความสามารถทางเทคโนโลยีอยู่ในระดับใด

☐ รับเทคโนโลยีจากภายนอกมาใช้ เช่น การควบคุมคุณภาพ การซ่อมบำรุง การปรับสินค้าให้ตรงการกับความต้องการของตลาดท้องถิ่น

☐ สามารถแก้ปัญหาเกี่ยวกับเทคโนโลยีได้เอง เช่น การปรับปรุงกระบวนการเพื่อลดต้นทุน การปรับปรุงผลิตภัณฑ์ การปรับเปลี่ยนเทคโนโลยีที่นำเข้า

☐ การพัฒนาผลิตภัณฑ์และกระบวนการใหม่

**ส่วนที่ 3 ความเชื่อมโยงภาครัฐ มหาวิทยาลัย และอุตสาหกรรม**

12. บริษัทท่านมีความเชื่อมโยงกับมหาวิทยาลัยหรือไม่

☐ ไม่มี เพราะ ......................................................................................................................

☐ มี โปรดระบุลักษณะและจำนวนความเชื่อมโยง

| | |
|---|---|
| ☐ การร่วมวิจัย | ☐ การใช้สิทธิ์ทรัพย์สินทางปัญญา |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การจ้างวิจัย | ☐ การบริการที่ปรึกษา |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ จุฬาลงกรณ์มหาวิทยาลัย |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การวิเคราะห์ทดสอบ | ☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การประชุม สัมมนา อบรม | ☐ การแลกเปลี่ยนบุคลากร |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |

☐ อื่นๆ ……….................................………………………………………………………………

13. บริษัทท่านมีความเชื่อมโยงกับหน่วยงานภาครัฐหรือไม่

☐ ไม่มี เพราะ ......................................................................................................................

☐ มี โปรดระบุลักษณะและจำนวนความเชื่อมโยง

| | |
|---|---|
| ☐ ถูกควบคุมโดยกฎหมาย ระเบียบข้อบังคับ | ☐ การให้ทุนโครงการความร่วมมือ (ร่วมมือกับมหาวทิยาลัย หรือหน่วยงานอื่น) |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ ศูนย์ศิลปาชีพระหว่างประเทศ |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ สำนักงานนวัตกรรมแห่งชาติ (NIA) |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ ช่วยภาครัฐจัดทำกฎระเบียบที่เอื้อประโยชน์ | ☐ การเชื่อมโยงกับหน่วยงานอื่น (เป็นตัวกลางเชื่อมโยง) |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ ศูนย์พัฒนาอุตสาหกรรมเซรามิก |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การสนับสนุนทางการเงินรายบริษัท | ☐ การประชุม สัมมนา อบรม |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ ศูนย์พัฒนาอุตสาหกรรมเซรามิก |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

☐ การสนับสนุนเงินในการออกงานแสดงสินค้า ☐ การบริการที่ปรึกษา

….. โครงการ กับ......................................................... ….. โครงการ กับ ศูนย์เทคโนโลยีโลหะและวัสดุแห่งชาติ (MTEC)

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

☐ การวิเคราะห์ สอบเทียบ ☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย

….. โครงการ กับ......................................................... ….. โครงการ กับ ศูนย์พัฒนาอุตสาหกรรมเซรามิก

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

☐ อื่นๆ ……………………………..........................……………………………………………………………

14. บริษัทท่านมีความเชื่อมโยงกับบริษัทอื่นหรือไม่

☐ ไม่มี เพราะ ........................................................................................................…………......

☐ มี โปรดระบุลักษณะและจำนวนความเชื่อมโยง

☐ ความสัมพันธ์ด้านการค้า ☐ การพัฒนาระบบการแลกเปลี่ยนข้อมูล

….. โครงการ (บริษัท) กับ บริษัทสมาชิก Ceracluster ….. โครงการ (ครั้ง) กับ บริษัทสมาชิก Ceracluster

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

☐ การวิเคราะห์ทดสอบ ☐ การพัฒนาผลิตภัณฑ์ และ/หรือกระบวนการในลักษณะเครือข่ายพันธมิตร

….. โครงการ กับ......................................................... ….. โครงการ (ชิ้นผลิตภัณฑ์) กับ บริษัทสมาชิก Ceracluster

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

☐ การเข้าร่วมสมาคมการค้า/อุตสาหกรรม ☐ การบริการที่ปรึกษาเพื่อแก้ปัญหาทางเทคนิค

….. โครงการ กับ สมาคมเครื่องปั้นดินเผาลำปาง ….. โครงการ กับ.........................................................

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย ☐ การบริการที่ปรึกษา

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

….. โครงการ กับ......................................................... ….. โครงการ กับ.........................................................

☐ อื่นๆ ……………...............................……………………………………………………………

## ส่วนที่ 4 ประโยชน์ที่ได้รับจากตัวกลางทางนวัตกรรม

15. ท่านมีการพัฒนาทางด้านใดบ้างจากการเชื่อมโยงกับตัวกลางทางนวัตกรรม (Ceracluster และศูนย์พัฒนาอุตสาหกรรมเซรามิก)

- ☐ การลดต้นทุน
- ☐ การพัฒนากระบวนการผลิต
- ☐ การพัฒนาผลิตภัณฑ์
- ☐ การพัฒนาขีดความสามารถของบุคลากร
- ☐ การแลกเปลี่ยนข้อมูล ข่าวสาร ความรู้
- ☐ ความเชื่อมโยงทางการค้าเพิ่มขึ้น

## ส่วนที่ 5 ประสิทธิภาพของหน่วยงานที่เป็นตัวกลางทางนวัตกรรม

16. บริษัทท่านมีความเชื่อมโยงกับหน่วนงานที่เป็นตัวกลางทางนวัตกรรมเหล่านี้หรือไม่

ได้แก่ 1. การสนับสนุนทางการเงิน – ศูนย์พัฒนาอุตสากรรมเซรามิก ศูนย์ศิลปาชีพระหว่างประเทศ

2. การเชื่อมโยงหน่วยงานต่างๆ – ศูนย์พัฒนาอุตสากรรมเซรามิก

3. การพัฒนาขีดความสามารถ – จุฬาลงกรณ์มหาวิทยาลัย MTEC

ถ้ามี ท่านจะประเมินประสิทธิภาพของหน่วยงานเหล่านี้ในด้านต่างๆ เหล่านี้อย่างไร

กรุณาใส่เครื่องหมาย ✓ ในช่องที่ท่านเห็นว่าเหมาะสม

| Effectiveness | | แย่มาก | แย่ | ปานกลาง | ดี | ดีมาก |
|---|---|---|---|---|---|---|
| 1. | **การสนับสนุนทางการเงิน** | | | | | |
| 1.1 | บริหารจัดการการสนับสนุนทางการเงิน (รวดเร็ว เพียงพอ) | | | | | |
| 1.2 | การบริหารจัดการเทคโนโลยี เช่น ทรัพย์สินทางปัญญาที่เกิดจากการร่วมวิจัย (หากมี) | | | | | |
| 2. | **การเชื่อมโยงหน่วยงานต่าง ๆ** | | | | | |
| 2.1 | การให้ข้อมูลเกี่ยวกับการประชุมความร่วมมือ และผู้ร่วมมือที่มีศักยภาพ (ให้ข้อมูลว่าควรเชื่อมโยงกับใคร) | | | | | |
| 2.2 | การจัดหาสิ่งอำนวยความสะดวกของโครงการความร่วมมือ (เช่น นัดพบปะ แนะนำการเขียนข้อเสนอโครงการ) | | | | | |
| 2.3 | การช่วยเหลือในการเข้าถึงแหล่งทรัพยากรจากภายนอก เช่น การสนับสนุนทางการเงิน และด้านเทคนิค (ให้ข้อมูลหน่วยงานสนับสนุนอื่นๆ) | | | | | |
| 3. | **การพัฒนาขีดความสามารถของอุตสาหกรรม** | | | | | |
| 3.1 | การให้บริการทางด้านเทคนิค เช่น วิเคราะห์ ทดสอบ สอบเทียบ ที่ปรึกษา | | | | | |
| 3.2 | การช่วยเหลือในการใช้ประโยชน์จากงานวิจัยภายนอก (ได้รับประโยชน์จากงานวิจัยเพียงใด) | | | | | |
| 3.3 | การช่วยเหลือในการทำวิจัยในบริษัท | | | | | |
| 3.4 | การอำนวยความสะดวกให้การไหลเวียนข้อมูล ข่าวสาร ความรู้ | | | | | |

**แบบสอบถาม**

อุตสาหกรรมเฟอร์นิเจอร์

**ส่วนที่ 1 ข้อมูลทั่วไปของบริษัท**

1. ชื่อบริษัท.......................................................................................................
2. อายุบริษัท ...................… ปี
3. ยอดขาย (ปี 2553) ......................................….. บาท
4. กำไร (ปี 2553)...........................................…. % ของยอดขาย
5. จำนวนพนักงาน

☐ น้อยกว่า 50 คน ☐ 50-200 คน ☐ มากกว่า 200 คน

6. จำนวนสินทรัพย์ถาวร

☐ น้อยกว่า 50 ล้านบาท ☐ 50-200 ล้านบาท ☐ มากกว่า 200 ล้านบาท

**ส่วนที่ 2 ทรัพยากรและขีดความสามารถ**

7. จำนวนพนักงานที่ใช้ในการพัฒนาเทคโนโลยี เช่น ปรับปรุงกระบวนการ/ผลิตภัณฑ์ วิจัยและพัฒนา เป็นต้น.........................….. คน
8. ประมาณการเครื่องมืออุปกรณ์ที่ใช้ในการทำวิจัยและพัฒนาคิดเป็นสัดส่วนกับสินทรัพย์ถาวร

☐ ไม่มี ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ มากกว่า 50%

9. จำนวนฐานข้อมูลหรือวารสารเกี่ยวกับการพัฒนาเทคโนโลยีและนวัตกรรมที่ติดตามและรับเป็นแหล่งข้อมูล.............แหล่ง
10. งบประมาณสำหรับการพัฒนาเทคโนโลยีและนวัตกรรมคิดเป็นสัดส่วนของยอดขาย

☐ ไม่มี ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ มากกว่า 50%

11. บริษัทท่านมีขีดความสามารถทางเทคโนโลยีอยู่ในระดับใด

☐ รับเทคโนโลยีจากภายนอกมาใช้ เช่น การควบคุมคุณภาพ การซ่อมบำรุง การปรับสินค้าให้ตรงการกับความต้องการของตลาดท้องถิ่น

☐ สามารถแก้ปัญหาเกี่ยวกับเทคโนโลยีได้เอง เช่น การปรับปรุงกระบวนการเพื่อลดต้นทุน การปรับปรุงผลิตภัณฑ์ การปรับเปลี่ยนเทคโนโลยีที่นำเข้า

☐ การพัฒนาผลิตภัณฑ์และกระบวนการใหม่

**ส่วนที่ 3 ความเชื่อมโยงภาครัฐ มหาวิทยาลัย และอุตสาหกรรม**

12. บริษัทท่านมีความเชื่อมโยงกับ**มหาวิทยาลัย**หรือไม่

☐ ไม่มี เพราะ ..........................................................................................................

☐ มี โปรดระบุจำนวนโครงการ/จำนวนครั้งของความเชื่อมโยง และชื่อมหาวิทยาลัยที่มีความเชื่อมโยง

| | |
|---|---|
| ☐ การร่วมวิจัย | ☐ การใช้สิทธิ์ทรัพย์สินทางปัญญา |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ☐ การจ้างวิจัย | ☐ การใช้บริการที่ปรึกษา |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ☐ การวิเคราะห์ทดสอบ | ☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ☐ การประชุม สัมมนา อบรม | ☐ การแลกเปลี่ยนบุคลากร |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |

☐ อื่นๆ ..........................................................................................................

13. บริษัทท่านมีความเชื่อมโยงกับ**หน่วยงานภาครัฐ**หรือไม่

☐ ไม่มี เพราะ ..........................................................................................................

☐ มี โปรดระบุจำนวนโครงการ/จำนวนครั้งของความเชื่อมโยง และชื่อหน่วยงานภาครัฐที่มีความเชื่อมโยง

| | |
|---|---|
| ☐ ถูกควบคุมโดยกฎหมาย ระเบียบข้อบังคับ | ☐ การให้ทุนโครงการที่ร่วมมือกับมหาวิทยาลัย |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ ITAP |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ☐ ช่วยภาครัฐจัดทำกฎระเบียบที่เอื้อประโยชน์ | ☐ การติดต่อเพื่อเชื่อมโยงกับหน่วยงานอื่นต่อไป |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ สมาคมอุตสาหกรรมเครื่องเรือนไทย |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ สภาอุตสาหกรรมแห่งประเทศไทย |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |
| ☐ การสนับสนุนทางการเงินรายบริษัท | ☐ การประชุม สัมมนา อบรม |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ ITAP |
| ..... โครงการ กับ.......................................... | ..... โครงการ กับ.......................................... |

| | |
|---|---|
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| ☐ การวิเคราะห์ สอบเทียบ/การรับรองคุณภาพ | ☐ การใช้บริการที่ปรึกษา |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| | ☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย |
| | ….. โครงการ กับ………………………………………… |
| | ….. โครงการ กับ………………………………………… |
| | ….. โครงการ กับ………………………………………… |

☐ อื่นๆ ……………………………………………………………………………………………

14. บริษัทท่านมีความเชื่อมโยงกับบริษัทอื่นหรือไม่

☐ ไม่มี เพราะ ……………………………………………………………………………………

☐ มี โปรดระบุจำนวนโครงการ/จำนวนครั้งของความเชื่อมโยง และชื่อบริษัทที่มีความเชื่อมโยง

| | |
|---|---|
| ☐ ความสัมพันธ์ด้านการค้า | ☐ การพัฒนาระบบการแลกเปลี่ยนข้อมูล |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| ☐ การวิเคราะห์ทดสอบ/การรับรองคุณภาพ | ☐ การพัฒนาผลิตภัณฑ์ และ/หรือกระบวนการในลักษณะเครือข่ายพันธมิตร |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| ☐ การเข้าร่วมสมาคมการค้า/อุตสาหกรรม | ☐ การรับบริการที่ปรึกษาเพื่อแก้ปัญหาทางเทคนิค |
| ….. โครงการ กับ สมาคมอุตสาหกรรมเครื่องเรือนไทย | ….. โครงการ กับ………………………………………… |
| ….. โครงการ กับ กลุ่มเฟอร์นิเจอร์ สภาอุตสาหกรรมฯ | ….. โครงการ กับ………………………………………… |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| ☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย | ☐ การให้บริการที่ปรึกษาแก่บริษัทอื่น |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |
| ….. โครงการ กับ………………………………………… | ….. โครงการ กับ………………………………………… |

☐ อื่นๆ ……………………………………………………………………………………

**ส่วนที่ 4 ประโยชน์ที่ได้รับจากตัวกลางทางนวัตกรรม**

15. ท่านมีการพัฒนาทางด้านใดบ้างจากการเชื่อมโยงกับตัวกลางทางนวัตกรรม (เช่น TFA, ITAP)

- ☐ การลดต้นทุน
- ☐ การพัฒนากระบวนการผลิต
- ☐ การพัฒนาผลิตภัณฑ์
- ☐ การพัฒนาขีดความสามารถของบุคลากร
- ☐ การแลกเปลี่ยนข้อมูล ข่าวสาร ความรู้
- ☐ การเพิ่มขึ้นของปริมาณการค้า

**ส่วนที่ 5 ประสิทธิภาพของหน่วยงานที่เป็นตัวกลางทางนวัตกรรม**

16. บริษัทท่านมีความเชื่อมโยงกับหน่วนงานที่เป็นตัวกลางทางนวัตกรรมเหล่านี้หรือไม่

ได้แก่ 1. การสนับสนุนทางการเงิน – ITAP และหน่วยงานให้ทุนอื่นๆ

2. การเชื่อมโยงหน่วยงานต่างๆ – สมาคมอุตสาหกรรมเครื่องเรือนไทย, สภาอุตสาหกรรมแห่งประเทศไทย, ITAP

3. การพัฒนาขีดความสามารถ – มหาวิทยาลัยต่างๆ และผู้เชี่ยวชาญภาคเอกชน

ถ้ามี ท่านจะประเมินประสิทธิภาพของหน่วยงานเหล่านี้ในด้านต่างๆ เหล่านี้อย่างไร กรุณาใส่เครื่องหมาย ✓ ในช่องที่ท่านเห็นว่าเหมาะสม

| Effectiveness | | แย่มาก | แย่ | ปานกลาง | ดี | ดีมาก |
|---|---|---|---|---|---|---|
| 1. | **การสนับสนุนทางการเงิน** (โดย ITAP หรือหน่วยงานอื่นๆที่ให้ทุน ) | | | | | |
| 1.1 | บริหารจัดการการสนับสนุนทางการเงิน | | | | | |
| 1.2 | การบริหารจัดการเทคโนโลยี เช่น ทรัพย์สินทางปัญญา | | | | | |
| 2. | **การเชื่อมโยงหน่วยงานต่าง ๆ** (โดย สมาคมอุตสาหกรรมเครื่องเรือนไทย, สภาอุตสาหกรรมฯ, ITAP) | | | | | |
| 2.1 | การให้ข้อมูลเกี่ยวกับการประชุมความร่วมมือ และผู้ร่วมมือที่มีศักยภาพ | | | | | |
| 2.2 | การจัดหาสิ่งอำนวยความสะดวกของโครงการความร่วมมือ | | | | | |
| 2.3 | การช่วยเหลือในการเข้าถึงแหล่งทรัพยากรจากภายนอก เช่น การสนับสนุนทางการเงิน และด้านเทคนิค | | | | | |
| 3. | **การพัฒนาขีดความสามารถของอุตสาหกรรม** (โดย มหาวิทยาลัยต่างๆ, ผู้เชี่ยวชาญภาคเอกชน) | | | | | |
| 3.1 | การให้บริการทางด้านเทคนิค เช่น วิเคราะห์ ทดสอบ สอบเทียบ ที่ปรึกษา | | | | | |
| 3.2 | การช่วยเหลือในการใช้ประโยชน์จากงานวิจัยภายนอก | | | | | |
| 3.3 | การช่วยเหลือในการทำวิจัยในบริษัท | | | | | |
| 3.4 | การอำนวยความสะดวกให้การไหลเวียนข้อมูล ข่าวสาร ความรู้ | | | | | |

**แบบสอบถาม**

อุตสาหกรรมสิ่งทอพื้นบ้าน

**ส่วนที่ 1 ข้อมูลทั่วไปของบริษัท**

1. ชื่อบริษัท (ชื่อผู้ประกอบการ, กลุ่มวิสาหกิจชุมชน)...............................................................
2. กิจกรรมการผลิต (ตอบได้มากกว่า 1 ข้อ)

☐ ปลูกฝ้าย/เลี้ยงไหม ☐ ผลิตเส้นใย,ย้อมสี ☐ ทอผ้า

3. อายุบริษัท (กลุ่ม) ...................… ปี
4. ยอดขายของกลุ่ม (ปี 2553) ......................................…. บาท
5. กำไร (ปี 2553) ........................................… % ของยอดขาย หรือ ...............................บาท
6. จำนวนพนักงาน (สมาชิกในกลุ่ม)

☐ น้อยกว่า 50 คน ☐ 50-200 คน ☐ มากกว่า 200 คน

7. จำนวนสินทรัพย์ถาวร (รวมถึงที่ดิน อุปกรณ์ในการผลิตเส้นใย การย้อมสี และการทอผ้า)

☐ น้อยกว่า 50 ล้านบาท ☐ 50-200 ล้านบาท ☐ มากกว่า 200 ล้านบาท

**ส่วนที่ 2 ทรัพยากรและขีดความสามารถ**

8. จำนวนพนักงานที่ใช้ในการพัฒนาเทคโนโลยี (เช่น การปรับปรุงกระบวนการย้อมสีและอุปกรณ์การย้อมสี การปรับกระบวนการปลูกฝ้าย การบำบัดน้ำเสีย เป็นต้น) ...........................….. คน
9. ประมาณการเครื่องมืออุปกรณ์ที่ใช้ในการพัฒนาเทคโนโลยี (เช่น อุปกรณ์ที่ใช้ในการบำบัดน้ำเสีย อุปกรณ์ในการย้อมสีที่ลดการใช้พลังงาน เป็นต้น) คิดเป็นสัดส่วนกับ<u>สินทรัพย์ถาวร</u>

☐ ไม่มี ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ มากกว่า 50%

10. จำนวนฐานข้อมูลหรือวารสารเกี่ยวกับการพัฒนาเทคโนโลยีและนวัตกรรมที่ติดตามและรับเป็นแหล่งข้อมูล.............แหล่ง (เช่น จดหมายข่าวฝ้ายแกมไหม เป็นต้น)
11. งบประมาณสำหรับการพัฒนาเทคโนโลยีและนวัตกรรม (เช่น รายจ่ายในการปรับปรุงระบบบำบัดน้ำเสีย การปรับปรุงเตาและหม้อย้อมสี เป็นต้น) คิดเป็นสัดส่วนของ<u>ยอดขาย</u>

☐ ไม่มี ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ มากกว่า 50%

12. บริษัท (กลุ่ม) ของท่านมีขีดความสามารถทางเทคโนโลยีอยู่ในระดับใด

☐ รับเทคโนโลยีจากภายนอกมาใช้ เช่น การควบคุมคุณภาพ การซ่อมบำรุง การปรับสินค้าให้ตรงการกับความต้องการของตลาดท้องถิ่น (รับเทคโนโลยีจากที่ปรึกษา และโครงการฝ้ายแกมไหมฯ เป็นต้น)

☐ สามารถแก้ปัญหาเกี่ยวกับเทคโนโลยีได้เอง เช่น การปรับปรุงกระบวนการเพื่อลดต้นทุน การปรับปรุงผลิตภัณฑ์ การปรับเปลี่ยนเทคโนโลยีที่ซื้อมาจากภายนอกได้เอง (ทำการพัฒนาเทคโนโลยีด้วยตัวเอง)

☐ การพัฒนาผลิตภัณฑ์และกระบวนการใหม่

**ส่วนที่ 3 ความเชื่อมโยงภาครัฐ มหาวิทยาลัย และอุตสาหกรรม**

13. บริษัทท่านมีความเชื่อมโยงกับมหาวิทยาลัยหรือไม่

☐ ไม่มี เพราะ ..............................................................................................………..................

☐ มี โปรดระบุลักษณะของความเชื่อมโยง

☐ การร่วมวิจัย
….. ครั้ง กับ โครงการฝ้ายแกมไหมฯ มช.
….. ครั้ง กับ ม.เกษตร (กำแพงแสน)
….. ครั้ง กับ คณะวิทยาศษสตร์ฯ มช.
….. ครั้ง กับ..............................................................

☐ การใช้สิทธิ์ทรัพย์สินทางปัญญา
….. ครั้ง กับ โครงการฝ้ายแกมไหมฯ เช่น เครื่องแกะเม็ดฝ้าย เครื่องตีฟู เครื่องปั่นเส้นด้าย (MC)
….. ครั้ง กับ ม.เกษตร (กำแพงแสน) เช่น พันธ์ไหมอีรี่
….. ครั้ง กับ.......................................................................

☐ การจ้างวิจัย
….. ครั้ง กับ..............................................................
….. ครั้ง กับ..............................................................
….. ครั้ง กับ..............................................................

☐ การบริการที่ปรึกษา
….. ครั้ง กับ คณะวิทยาศาสตร์ฯ มช.
….. ครั้ง กับ สถาบันวิจัยวิทยาศาสตร์ฯ มช.
….. ครั้ง กับ.......................................................................

☐ การวิเคราะห์ทดสอบ
….. ครั้ง กับ คณะวิทยาศาสตร์ มช.
….. ครั้ง กับ..............................................................
….. ครั้ง กับ..............................................................

☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย
….. ครั้ง กับ คณะวิทยาศาสตร์ฯ มช.
….. ครั้ง กับ โครงการฝ้ายแกมไหม มช.
….. ครั้ง กับ.......................................................................

☐ การประชุม สัมมนา อบรม
….. ครั้ง กับ โครงการฝ้ายแกมไหมฯ มช.
….. ครั้ง กับ..............................................................
….. ครั้ง กับ..............................................................

☐ การแลกเปลี่ยนบุคลากร (ส่งบุคลากรมาเรียนรู้กับกลุ่มฯ)
….. ครั้ง กับ.......................................................................
….. ครั้ง กับ.......................................................................
….. ครั้ง กับ.......................................................................

☐ อื่นๆ ……..........................……………………………………………………………….......................

14. บริษัทท่านมีความเชื่อมโยงกับหน่วยงานภาครัฐหรือไม่

☐ ไม่มี เพราะ ..............................................................................................………..................

☐ มี โปรดระบุลักษณะของความเชื่อมโยง

☐ ถูกควบคุมโดยกฎหมาย ระเบียบข้อบังคับ
….. ครั้ง กับ..............................................................
….. ครั้ง กับ..............................................................
….. ครั้ง กับ..............................................................

☐ การให้ทุนโครงการความร่วมมือ (สนับสนุนให้ทุนร่วมกันหลายกลุ่มวิสาหกิจฯ หรือร่วมกับมหาวิทยาลัย)
….. ครั้ง กับ สำนักงานคณะกรรมการวิจัยแห่งชาติ (วช.)
….. ครั้ง กับ..............................................................
….. ครั้ง กับ..............................................................

☐ ช่วยภาครัฐจัดทำกฎระเบียบที่เอื้อประโยชน์
….. ครั้ง กับ..............................................................
….. ครั้ง กับ..............................................................
….. ครั้ง กับ..............................................................

☐ การเชื่อมโยงกับหน่วยงานอื่น
….. ครั้ง กับ ส่วนราชการท้องถิ่น (อำเภอ เทศบาล อบต.)
….. ครั้ง กับ กรมส่งเสริมอุตสาหกรรม
….. ครั้ง กับ..............................................................

☐ การสนับสนุนทางการเงินรายบริษัท (รายกลุ่มฯ)
….. ครั้ง กับ ส่วนราชการท้องถิ่น (อำเภอ เทศบาล อบต.)
….. ครั้ง กับ กรมส่งเสริมสหกรณ์

☐ การประชุม สัมมนา อบรม
….. ครั้ง กับ ส่วนราชการท้องถิ่น (อำเภอ เทศบาล อบต.)
….. ครั้ง กับ กรมส่งเสริมคุณภาพสิ่งแวดล้อม

….. ครั้ง กับ กรมการพัฒนาชุมชน

….. ครั้ง กับ..................................................................

☐ การสนับสนุนวัตถุดิบแบบให้เปล่า (ฝ้าย พันธุ์ไหมอีรี่)

….. ครั้ง กับ ส่วนราชการท้องถิ่น (อำเภอ เทศบาล อบต.)

….. ครั้ง กับ กรมการพัฒนาชุมชน

….. ครั้ง กับ..................................................................

☐ การวิเคราะห์ ทดสอบ

….. ครั้ง กับ กรมส่งเสริมคุณภาพสิ่งแวดล้อม

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

….. ครั้ง กับ สำนักงานกองทุนสนับสนุนการวิจัย (สกว.)

….. ครั้ง กับ..................................................................

☐ การบริการที่ปรึกษา

….. ครั้ง กับ กรมส่งเสริมคุณภาพสิ่งแวดล้อม

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

☐ อื่นๆ ……………………………..................................……………………………………………………………

15. บริษัทท่านมีความเชื่อมโยงกับ<u>บริษัท</u> (กลุ่มวิสาหกิจ) อื่นหรือไม่

☐ ไม่มี เพราะ

..................................................................................................………….......................

☐ มี โปรดระบุลักษณะของความเชื่อมโยง

☐ ความสัมพันธ์ด้านการค้า (เชื่อมโยงการผลิต)

….. ครั้ง กับ กลุ่มวิสาหกิจฯ อื่นๆ

….. ราย กับ ผู้รับซื้อ (ตัวกลางติดต่อซื้อขาย)

….. ครั้ง กับ..................................................................

☐ การวิเคราะห์ทดสอบ (โปรดระบุว่าเป็นการส่งไปทดสอบ หรือรับทดสอบ)

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

☐ การเข้าร่วมกลุ่มวิสาหกิจชุมชน/สมาคม

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

☐ การพัฒนาระบบการแลกเปลี่ยนข้อมูล

….. ครั้ง กับ กลุ่มวิสาหกิจอื่นๆ ในโครงการฝ้ายแกมไหมฯ

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

☐ การพัฒนาผลิตภัณฑ์ และ/หรือกระบวนการในลักษณะเครือข่ายพันธมิตร

….. ครั้ง กับ กลุ่มวิสาหกิจอื่นๆ ในโครงการฝ้ายแกมไหมฯ

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

☐ การ**ให้**บริการที่ปรึกษาเพื่อแก้ปัญหาทางเทคนิค

….. ครั้ง กับ กลุ่มวิสาหกิจอื่นๆ ในโครงการฝ้ายแกมไหมฯ

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

☐ การ**ใช้**บริการที่ปรึกษาเพื่อแก้ปัญหาทางเทคนิค

….. ครั้ง กับ กลุ่มวิสาหกิจอื่นๆ ในโครงการฝ้ายแกมไหมฯ

….. ครั้ง กับ..................................................................

….. ครั้ง กับ..................................................................

☐ อื่นๆ ……………..........................………………………………………………………………

## ส่วนที่ 4  ประโยชน์ที่ได้รับจากตัวกลางทางนวัตกรรม

16. ท่านมีการพัฒนาทางด้านใดบ้างจากการเชื่อมโยงกับศูนย์วิชากรและเทคโนโลยีสิ่งทอพื้นบ้าน (ฝ้ายแกมไหม)

- ☐ การลดต้นทุน
- ☐ การพัฒนากระบวนการผลิต (เร็วขึ้น)
- ☐ การพัฒนาผลิตภัณฑ์ใหม่
- ☐ การพัฒนาขีดความสามารถของบุคลากร
- ☐ การแลกเปลี่ยนข้อมูล ข่าวสาร ความรู้
- ☐ การติดต่อทางการค้าเพิ่มขึ้น

## ส่วนที่ 5 ประสิทธิภาพของหน่วยงานที่เป็นตัวกลางทางนวัตกรรม

17. บริษัทท่านมีความเชื่อมโยงกับหน่วนงานที่เป็นตัวกลางทางนวัตกรรมเหล่านี้หรือไม่

ได้แก่ 1. การสนับสนุนทางการเงิน เช่น ส่วนราชการท้องถิ่น อุทยานวิทยาศาสตร์ภาคเหนือ

2. การเชื่อมโยงหน่วยงานต่างๆ เช่น ศูนย์วิชาการและเทคโนโลยีสิ่งทอพื้นบ้าน (ฝ้ายแกมไหม)

3. การพัฒนาขีดความสามารถ เช่น คณะวิทยาศาสตร์ (มช.) ผู้เชี่ยวชาญและวิทยากรของศูนย์วิชาการฯ

ถ้ามี ท่านจะประเมินประสิทธิภาพของหน่วยงานเหล่านี้ในด้านต่างๆ เหล่านี้อย่างไร

กรุณาใส่เครื่องหมาย ✓ ในช่องที่ท่านเห็นว่าเหมาะสม

| Effectiveness | | แย่มาก | แย่ | ปานกลาง | ดี | ดีมาก |
|---|---|---|---|---|---|---|
| 1. | **การสนับสนุนทางการเงิน** (โดย ส่วนราชการท้องถิ่น อุทยานวิทยาศาสตร์ภาคเหนือ) | | | | | |
| 1.1 | บริหารจัดการการสนับสนุนทางการเงิน (มีความรวดเร็ว ขั้นตอนสะดวก) | | | | | |
| 1.2 | การบริหารจัดการเทคโนโลยี เช่น การสนับสนุนให้ใช้ทรัพย์สินทางปัญญา ได้แก่ เครื่องแกะเม็ด เครื่องตีฟู MC | | | | | |
| 2. | **การเชื่อมโยงหน่วยงานต่าง ๆ** (โดย ศูนย์วิชาการและเทคโนโลยีสิ่งทอพื้นบ้าน (ฝ้ายแกมไหม)) | | | | | |
| 2.1 | การให้ข้อมูลเกี่ยวกับการประชุมความร่วมมือ และผู้ร่วมมือที่มีศักยภาพ (ให้ข้อมูลว่าควรเชื่อมโยงกับใคร) | | | | | |
| 2.2 | การจัดหาสิ่งอำนวยความสะดวกของโครงการความร่วมมือ เช่น การนัดพบปะ การแนะนำการเขียนข้อเสนอโครงการ | | | | | |
| 2.3 | การช่วยเหลือในการเข้าถึงแหล่งทรัพยากรจากภายนอก เช่น การสนับสนุนทางการเงิน และด้านเทคนิคของหน่วยงานอื่นๆ (แนะนำหน่วยงานที่ให้การสนับสนุนอื่น) | | | | | |
| 3. | **การพัฒนาขีดความสามารถของอุตสาหกรรม** (โดย คณะวิทยาศาสตร์ (มช.) ผู้เชี่ยวชาญและวิทยากรของโครงการฝ้ายแกมไหมฯ และกรมส่งเสริมคุณภาพสิ่งแวดล้อม และอื่นๆ) | | | | | |
| 3.1 | การให้บริการทางด้านเทคนิค เช่น วิเคราะห์ ทดสอบ ที่ปรึกษา ฝึกอบรม | | | | | |
| 3.2 | การช่วยเหลือในการใช้ประโยชน์จากงานวิจัยภายนอก (ได้ประโยชน์จากการนำเสนอผลงานวิจัยที่เกี่ยวข้องเพียงใด) | | | | | |
| 3.3 | การช่วยเหลือในการทำวิจัยและพัฒนาเทคโนโลยีของกลุ่ม (กรุณาระบุหากมีการทำวิจัย หากไม่มีให้ขีดคร่อม) | | | | | |
| 3.4 | การอำนวยความสะดวกให้การไหลเวียนข้อมูล ข่าวสาร ความรู้ (รับทราบปัญหาของกลุ่มแล้วนำไปเสนอหน่วยงานที่เกี่ยวข้อง หรือแบ่งปันประสบการณ์ของกลุ่มอื่นๆ) | | | | | |

อุตสาหกรรมข้าวแต๋น

**แบบสอบถาม**

**ส่วนที่ 1 ข้อมูลทั่วไปของบริษัท**

1. ชื่อบริษัท/กลุ่มวิสาหกิจ

   ................................................................................................

2. อายุบริษัท/กลุ่มวิสาหกิจ ..................… ปี
3. ยอดขาย (ปี 2553) ......................................….. บาท
4. กำไร (ปี 2553)...........................................…. % ของยอดขาย
5. จำนวนพนักงาน

☐ น้อยกว่า 50 คน ☐ 50-200 คน ☐ มากกว่า 200 คน

6. จำนวนสินทรัพย์ถาวร

☐ น้อยกว่า 50 ล้านบาท ☐ 50-200 ล้านบาท ☐ มากกว่า 200 ล้านบาท

**ส่วนที่ 2 ทรัพยากรและขีดความสามารถ**

7. จำนวนพนักงานที่ใช้ในการพัฒนาเทคโนโลยี ............................….. คน
8. ประมาณการเครื่องมืออุปกรณ์ที่ใช้ในการทำวิจัยและพัฒนาคิดเป็นสัดส่วนกับสินทรัพย์ถาวร

☐ ไม่มี ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ มากกว่า 50%

9. จำนวนฐานข้อมูลหรือวารสารเกี่ยวกับการพัฒนาเทคโนโลยีและนวัตกรรมที่ติดตามและรับเป็นแหล่งข้อมูล..............แหล่ง
10. งบประมาณสำหรับการพัฒนาเทคโนโลยีและนวัตกรรมคิดเป็นสัดส่วนของยอดขาย

☐ ไม่มี ☐ 1-10% ☐ 11-30% ☐ 30-50% ☐ มากกว่า 50%

11. บริษัทท่านมีขีดความสามารถทางเทคโนโลยีอยู่ในระดับใด

☐ รับเทคโนโลยีจากภายนอกมาใช้ เช่น การควบคุมคุณภาพ การซ่อมบำรุง การปรับสินค้าให้ตรงการกับความต้องการของตลาดท้องถิ่น

☐ สามารถแก้ปัญหาเกี่ยวกับเทคโนโลยีได้เอง เช่น การปรับปรุงกระบวนการเพื่อลดต้นทุน การปรับปรุงผลิตภัณฑ์ การปรับเปลี่ยนเทคโนโลยีที่นำเข้า

☐ การพัฒนาผลิตภัณฑ์และกระบวนการใหม่ด้วยตัวเอง

**ส่วนที่ 3 ความเชื่อมโยงภาครัฐ มหาวิทยาลัย และอุตสาหกรรม**

12. บริษัทท่านมีความเชื่อมโยงกับ**มหาวิทยาลัย**หรือไม่

☐ ไม่มี เพราะ

..........................................................................................……….....................

☐ มี โปรดระบุจำนวนโครงการที่มีความเชื่อมโยง และรายชื่อมหาวิทยาลัยที่มีความเชื่อมโยง

☐ การร่วมวิจัย
….. โครงการ กับ มหาวิทยาลัยราชมงคลล้านนา ลำปาง
….. โครงการ กับ มหาวิทยาลัยราชภัฏลำปาง
….. โครงการ กับ .......................................................

☐ การใช้สิทธิ์ทรัพย์สินทางปัญญา
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ การจ้างวิจัย
….. โครงการ กับ มหาวิทยาลัยราชมงคลล้านนา ลำปาง
….. โครงการ กับ มหาวิทยาลัยราชภัฏ ลำปาง
….. โครงการ กับ .......................................................

☐ การบริการที่ปรึกษา
….. โครงการ กับ มหาวิทยาลัยราชมงคลล้านนาลำปาง
….. โครงการ กับ มหาวิทยาลัยราชภัฏ ลำปาง
….. โครงการ กับ ........................................................

☐ การวิเคราะห์ทดสอบ
….. โครงการ กับ........................................................
….. โครงการ กับ........................................................
….. โครงการ กับ........................................................

☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ การประชุม สัมมนา อบรม
….. โครงการ กับ........................................................
….. โครงการ กับ........................................................
….. โครงการ กับ........................................................

☐ การแลกเปลี่ยนบุคลากร
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ อื่นๆ ………...............................…………………………………………………………

13. บริษัทท่านมีความเชื่อมโยงกับ**หน่วยงานภาครัฐ**หรือไม่

☐ ไม่มี เพราะ

..........................................................................................……….....................

☐ มี โปรดระบุจำนวนโครงการที่มีความเชื่อมโยง และรายชื่อหน่วยงานภาครัฐที่มีความเชื่อมโยง

☐ ถูกควบคุมโดยกฎหมาย ระเบียบข้อบังคับ เช่น การรับรอง อย., GMP, HACCP
….. โครงการ กับ สำนักงานคณะกรรมการอาหารและยา
….. โครงการ กับ สถาบันวิจัยวิทยาศาสตร์และเทคโนโลยี
….. โครงการ กับ........................................................

☐ การให้ทุนโครงการความร่วมมือ เช่น การร่วมวิจัยกับมหาวิทยาลัย และ/หรือ หน่วยงานภาครัฐ
….. โครงการ กับ สกว. ในโครงการ IRPUS
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ ช่วยภาครัฐจัดทำกฎระเบียบที่เอื้อประโยชน์
….. โครงการ กับ........................................................
….. โครงการ กับ........................................................
….. โครงการ กับ........................................................

☐ การเชื่อมโยงกับหน่วยงานอื่น
….. โครงการ กับ สำนักงานอุตสาหกรรมจังหวัดลำปาง
….. โครงการ กับ.........................................................
….. โครงการ กับ.........................................................

☐ การสนับสนุนทางการเงินรายบริษัท
….. โครงการ กับ ธกส. ธนาคารออมสิน (เงินกู้)

☐ การประชุม สัมมนา อบรม
….. โครงการ กับ กรมพัฒนาชุมชน

| | |
|---|---|
| ….. โครงการ กับ กรมพัฒนาชุมชน (เงินให้เปล่า) | ….. โครงการ กับ สำนักงานพาณิชย์จังหวัดลำปาง |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การสนับสนุนเงินในการออกงานแสดงสินค้า | ☐ การบริการที่ปรึกษา |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การวิเคราะห์ สอบเทียบ | ☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |

☐ อื่นๆ ……………………………...............................……………………………………………………………

14. บริษัทท่านมีความเชื่อมโยงกับ**<u>บริษัท/กลุ่มวิสาหกิจ</u>**อื่นหรือไม่

☐ ไม่มี เพราะ .......................................................................................................…………......

☐ มี โปรดระบุจำนวนโครงการที่มีความเชื่อมโยง และรายชื่อบริษัท/กลุ่มวิสาหกิจที่มีความเชื่อมโยง

| | |
|---|---|
| ☐ ความสัมพันธ์ด้านการค้า | ☐ การพัฒนาระบบการแลกเปลี่ยนข้อมูล |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การวิเคราะห์ทดสอบ | ☐ การพัฒนาผลิตภัณฑ์ และ/หรือกระบวนการในลักษณะเครือข่ายพันธมิตร |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ บริษัทในกลุ่มคลัสเตอร์ข้าวแต๋น |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การเข้าร่วมสมาคมการค้า/อุตสาหกรรม | ☐ การ<u>ให้</u>บริการที่ปรึกษาเพื่อแก้ปัญหาทางเทคนิค |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ☐ การร่วมใช้อุปกรณ์เครื่องมือทำวิจัย | ☐ การ<u>รับ</u>บริการที่ปรึกษา เพื่อแก้ปัญหาทางเทคนิค |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |
| ….. โครงการ กับ.......................................................... | ….. โครงการ กับ.......................................................... |

☐ อื่นๆ ……………...............................……………………………………………………………

## ส่วนที่ 4 ประโยชน์ที่ได้รับจากตัวกลางทางนวัตกรรม

15. ท่านมีการพัฒนาทางด้านใดบ้างจากการเชื่อมโยงกับตัวกลางทางนวัตกรรม (สำนักงานอุตสาหกรรมจังหวัด)

☐ การลดต้นทุน
☐ การพัฒนากระบวนการผลิต
☐ การพัฒนาผลิตภัณฑ์
☐ การพัฒนาขีดความสามารถของบุคลากร
☐ การแลกเปลี่ยนข้อมูล ข่าวสาร ความรู้
☐ การเชื่อมโยงทางการค้าเพิ่มขึ้น

## ส่วนที่ 5 ประสิทธิภาพของหน่วยงานที่เป็นตัวกลางทางนวัตกรรม

16. บริษัทท่านมีความเชื่อมโยงกับหน่วนงานที่เป็นตัวกลางทางนวัตกรรมเหล่านี้หรือไม่ ได้แก่ 1. การสนับสนุนทางการเงิน – สำนักงานกองทุนสนับสนุนการวิจัย (IRPUS) กรมพัฒนาชุมชน

2. การเชื่อมโยงหน่วยงานต่างๆ – สำนักงานอุตสาหกรรมจังหวัด

3. การพัฒนาขีดความสามารถ – มหาวิทยาลัยต่างๆ

ถ้ามี ท่านจะประเมินประสิทธิภาพของหน่วยงานเหล่านี้ในด้านต่างๆ เหล่านี้อย่างไร กรุณาใส่เครื่องหมาย ✓ ในช่องที่ท่านเห็นว่าเหมาะสม

| Effectiveness | | แย่มาก | แย่ | ปานกลาง | ดี | ดีมาก |
|---|---|---|---|---|---|---|
| 1. | **การสนับสนุนทางการเงิน** (โดย สำนักงานกองทุนสนับสนุนการวิจัย (IRPUS) กรมพัฒนาชุมชน) | | | | | |
| 1.1 | บริหารจัดการการสนับสนุนทางการเงิน | | | | | |
| 1.2 | การบริหารจัดการเทคโนโลยี เช่น ทรัพย์สินทางปัญญา | | | | | |
| 2. | **การเชื่อมโยงหน่วยงานต่าง ๆ** (โดย สำนักงานอุตสาหกรรมจังหวัด) | | | | | |
| 2.1 | การให้ข้อมูลเกี่ยวกับการประชุมความร่วมมือ และผู้ร่วมมือที่มีศักยภาพ | | | | | |
| 2.2 | การจัดหาสิ่งอำนวยความสะดวกของโครงการความร่วมมือ เช่น การเขียนโครงการ | | | | | |
| 2.3 | การช่วยเหลือในการเข้าถึงแหล่งทรัพยากรจากภายนอก เช่น การสนับสนุนทางการเงิน และด้านเทคนิค | | | | | |
| 3. | **การพัฒนาขีดความสามารถของอุตสาหกรรม** (โดย มหาวิทยาลัยต่างๆ สำนักงานพาณิชย์จังหวัด) | | | | | |
| 3.1 | การให้บริการทางด้านเทคนิค เช่น วิเคราะห์ ทดสอบ สอบเทียบ ที่ปรึกษา | | | | | |
| 3.2 | การช่วยเหลือในการใช้ประโยชน์จากงานวิจัยภายนอก | | | | | |
| 3.3 | การช่วยเหลือในการทำวิจัยในบริษัท | | | | | |
| 3.4 | การอำนวยความสะดวกให้การไหลเวียนข้อมูล ข่าวสาร ความรู้ | | | | | |

# Appendix 7

# Statistical Tests for H1

## HDD industry

**Descriptive Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| II links | 6.71 | 14.739 | 7 |
| TECHEMP | 39.43 | 87.727 | 7 |
| TECHEQ | 1.71 | .488 | 7 |
| INFO | 4.14 | 7.128 | 7 |
| RDBUD | 1.71 | .488 | 7 |

**Correlations**

| | | II links | TECHEMP | TECHEQ | INFO | RDBUD |
|---|---|---|---|---|---|---|
| Pearson Correlation | II links | 1.000 | .993 | .288 | .981 | .288 |
| | TECHEMP | .993 | 1.000 | .307 | .987 | .307 |
| | TECHEQ | .288 | .307 | 1.000 | .397 | 1.000 |
| | INFO | .981 | .987 | .397 | 1.000 | .397 |
| | RDBUD | .288 | .307 | 1.000 | .397 | 1.000 |
| Sig. (1-tailed) | II links | . | .000 | .266 | .000 | .266 |
| | TECHEMP | .000 | . | .251 | .000 | .251 |
| | TECHEQ | .266 | .251 | . | .189 | .000 |
| | INFO | .000 | .000 | .189 | . | .189 |
| | RDBUD | .266 | .251 | .000 | .189 | . |
| N | II links | 7 | 7 | 7 | 7 | 7 |
| | TECHEMP | 7 | 7 | 7 | 7 | 7 |
| | TECHEQ | 7 | 7 | 7 | 7 | 7 |
| | INFO | 7 | 7 | 7 | 7 | 7 |
| | RDBUD | 7 | 7 | 7 | 7 | 7 |

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | RDBUD, TECHEMP, INFO[b] | . | Enter |

a. Dependent Variable: II links

b. Tolerance = .000 limits reached.

**Model Summary[b]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .993[a] | .987 | .974 | 2.384 | 2.367 |

a. Predictors: (Constant), RDBUD, TECHEMP, INFO

b. Dependent Variable: II links

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 1286.372 | 3 | 428.791 | 75.419 | .003[b] |
| | Residual | 17.056 | 3 | 5.685 | | |
| | Total | 1303.429 | 6 | | | |

a. Dependent Variable: II links

b. Predictors: (Constant), RDBUD, TECHEMP, INFO

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 1 | (Constant) | 1.467 | 3.963 | | .370 | .736 | | |
| | TECHEMP | .147 | .086 | .876 | 1.704 | .187 | .017 | 60.565 |
| | INFO | .266 | 1.102 | .129 | .242 | .825 | .015 | 65.122 |
| | RDBUD | -.967 | 2.679 | -.032 | -.361 | .742 | .554 | 1.804 |

a. Dependent Variable: II links

**Excluded Variables[a]**

| Model | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics | | |
|---|---|---|---|---|---|---|---|
| | | | | | Tolerance | VIF | Minimum Tolerance |
| 1 TECHEQ | .[b] | . | . | . | .000 | . | .000 |

a. Dependent Variable: II links

b. Predictors in the Model: (Constant), RDBUD, TECHEMP, INFO

**Collinearity Diagnostics[a]**

| Model | Dimension | Eigenvalue | Condition Index | Variance Proportions | | | |
|---|---|---|---|---|---|---|---|
| | | | | (Constant) | TECHEMP | INFO | RDBUD |
| 1 | 1 | 3.009 | 1.000 | .00 | .00 | .00 | .00 |
| | 2 | .953 | 1.777 | .02 | .00 | .00 | .01 |
| | 3 | .033 | 9.528 | .70 | .02 | .01 | .49 |
| | 4 | .006 | 23.347 | .28 | .97 | .98 | .50 |

a. Dependent Variable: II links

**Residuals Statistics[a]**

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| Predicted Value | .50 | 39.88 | 6.71 | 14.642 | 7 |
| Residual | -2.273 | 3.199 | .000 | 1.686 | 7 |
| Std. Predicted Value | -.424 | 2.265 | .000 | 1.000 | 7 |
| Std. Residual | -.953 | 1.341 | .000 | .707 | 7 |

a. Dependent Variable: II links

**One-Sample Kolmogorov-Smirnov Test**

| | | Standardized Residual |
|---|---|---|
| N | | 7 |
| Normal Parameters[a,b] | Mean | 0E-7 |
| | Std. Deviation | .70710678 |
| Most Extreme Differences | Absolute | .241 |
| | Positive | .241 |
| | Negative | -.120 |
| Kolmogorov-Smirnov Z | | .636 |
| Asymp. Sig. (2-tailed) | | .813 |

a. Test distribution is Normal.

b. Calculated from data.

## Stepwise selection

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | TECHEMP | . | Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). |

a. Dependent Variable: II links

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .993[a] | .986 | .984 | 1.887 |

a. Predictors: (Constant), TECHEMP

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 1285.629 | 1 | 1285.629 | 361.134 | .000[b] |
| | Residual | 17.800 | 5 | 3.560 | | |
| | Total | 1303.429 | 6 | | | |

a. Dependent Variable: II links

b. Predictors: (Constant), TECHEMP

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | .135 | .793 | | .171 | .871 |
| | TECHEMP | .167 | .009 | .993 | 19.004 | .000 |

a. Dependent Variable: II links

**Excluded Variables[a]**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| 1 | TECHEQ | -.019[b] | -.308 | .774 | -.152 | .906 |
| | INFO | .009[b] | .024 | .982 | .012 | .025 |
| | RDBUD | -.019[b] | -.308 | .774 | -.152 | .906 |

a. Dependent Variable: II links

b. Predictors in the Model: (Constant), TECHEMP

## Automotive Industry

**Descriptive Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| IILINK | 3.37 | 3.729 | 43 |
| TECHEM | 20.77 | 32.323 | 43 |
| TECHEQ | 1.95 | .872 | 43 |
| INFO | 1.91 | 2.080 | 43 |
| RDBUD | 1.77 | .718 | 43 |

**Correlations**

| | | IILINK | TECHEM | TECHEQ | INFO | RDBUD |
|---|---|---|---|---|---|---|
| Pearson Correlation | IILINK | 1.000 | -.100 | -.024 | .284 | .042 |
| | TECHEM | -.100 | 1.000 | .324 | .469 | .248 |
| | TECHEQ | -.024 | .324 | 1.000 | .339 | .591 |
| | INFO | .284 | .469 | .339 | 1.000 | .272 |
| | RDBUD | .042 | .248 | .591 | .272 | 1.000 |
| Sig. (1-tailed) | IILINK | . | .261 | .440 | .032 | .395 |
| | TECHEM | .261 | . | .017 | .001 | .055 |
| | TECHEQ | .440 | .017 | . | .013 | .000 |
| | INFO | .032 | .001 | .013 | . | .039 |
| | RDBUD | .395 | .055 | .000 | .039 | . |
| N | IILINK | 43 | 43 | 43 | 43 | 43 |
| | TECHEM | 43 | 43 | 43 | 43 | 43 |
| | TECHEQ | 43 | 43 | 43 | 43 | 43 |
| | INFO | 43 | 43 | 43 | 43 | 43 |
| | RDBUD | 43 | 43 | 43 | 43 | 43 |

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | RDBUD, TECHEM, INFO, TECHEQ[b] | . | Enter |

a. Dependent Variable: IILINK

b. All requested variables entered.

**Model Summary[b]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .398[a] | .159 | .070 | 3.596 | 2.463 |

a. Predictors: (Constant), RDBUD, TECHEM, INFO, TECHEQ

b. Dependent Variable: IILINK

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 92.723 | 4 | 23.181 | 1.793 | .150[b] |
| | Residual | 491.323 | 38 | 12.930 | | |
| | Total | 584.047 | 42 | | | |

a. Dependent Variable: IILINK

b. Predictors: (Constant), RDBUD, TECHEM, INFO, TECHEQ

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 1 | (Constant) | 2.962 | 1.573 | | 1.883 | .067 | | |
| | TECHEM | -.033 | .020 | -.284 | -1.649 | .107 | .748 | 1.336 |
| | TECHEQ | -.504 | .819 | -.118 | -.615 | .542 | .603 | 1.657 |
| | INFO | .789 | .311 | .440 | 2.539 | .015 | .737 | 1.356 |
| | RDBUD | .323 | .962 | .062 | .335 | .739 | .644 | 1.552 |

a. Dependent Variable: IILINK

**Collinearity Diagnostics[a]**

| Model | Dimension | Eigenvalue | Condition Index | Variance Proportions | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | (Constant) | TECHEM | TECHEQ | INFO | RDBUD |
| 1 | 1 | 3.941 | 1.000 | .01 | .02 | .01 | .02 | .01 |
| | 2 | .608 | 2.546 | .03 | .52 | .01 | .08 | .01 |
| | 3 | .309 | 3.570 | .01 | .44 | .00 | .90 | .00 |
| | 4 | .083 | 6.905 | .86 | .02 | .43 | .01 | .06 |
| | 5 | .060 | 8.130 | .10 | .00 | .55 | .00 | .92 |

a. Dependent Variable: IILINK

**Residuals Statistics[a]**

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| Predicted Value | .12 | 6.44 | 3.37 | 1.486 | 43 |
| Residual | -4.177 | 12.620 | .000 | 3.420 | 43 |
| Std. Predicted Value | -2.190 | 2.068 | .000 | 1.000 | 43 |
| Std. Residual | -1.162 | 3.510 | .000 | .951 | 43 |

a. Dependent Variable: IILINK

**One-Sample Kolmogorov-Smirnov Test**

| | | Standardized Residual |
|---|---|---|
| N | | 43 |
| Normal Parameters[a,b] | Mean | 0E-7 |
| | Std. Deviation | .95118973 |
| Most Extreme Differences | Absolute | .183 |
| | Positive | .183 |
| | Negative | -.114 |
| Kolmogorov-Smirnov Z | | 1.199 |
| Asymp. Sig. (2-tailed) | | .113 |

a. Test distribution is Normal.

b. Calculated from data.

## Backward selection

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | RDBUD, TECHEM, INFO, TECHEQ[b] | . | Enter |
| 2 | . | RDBUD | Backward (criterion: Probability of F-to-remove >= .100). |
| 3 | . | TECHEQ | Backward (criterion: Probability of F-to-remove >= .100). |

a. Dependent Variable: IILINK

b. All requested variables entered.

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .398[a] | .159 | .070 | 3.596 |
| 2 | .395[b] | .156 | .091 | 3.555 |
| 3 | .388[c] | .150 | .108 | 3.522 |

a. Predictors: (Constant), RDBUD, TECHEM, INFO, TECHEQ

b. Predictors: (Constant), TECHEM, INFO, TECHEQ

c. Predictors: (Constant), TECHEM, INFO

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 92.723 | 4 | 23.181 | 1.793 | .150[b] |
| | Residual | 491.323 | 38 | 12.930 | | |
| | Total | 584.047 | 42 | | | |
| 2 | Regression | 91.270 | 3 | 30.423 | 2.408 | .082[c] |
| | Residual | 492.777 | 39 | 12.635 | | |
| | Total | 584.047 | 42 | | | |
| 3 | Regression | 87.830 | 2 | 43.915 | 3.540 | .038[d] |
| | Residual | 496.216 | 40 | 12.405 | | |
| | Total | 584.047 | 42 | | | |

a. Dependent Variable: IILINK

b. Predictors: (Constant), RDBUD, TECHEM, INFO, TECHEQ

c. Predictors: (Constant), TECHEM, INFO, TECHEQ

d. Predictors: (Constant), TECHEM, INFO

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 2.962 | 1.573 | | 1.883 | .067 |
| | TECHEM | -.033 | .020 | -.284 | -1.649 | .107 |
| | TECHEQ | -.504 | .819 | -.118 | -.615 | .542 |
| | INFO | .789 | .311 | .440 | 2.539 | .015 |
| | RDBUD | .323 | .962 | .062 | .335 | .739 |
| 2 | (Constant) | 3.223 | 1.350 | | 2.388 | .022 |
| | TECHEM | -.032 | .020 | -.281 | -1.656 | .106 |
| | TECHEQ | -.356 | .683 | -.083 | -.522 | .605 |
| | INFO | .796 | .306 | .444 | 2.599 | .013 |
| 3 | (Constant) | 2.638 | .744 | | 3.544 | .001 |
| | TECHEM | -.034 | .019 | -.299 | -1.812 | .077 |
| | INFO | .760 | .296 | .424 | 2.570 | .014 |

a. Dependent Variable: IILINK

**Excluded Variables[a]**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| 2 | RDBUD | .062[b] | .335 | .739 | .054 | .644 |
| 3 | RDBUD | .001[c] | .005 | .996 | .001 | .907 |
| | TECHEQ | -.083[c] | -.522 | .605 | -.083 | .850 |

a. Dependent Variable: IILINK

b. Predictors in the Model: (Constant), TECHEM, INFO, TECHEQ

c. Predictors in the Model: (Constant), TECHEM, INFO

## Ceramic industry

**Descriptive Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| IILINK | 3.20 | 3.156 | 30 |
| TECHEM | 5.83 | 7.216 | 30 |
| TECHEQ | 1.83 | .648 | 30 |
| INFO | 1.77 | 2.012 | 30 |
| RDBUD | 2.00 | .983 | 30 |

**Correlations**

| | | IILINK | TECHEM | TECHEQ | INFO | RDBUD |
|---|---|---|---|---|---|---|
| Pearson Correlation | IILINK | 1.000 | -.200 | .084 | .480 | .200 |
| | TECHEM | -.200 | 1.000 | .473 | .116 | .224 |
| | TECHEQ | .084 | .473 | 1.000 | .313 | .271 |
| | INFO | .480 | .116 | .313 | 1.000 | .140 |
| | RDBUD | .200 | .224 | .271 | .140 | 1.000 |
| Sig. (1-tailed) | IILINK | . | .145 | .329 | .004 | .144 |
| | TECHEM | .145 | . | .004 | .271 | .117 |
| | TECHEQ | .329 | .004 | . | .046 | .074 |
| | INFO | .004 | .271 | .046 | . | .231 |
| | RDBUD | .144 | .117 | .074 | .231 | . |
| N | IILINK | 30 | 30 | 30 | 30 | 30 |
| | TECHEM | 30 | 30 | 30 | 30 | 30 |
| | TECHEQ | 30 | 30 | 30 | 30 | 30 |
| | INFO | 30 | 30 | 30 | 30 | 30 |
| | RDBUD | 30 | 30 | 30 | 30 | 30 |

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | RDBUD, INFO, TECHEM, TECHEQ[b] | . | Enter |

a. Dependent Variable: IILINK

b. All requested variables entered.

**Model Summary**[b]

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .578[a] | .335 | .228 | 2.772 | 2.555 |

a. Predictors: (Constant), RDBUD, INFO, TECHEM, TECHEQ

b. Dependent Variable: IILINK

**ANOVA**[a]

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 96.645 | 4 | 24.161 | 3.143 | .032[b] |
| | Residual | 192.155 | 25 | 7.686 | | |
| | Total | 288.800 | 29 | | | |

a. Dependent Variable: IILINK

b. Predictors: (Constant), RDBUD, INFO, TECHEM, TECHEQ

**Coefficients**[a]

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 1 | (Constant) | 1.152 | 1.731 | | .666 | .512 | | |
| | TECHEM | -.137 | .082 | -.313 | -1.678 | .106 | .764 | 1.308 |
| | TECHEQ | .143 | .958 | .029 | .149 | .882 | .689 | 1.452 |
| | INFO | .753 | .270 | .480 | 2.787 | .010 | .897 | 1.115 |
| | RDBUD | .627 | .549 | .195 | 1.142 | .264 | .911 | 1.098 |

a. Dependent Variable: IILINK

**Collinearity Diagnostics**[a]

| Model | Dimension | Eigenvalue | Condition Index | Variance Proportions | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | (Constant) | TECHEM | TECHEQ | INFO | RDBUD |
| 1 | 1 | 3.928 | 1.000 | .00 | .02 | .00 | .02 | .01 |
| | 2 | .512 | 2.771 | .00 | .48 | .00 | .45 | .00 |
| | 3 | .395 | 3.152 | .03 | .33 | .01 | .48 | .06 |
| | 4 | .120 | 5.732 | .12 | .01 | .12 | .02 | .90 |
| | 5 | .045 | 9.311 | .84 | .16 | .86 | .04 | .02 |

a. Dependent Variable: IILINK

**Residuals Statistics[a]**

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| Predicted Value | -.13 | 8.85 | 3.20 | 1.826 | 30 |
| Residual | -4.463 | 7.343 | .000 | 2.574 | 30 |
| Std. Predicted Value | -1.825 | 3.097 | .000 | 1.000 | 30 |
| Std. Residual | -1.610 | 2.649 | .000 | .928 | 30 |

a. Dependent Variable: IILINK

**One-Sample Kolmogorov-Smirnov Test**

| | | IILINK |
|---|---|---|
| N | | 30 |
| Normal Parameters[a,b] | Mean | 3.20 |
| | Std. Deviation | 3.156 |
| Most Extreme Differences | Absolute | .215 |
| | Positive | .215 |
| | Negative | -.155 |
| Kolmogorov-Smirnov Z | | 1.176 |
| Asymp. Sig. (2-tailed) | | .126 |

a. Test distribution is Normal.

b. Calculated from data.

Stepwise selection

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | INFO | . | Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). |

a. Dependent Variable: IILINK

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .480[a] | .231 | .203 | 2.817 |

a. Predictors: (Constant), INFO

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 66.582 | 1 | 66.582 | 8.390 | .007[b] |
| | Residual | 222.218 | 28 | 7.936 | | |
| | Total | 288.800 | 29 | | | |

a. Dependent Variable: IILINK

b. Predictors: (Constant), INFO

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 1.869 | .690 | | 2.711 | .011 |
| | INFO | .753 | .260 | .480 | 2.896 | .007 |

a. Dependent Variable: IILINK

**Excluded Variables[a]**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| 1 | TECHEM | -.259[b] | -1.594 | .122 | -.293 | .987 |
| | TECHEQ | -.073[b] | -.413 | .683 | -.079 | .902 |
| | RDBUD | .136[b] | .806 | .427 | .153 | .981 |

a. Dependent Variable: IILINK

b. Predictors in the Model: (Constant), INFO

## Furniture industry

**Descriptive Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| IILINK | .82 | .809 | 17 |
| TECHEM | 6.24 | 9.582 | 17 |
| TECHEQ | 1.71 | .686 | 17 |
| INFO | 1.06 | 1.676 | 17 |
| RDBUD | 1.71 | .686 | 17 |

**Correlations**

| | | IILINK | TECHEM | TECHEQ | INFO | RDBUD |
|---|---|---|---|---|---|---|
| Pearson Correlation | IILINK | 1.000 | .441 | .238 | .193 | .126 |
| | TECHEM | .441 | 1.000 | .468 | .754 | .458 |
| | TECHEQ | .238 | .468 | 1.000 | .614 | .867 |
| | INFO | .193 | .754 | .614 | 1.000 | .668 |
| | RDBUD | .126 | .458 | .867 | .668 | 1.000 |
| Sig. (1-tailed) | IILINK | . | .038 | .178 | .230 | .315 |
| | TECHEM | .038 | . | .029 | .000 | .032 |
| | TECHEQ | .178 | .029 | . | .004 | .000 |
| | INFO | .230 | .000 | .004 | . | .002 |
| | RDBUD | .315 | .032 | .000 | .002 | . |
| N | IILINK | 17 | 17 | 17 | 17 | 17 |
| | TECHEM | 17 | 17 | 17 | 17 | 17 |
| | TECHEQ | 17 | 17 | 17 | 17 | 17 |
| | INFO | 17 | 17 | 17 | 17 | 17 |
| | RDBUD | 17 | 17 | 17 | 17 | 17 |

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | RDBUD, TECHEM, INFO, TECHEQ[b] | . | Enter |

a. Dependent Variable: IILINK

b. All requested variables entered.

**Model Summary[b]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .527[a] | .278 | .037 | .794 | 2.483 |

a. Predictors: (Constant), RDBUD, TECHEM, INFO, TECHEQ

b. Dependent Variable: IILINK

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| | Regression | 2.906 | 4 | .726 | 1.152 | .379[b] |
| 1 | Residual | 7.565 | 12 | .630 | | |
| | Total | 10.471 | 16 | | | |

a. Dependent Variable: IILINK

b. Predictors: (Constant), RDBUD, TECHEM, INFO, TECHEQ

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| | (Constant) | .428 | .623 | | .687 | .505 | | |
| | TECHEM | .055 | .032 | .653 | 1.726 | .110 | .420 | 2.380 |
| 1 | TECHEQ | .455 | .589 | .386 | .773 | .455 | .242 | 4.139 |
| | INFO | -.172 | .217 | -.357 | -.796 | .442 | .299 | 3.342 |
| | RDBUD | -.318 | .627 | -.269 | -.506 | .622 | .213 | 4.701 |

a. Dependent Variable: IILINK

**Collinearity Diagnostics[a]**

| Model | Dimension | Eigenvalue | Condition Index | Variance Proportions | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | (Constant) | TECHEM | TECHEQ | INFO | RDBUD |
| | 1 | 4.017 | 1.000 | .00 | .01 | .00 | .01 | .00 |
| | 2 | .730 | 2.346 | .03 | .13 | .00 | .09 | .00 |
| 1 | 3 | .181 | 4.706 | .03 | .78 | .00 | .50 | .00 |
| | 4 | .055 | 8.576 | .92 | .04 | .14 | .34 | .07 |
| | 5 | .017 | 15.547 | .02 | .03 | .85 | .06 | .93 |

a. Dependent Variable: IILINK

**Residuals Statistics**[a]

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| Predicted Value | .13 | 2.05 | .82 | .426 | 17 |
| Residual | -1.047 | 1.194 | .000 | .688 | 17 |
| Std. Predicted Value | -1.626 | 2.871 | .000 | 1.000 | 17 |
| Std. Residual | -1.318 | 1.504 | .000 | .866 | 17 |

a. Dependent Variable: IILINK

**One-Sample Kolmogorov-Smirnov Test**

| | | Standardized Residual |
|---|---|---|
| N | | 17 |
| Normal Parameters[a,b] | Mean | 0E-7 |
| | Std. Deviation | .86602540 |
| Most Extreme Differences | Absolute | .191 |
| | Positive | .191 |
| | Negative | -.132 |
| Kolmogorov-Smirnov Z | | .789 |
| Asymp. Sig. (2-tailed) | | .563 |

a. Test distribution is Normal.

b. Calculated from data.

## Backward selection

**Variables Entered/Removed**[a]

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | RDBUD, TECHEM, INFO, TECHEQ[b] | . | Enter |
| 2 | . | RDBUD | Backward (criterion: Probability of F-to-remove >= .100). |
| 3 | . | TECHEQ | Backward (criterion: Probability of F-to-remove >= .100). |
| 4 | . | INFO | Backward (criterion: Probability of F-to-remove >= .100). |

a. Dependent Variable: IILINK

b. All requested variables entered.

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .527[a] | .278 | .037 | .794 |
| 2 | .512[b] | .262 | .092 | .771 |
| 3 | .490[c] | .240 | .132 | .754 |
| 4 | .441[d] | .195 | .141 | .750 |

a. Predictors: (Constant), RDBUD, TECHEM, INFO, TECHEQ

b. Predictors: (Constant), TECHEM, INFO, TECHEQ

c. Predictors: (Constant), TECHEM, INFO

d. Predictors: (Constant), TECHEM

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 2.906 | 4 | .726 | 1.152 | .379[b] |
| | Residual | 7.565 | 12 | .630 | | |
| | Total | 10.471 | 16 | | | |
| 2 | Regression | 2.744 | 3 | .915 | 1.539 | .251[c] |
| | Residual | 7.726 | 13 | .594 | | |
| | Total | 10.471 | 16 | | | |
| 3 | Regression | 2.514 | 2 | 1.257 | 2.211 | .146[d] |
| | Residual | 7.957 | 14 | .568 | | |
| | Total | 10.471 | 16 | | | |
| 4 | Regression | 2.037 | 1 | 2.037 | 3.623 | .076[e] |
| | Residual | 8.433 | 15 | .562 | | |
| | Total | 10.471 | 16 | | | |

a. Dependent Variable: IILINK

b. Predictors: (Constant), RDBUD, TECHEM, INFO, TECHEQ

c. Predictors: (Constant), TECHEM, INFO, TECHEQ

d. Predictors: (Constant), TECHEM, INFO

e. Predictors: (Constant), TECHEM

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | .428 | .623 | | .687 | .505 |
| | TECHEM | .055 | .032 | .653 | 1.726 | .110 |
| | TECHEQ | .455 | .589 | .386 | .773 | .455 |
| | INFO | -.172 | .217 | -.357 | -.796 | .442 |
| | RDBUD | -.318 | .627 | -.269 | -.506 | .622 |
| 2 | (Constant) | .309 | .561 | | .552 | .591 |
| | TECHEM | .058 | .031 | .684 | 1.886 | .082 |
| | TECHEQ | .222 | .356 | .188 | .623 | .544 |
| | INFO | -.212 | .196 | -.439 | -1.080 | .300 |
| 3 | (Constant) | .628 | .224 | | 2.807 | .014 |
| | TECHEM | .058 | .030 | .686 | 1.934 | .074 |
| | INFO | -.157 | .171 | -.325 | -.916 | .375 |
| 4 | (Constant) | .591 | .219 | | 2.700 | .016 |
| | TECHEM | .037 | .020 | .441 | 1.904 | .076 |

a. Dependent Variable: IILINK

**Excluded Variables[a]**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| 2 | RDBUD | -.269[b] | -.506 | .622 | -.145 | .213 |
| 3 | RDBUD | .052[c] | .160 | .875 | .044 | .548 |
| | TECHEQ | .188[c] | .623 | .544 | .170 | .623 |
| 4 | RDBUD | -.096[d] | -.359 | .725 | -.095 | .790 |
| | TECHEQ | .041[d] | .152 | .881 | .041 | .781 |
| | INFO | -.325[d] | -.916 | .375 | -.238 | .431 |

a. Dependent Variable: IILINK

b. Predictors in the Model: (Constant), TECHEM, INFO, TECHEQ

c. Predictors in the Model: (Constant), TECHEM, INFO

d. Predictors in the Model: (Constant), TECHEM

## Local textile

**Descriptive Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| IILINK | 8.90 | 17.882 | 31 |
| TECHEM | 2.90 | 4.962 | 31 |
| TECHEQ | 1.29 | .461 | 31 |
| INFO | .97 | 1.329 | 31 |
| RDBUD | 1.32 | .475 | 31 |

**Correlations**

| | | IILINK | TECHEM | TECHEQ | INFO | RDBUD |
|---|---|---|---|---|---|---|
| Pearson Correlation | IILINK | 1.000 | .092 | .072 | .684 | .180 |
| | TECHEM | .092 | 1.000 | .304 | .475 | .254 |
| | TECHEQ | .072 | .304 | 1.000 | .559 | .623 |
| | INFO | .684 | .475 | .559 | 1.000 | .492 |
| | RDBUD | .180 | .254 | .623 | .492 | 1.000 |
| Sig. (1-tailed) | IILINK | . | .312 | .350 | .000 | .166 |
| | TECHEM | .312 | . | .048 | .003 | .084 |
| | TECHEQ | .350 | .048 | . | .001 | .000 |
| | INFO | .000 | .003 | .001 | . | .002 |
| | RDBUD | .166 | .084 | .000 | .002 | . |
| N | IILINK | 31 | 31 | 31 | 31 | 31 |
| | TECHEM | 31 | 31 | 31 | 31 | 31 |
| | TECHEQ | 31 | 31 | 31 | 31 | 31 |
| | INFO | 31 | 31 | 31 | 31 | 31 |
| | RDBUD | 31 | 31 | 31 | 31 | 31 |

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | RDBUD, TECHEM, INFO, TECHEQ[b] | . | Enter |

a. Dependent Variable: IILINK

b. All requested variables entered.

**Model Summary[b]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .818[a] | .669 | .619 | 11.043 | 1.574 |

a. Predictors: (Constant), RDBUD, TECHEM, INFO, TECHEQ

b. Dependent Variable: IILINK

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 6422.300 | 4 | 1605.575 | 13.167 | .000[b] |
| | Residual | 3170.409 | 26 | 121.939 | | |
| | Total | 9592.710 | 30 | | | |

a. Dependent Variable: IILINK

b. Predictors: (Constant), RDBUD, TECHEM, INFO, TECHEQ

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 1 | (Constant) | 19.809 | 7.089 | | 2.795 | .010 | | |
| | TECHEM | -1.008 | .462 | -.280 | -2.181 | .038 | .773 | 1.294 |
| | TECHEQ | -16.956 | 6.021 | -.438 | -2.816 | .009 | .527 | 1.899 |
| | INFO | 14.282 | 2.027 | 1.061 | 7.045 | .000 | .560 | 1.785 |
| | RDBUD | .059 | 5.561 | .002 | .011 | .992 | .582 | 1.718 |

a. Dependent Variable: IILINK

**Collinearity Diagnostics[a]**

| Model | Dimension | Eigenvalue | Condition Index | Variance Proportions | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | (Constant) | TECHEM | TECHEQ | INFO | RDBUD |
| 1 | 1 | 3.882 | 1.000 | .00 | .02 | .00 | .02 | .00 |
| | 2 | .680 | 2.389 | .02 | .46 | .01 | .09 | .01 |
| | 3 | .350 | 3.332 | .01 | .52 | .00 | .66 | .00 |
| | 4 | .048 | 8.978 | .85 | .00 | .04 | .19 | .56 |
| | 5 | .041 | 9.782 | .11 | .00 | .95 | .05 | .43 |

a. Dependent Variable: IILINK

**Residuals Statistics[a]**

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| Predicted Value | -14.99 | 69.69 | 8.90 | 14.631 | 31 |
| Residual | -17.463 | 29.763 | .000 | 10.280 | 31 |
| Std. Predicted Value | -1.633 | 4.155 | .000 | 1.000 | 31 |
| Std. Residual | -1.581 | 2.695 | .000 | .931 | 31 |

a. Dependent Variable: IILINK

**One-Sample Kolmogorov-Smirnov Test**

| | | Standardized Residual |
|---|---|---|
| N | | 31 |
| Normal Parameters[a,b] | Mean | 0E-7 |
| | Std. Deviation | .93094934 |
| Most Extreme Differences | Absolute | .168 |
| | Positive | .168 |
| | Negative | -.105 |
| Kolmogorov-Smirnov Z | | .933 |
| Asymp. Sig. (2-tailed) | | .349 |

a. Test distribution is Normal.

b. Calculated from data.

## Stepwise selection

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | INFO | . | Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). |
| 2 | TECHEQ | . | Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). |
| 3 | TECHEM | . | Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). |

a. Dependent Variable: IILINK

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .684[a] | .469 | .450 | 13.259 |
| 2 | .780[b] | .609 | .581 | 11.573 |
| 3 | .818[c] | .669 | .633 | 10.836 |

a. Predictors: (Constant), INFO

b. Predictors: (Constant), INFO, TECHEQ

c. Predictors: (Constant), INFO, TECHEQ, TECHEM

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 4494.236 | 1 | 4494.236 | 25.563 | .000[b] |
| | Residual | 5098.473 | 29 | 175.809 | | |
| | Total | 9592.710 | 30 | | | |
| 2 | Regression | 5842.513 | 2 | 2921.256 | 21.811 | .000[c] |
| | Residual | 3750.197 | 28 | 133.936 | | |
| | Total | 9592.710 | 30 | | | |
| 3 | Regression | 6422.287 | 3 | 2140.762 | 18.231 | .000[d] |
| | Residual | 3170.423 | 27 | 117.423 | | |
| | Total | 9592.710 | 30 | | | |

a. Dependent Variable: IILINK

b. Predictors: (Constant), INFO

c. Predictors: (Constant), INFO, TECHEQ

d. Predictors: (Constant), INFO, TECHEQ, TECHEM

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | -.011 | 2.963 | | -.004 | .997 |
| | INFO | 9.211 | 1.822 | .684 | 5.056 | .000 |
| 2 | (Constant) | 19.312 | 6.616 | | 2.919 | .007 |
| | INFO | 12.617 | 1.919 | .938 | 6.576 | .000 |
| | TECHEQ | -17.529 | 5.525 | -.452 | -3.173 | .004 |
| 3 | (Constant) | 19.843 | 6.200 | | 3.201 | .003 |
| | INFO | 14.286 | 1.947 | 1.062 | 7.337 | .000 |
| | TECHEQ | -16.925 | 5.180 | -.437 | -3.267 | .003 |
| | TECHEM | -1.008 | .454 | -.280 | -2.222 | .035 |

a. Dependent Variable: IILINK

**Excluded Variables[a]**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| 1 | TECHEM | -.301[b] | -2.066 | .048 | -.364 | .775 |
| | TECHEQ | -.452[b] | -3.173 | .004 | -.514 | .687 |
| | RDBUD | -.207[b] | -1.347 | .189 | -.247 | .758 |
| 2 | TECHEM | -.280[c] | -2.222 | .035 | -.393 | .773 |
| | RDBUD | .001[c] | .007 | .995 | .001 | .582 |
| 3 | RDBUD | .002[d] | .011 | .992 | .002 | .582 |

a. Dependent Variable: IILINK

b. Predictors in the Model: (Constant), INFO

c. Predictors in the Model: (Constant), INFO, TECHEQ

d. Predictors in the Model: (Constant), INFO, TECHEQ, TECHEM

## Rice cracker

**Descriptive Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| IILINK | 4.71 | 4.210 | 17 |
| TECHEM | 2.18 | 3.610 | 17 |
| TECHEQ | 1.76 | .831 | 17 |
| INFO | 1.24 | 2.635 | 17 |
| RDBUD | 1.65 | .702 | 17 |

**Correlations**

| | | IILINK | TECHEM | TECHEQ | INFO | RDBUD |
|---|---|---|---|---|---|---|
| Pearson Correlation | IILINK | 1.000 | -.103 | .229 | .559 | .428 |
| | TECHEM | -.103 | 1.000 | .202 | .081 | .100 |
| | TECHEQ | .229 | .202 | 1.000 | .341 | .920 |
| | INFO | .559 | .081 | .341 | 1.000 | .419 |
| | RDBUD | .428 | .100 | .920 | .419 | 1.000 |
| Sig. (1-tailed) | IILINK | . | .347 | .188 | .010 | .043 |
| | TECHEM | .347 | . | .218 | .379 | .351 |
| | TECHEQ | .188 | .218 | . | .090 | .000 |
| | INFO | .010 | .379 | .090 | . | .047 |
| | RDBUD | .043 | .351 | .000 | .047 | . |
| N | IILINK | 17 | 17 | 17 | 17 | 17 |
| | TECHEM | 17 | 17 | 17 | 17 | 17 |
| | TECHEQ | 17 | 17 | 17 | 17 | 17 |
| | INFO | 17 | 17 | 17 | 17 | 17 |
| | RDBUD | 17 | 17 | 17 | 17 | 17 |

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | RDBUD, TECHEM, INFO, TECHEQ[b] | . | Enter |

a. Dependent Variable: IILINK

b. All requested variables entered.

**Model Summary[b]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .706[a] | .498 | .331 | 3.443 | 1.171 |

a. Predictors: (Constant), RDBUD, TECHEM, INFO, TECHEQ

b. Dependent Variable: IILINK

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 141.297 | 4 | 35.324 | 2.980 | .064[b] |
| | Residual | 142.233 | 12 | 11.853 | | |
| | Total | 283.529 | 16 | | | |

a. Dependent Variable: IILINK

b. Predictors: (Constant), RDBUD, TECHEM, INFO, TECHEQ

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 1 | (Constant) | 1.337 | 2.279 | | .587 | .568 | | |
| | TECHEM | -.074 | .251 | -.063 | -.295 | .773 | .905 | 1.105 |
| | TECHEQ | -4.577 | 2.780 | -.904 | -1.646 | .126 | .139 | 7.212 |
| | INFO | .661 | .364 | .414 | 1.816 | .094 | .805 | 1.242 |
| | RDBUD | 6.551 | 3.360 | 1.092 | 1.950 | .075 | .133 | 7.508 |

a. Dependent Variable: IILINK

**Collinearity Diagnostics[a]**

| Model | Dimension | Eigenvalue | Condition Index | Variance Proportions | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | (Constant) | TECHEM | TECHEQ | INFO | RDBUD |
| 1 | 1 | 3.583 | 1.000 | .01 | .02 | .00 | .02 | .00 |
| | 2 | .718 | 2.234 | .00 | .31 | .00 | .59 | .00 |
| | 3 | .589 | 2.466 | .02 | .59 | .00 | .26 | .00 |
| | 4 | .099 | 6.010 | .85 | .00 | .06 | .08 | .02 |
| | 5 | .011 | 17.981 | .11 | .07 | .94 | .06 | .97 |

a. Dependent Variable: IILINK

**Residuals Statistics[a]**

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| Predicted Value | -1.64 | 11.90 | 4.71 | 2.972 | 17 |
| Residual | -4.211 | 5.318 | .000 | 2.982 | 17 |
| Std. Predicted Value | -2.134 | 2.420 | .000 | 1.000 | 17 |
| Std. Residual | -1.223 | 1.545 | .000 | .866 | 17 |

a. Dependent Variable: IILINK

**One-Sample Kolmogorov-Smirnov Test**

| | | Standardized Residual |
|---|---|---|
| N | | 17 |
| Normal Parameters[a,b] | Mean | 0E-7 |
| | Std. Deviation | .86602540 |
| Most Extreme Differences | Absolute | .149 |
| | Positive | .149 |
| | Negative | -.106 |
| Kolmogorov-Smirnov Z | | .616 |
| Asymp. Sig. (2-tailed) | | .842 |

a. Test distribution is Normal.

b. Calculated from data.

## Stepwise selection

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | INFO | . | Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). |

a. Dependent Variable: IILINK

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .559[a] | .312 | .267 | 3.605 |

a. Predictors: (Constant), INFO

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 88.565 | 1 | 88.565 | 6.814 | .020[b] |
| | Residual | 194.964 | 15 | 12.998 | | |
| | Total | 283.529 | 16 | | | |

a. Dependent Variable: IILINK

b. Predictors: (Constant), INFO

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 3.603 | .971 | | 3.710 | .002 |
| | INFO | .893 | .342 | .559 | 2.610 | .020 |

a. Dependent Variable: IILINK

**Excluded Variables[a]**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| 1 | TECHEM | -.149[b] | -.683 | .506 | -.180 | .993 |
| | TECHEQ | .044[b] | .185 | .856 | .049 | .884 |
| | RDBUD | .235[b] | .996 | .336 | .257 | .824 |

a. Dependent Variable: IILINK

b. Predictors in the Model: (Constant), INFO

## All industries

**Descriptive Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| IILINK | 4.54 | 9.514 | 145 |
| TECHEM | 10.88 | 27.422 | 145 |
| TECHEQ | 1.72 | .741 | 145 |
| INFO | 1.61 | 2.476 | 145 |
| RDBUD | 1.70 | .748 | 145 |

**Correlations**

| | | IILINK | TECHEM | TECHEQ | INFO | RDBUD |
|---|---|---|---|---|---|---|
| Pearson Correlation | IILINK | 1.000 | .178 | -.026 | .399 | .035 |
| | TECHEM | .178 | 1.000 | .269 | .639 | .177 |
| | TECHEQ | -.026 | .269 | 1.000 | .346 | .600 |
| | INFO | .399 | .639 | .346 | 1.000 | .291 |
| | RDBUD | .035 | .177 | .600 | .291 | 1.000 |
| Sig. (1-tailed) | IILINK | . | .016 | .378 | .000 | .339 |
| | TECHEM | .016 | . | .001 | .000 | .017 |
| | TECHEQ | .378 | .001 | . | .000 | .000 |
| | INFO | .000 | .000 | .000 | . | .000 |
| | RDBUD | .339 | .017 | .000 | .000 | . |
| N | IILINK | 145 | 145 | 145 | 145 | 145 |
| | TECHEM | 145 | 145 | 145 | 145 | 145 |
| | TECHEQ | 145 | 145 | 145 | 145 | 145 |
| | INFO | 145 | 145 | 145 | 145 | 145 |
| | RDBUD | 145 | 145 | 145 | 145 | 145 |

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | RDBUD, TECHEM, TECHEQ, INFO[b] | . | Enter |

a. Dependent Variable: IILINK

b. All requested variables entered.

**Model Summary[b]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .445[a] | .198 | .175 | 8.640 | 2.062 |

a. Predictors: (Constant), RDBUD, TECHEM, TECHEQ, INFO

b. Dependent Variable: IILINK

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 2583.008 | 4 | 645.752 | 8.650 | .000[b] |
| | Residual | 10451.034 | 140 | 74.650 | | |
| | Total | 13034.041 | 144 | | | |

a. Dependent Variable: IILINK

b. Predictors: (Constant), RDBUD, TECHEM, TECHEQ, INFO

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 1 | (Constant) | 5.559 | 1.997 | | 2.784 | .006 | | |
| | TECHEM | -.040 | .034 | -.115 | -1.169 | .245 | .587 | 1.702 |
| | TECHEQ | -2.398 | 1.252 | -.187 | -1.916 | .057 | .603 | 1.657 |
| | INFO | 2.053 | .392 | .534 | 5.240 | .000 | .551 | 1.815 |
| | RDBUD | .147 | 1.212 | .012 | .122 | .903 | .630 | 1.587 |

a. Dependent Variable: IILINK

**Collinearity Diagnostics[a]**

| Model | Dimension | Eigenvalue | Condition Index | Variance Proportions | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | (Constant) | TECHEM | TECHEQ | INFO | RDBUD |
| 1 | 1 | 3.627 | 1.000 | .01 | .02 | .01 | .02 | .01 |
| | 2 | .956 | 1.948 | .02 | .27 | .01 | .09 | .01 |
| | 3 | .270 | 3.667 | .01 | .70 | .00 | .86 | .00 |
| | 4 | .085 | 6.515 | .94 | .00 | .11 | .03 | .32 |
| | 5 | .062 | 7.636 | .03 | .01 | .88 | .00 | .66 |

a. Dependent Variable: IILINK

**Residuals Statistics[a]**

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| Predicted Value | -5.54 | 32.59 | 4.54 | 4.235 | 145 |
| Residual | -11.588 | 70.704 | .000 | 8.519 | 145 |
| Std. Predicted Value | -2.380 | 6.624 | .000 | 1.000 | 145 |
| Std. Residual | -1.341 | 8.183 | .000 | .986 | 145 |

a. Dependent Variable: IILINK

**One-Sample Kolmogorov-Smirnov Test**

| | | Standardized Residual |
|---|---|---|
| N | | 145 |
| Normal Parameters[a,b] | Mean | 0E-7 |
| | Std. Deviation | .98601330 |
| Most Extreme Differences | Absolute | .226 |
| | Positive | .226 |
| | Negative | -.183 |
| Kolmogorov-Smirnov Z | | 2.717 |
| Asymp. Sig. (2-tailed) | | .000 |

a. Test distribution is Normal.

b. Calculated from data.

## Stepwise selection

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | INFO | . | Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). |
| 2 | TECHEQ | . | Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). |

a. Dependent Variable: IILINK

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .399[a] | .160 | .154 | 8.753 |
| 2 | .436[b] | .190 | .179 | 8.622 |

a. Predictors: (Constant), INFO

b. Predictors: (Constant), INFO, TECHEQ

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 2079.225 | 1 | 2079.225 | 27.141 | .000[b] |
| | Residual | 10954.817 | 143 | 76.607 | | |
| | Total | 13034.041 | 144 | | | |
| 2 | Regression | 2478.335 | 2 | 1239.168 | 16.670 | .000[c] |
| | Residual | 10555.706 | 142 | 74.336 | | |
| | Total | 13034.041 | 144 | | | |

a. Dependent Variable: IILINK

b. Predictors: (Constant), INFO

c. Predictors: (Constant), INFO, TECHEQ

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 2.072 | .867 | | 2.388 | .018 |
| | INFO | 1.535 | .295 | .399 | 5.210 | .000 |
| 2 | (Constant) | 5.804 | 1.824 | | 3.183 | .002 |
| | INFO | 1.783 | .309 | .464 | 5.764 | .000 |
| | TECHEQ | -2.396 | 1.034 | -.186 | -2.317 | .022 |

a. Dependent Variable: IILINK

**Excluded Variables[a]**

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| 1 | TECHEM | -.131[b] | -1.317 | .190 | -.110 | .592 |
| | TECHEQ | -.186[b] | -2.317 | .022 | -.191 | .880 |
| | RDBUD | -.089[b] | -1.113 | .268 | -.093 | .915 |
| 2 | TECHEM | -.116[c] | -1.182 | .239 | -.099 | .589 |
| | RDBUD | .018[c] | .191 | .848 | .016 | .632 |

a. Dependent Variable: IILINK

b. Predictors in the Model: (Constant), INFO

c. Predictors in the Model: (Constant), INFO, TECHEQ

# Appendix 8

## Tests of normality and homogeneity of H3(II)

### HDD industry

**One-Sample Kolmogorov-Smirnov Test**

| | | Financial support management | IP management | Technical services | R&D utilisation | In-house R&D | Knowledge circulation |
|---|---|---|---|---|---|---|---|
| N | | 3 | 3 | 6 | 6 | 6 | 6 |
| Normal Parameters[a,b] | Mean | 2.33 | 3.00 | 3.0000 | 3.1667 | 3.3333 | 3.1667 |
| | Std. Deviation | 1.155 | .000[c] | .00000[c] | .40825 | .51640 | .40825 |
| Most Extreme Differences | Absolute | .385 | | | .492 | .407 | .492 |
| | Positive | .282 | | | .492 | .407 | .492 |
| | Negative | -.385 | | | -.342 | -.259 | -.342 |
| Kolmogorov-Smirnov Z | | .667 | | | 1.205 | .998 | 1.205 |
| Asymp. Sig. (2-tailed) | | .766 | | | .110 | .272 | .110 |

a. Test distribution is Normal.

b. Calculated from data.

c. The distribution has no variance for this variable. One-Sample Kolmogorov-Smirnov Test cannot be performed.

## Automotive industry

**One-Sample Kolmogorov-Smirnov Test**

| | | Financial support management | IP management | Info about partners | Facilitating | Access to external resources | Technical services | R&D utilisation | In-house R&D | Knowledge circulation |
|---|---|---|---|---|---|---|---|---|---|---|
| N | | 4 | 4 | 22 | 22 | 20 | 22 | 19 | 18 | 20 |
| Normal Parameters[a,b] | Mean | 2.50 | 2.75 | 3.32 | 3.05 | 2.60 | 3.2273 | 2.7895 | 2.7222 | 3.1000 |
| | Std. Deviation | 1.291 | 1.500 | .646 | .785 | .940 | .92231 | .85498 | 1.01782 | .55251 |
| Most Extreme Differences | Absolute | .151 | .298 | .280 | .295 | .365 | .221 | .334 | .274 | .372 |
| | Positive | .151 | .202 | .280 | .250 | .235 | .188 | .245 | .170 | .372 |
| | Negative | -.151 | -.298 | -.263 | -.295 | -.365 | -.221 | -.334 | -.274 | -.328 |
| Kolmogorov-Smirnov Z | | .301 | .595 | 1.312 | 1.384 | 1.631 | 1.036 | 1.456 | 1.163 | 1.663 |
| Asymp. Sig. (2-tailed) | | 1.000 | .870 | .064 | .043 | .010 | .233 | .029 | .133 | .008 |

a. Test distribution is Normal.

b. Calculated from data.

## Ceramic industry

**One-Sample Kolmogorov-Smirnov Test**

| | | Financial support management | IP management | Info about partners | Facilitating | Access to external resources | Technical services | R&D utilisation | In-house R&D | Knowledge circulation |
|---|---|---|---|---|---|---|---|---|---|---|
| N | | 6 | 5 | 16 | 16 | 17 | 17 | 16 | 14 | 17 |
| Normal Parameters[a,b] | Mean | 3.17 | 3.2000 | 3.56 | 3.44 | 3.29 | 3.59 | 2.94 | 2.9286 | 3.24 |
| | Std. Deviation | 1.329 | .83666 | .512 | .964 | .849 | .795 | .998 | .82874 | 1.200 |
| Most Extreme Differences | Absolute | .283 | .231 | .366 | .283 | .224 | .241 | .225 | .320 | .267 |
| | Positive | .217 | .194 | .301 | .217 | .224 | .241 | .225 | .251 | .201 |
| | Negative | -.283 | -.231 | -.366 | -.283 | -.209 | -.227 | -.212 | -.320 | -.267 |
| Kolmogorov-Smirnov Z | | .694 | .515 | 1.464 | 1.131 | .923 | .993 | .900 | 1.198 | 1.102 |
| Asymp. Sig. (2-tailed) | | .721 | .953 | .028 | .155 | .362 | .278 | .393 | .114 | .176 |

a. Test distribution is Normal.

b. Calculated from data.

## Furniture industry

**One-Sample Kolmogorov-Smirnov Test**

| | | info about partners | facilitating | access to external resources | technical services | R&D utilisation | in-house R&D | knowledge circulation |
|---|---|---|---|---|---|---|---|---|
| N | | 7 | 7 | 7 | 4 | 4 | 3 | 3 |
| Normal Parameters[a,b] | Mean | 3.14 | 3.14 | 2.86 | 3.25 | 3.00 | 3.0000 | 3.00 |
| | Std. Deviation | .378 | .378 | .378 | .500 | .000[c] | .00000[c] | .000[c] |
| Most Extreme Differences | Absolute | .504 | .504 | .504 | .441 | | | |
| | Positive | .504 | .504 | .353 | .441 | | | |
| | Negative | -.353 | -.353 | -.504 | -.309 | | | |
| Kolmogorov-Smirnov Z | | 1.335 | 1.335 | 1.335 | .883 | | | |
| Asymp. Sig. (2-tailed) | | .057 | .057 | .057 | .417 | | | |

a. Test distribution is Normal.

b. Calculated from data.

c. The distribution has no variance for this variable. One-Sample Kolmogorov-Smirnov Test cannot be performed.

## Local textile industry

**One-Sample Kolmogorov-Smirnov Test**

| | | Financial support management | IP management | Info about partners | Facilitating | Access to external resources | Technical services | R&D utilisation | In-house R&D | Knowledge circulation |
|---|---|---|---|---|---|---|---|---|---|---|
| N | | 5 | 3 | 15 | 15 | 14 | 17 | 16 | 9 | 17 |
| Normal Parameters[a,b] | Mean | 3.60 | 3.67 | 4.13 | 3.73 | 3.57 | 3.76 | 3.69 | 3.78 | 3.76 |
| | Std. Deviation | .894 | 1.528 | .915 | .799 | .852 | .664 | .704 | .667 | .752 |
| Most Extreme Differences | Absolute | .349 | .253 | .242 | .297 | .249 | .403 | .273 | .297 | .329 |
| | Positive | .349 | .196 | .172 | .236 | .249 | .303 | .273 | .258 | .260 |
| | Negative | -.251 | -.253 | -.242 | -.297 | -.193 | -.403 | -.234 | -.297 | -.329 |
| Kolmogorov-Smirnov Z | | .780 | .438 | .938 | 1.152 | .931 | 1.662 | 1.092 | .892 | 1.355 |
| Asymp. Sig. (2-tailed) | | .577 | .991 | .343 | .141 | .351 | .008 | .184 | .404 | .051 |

a. Test distribution is Normal.

b. Calculated from data.

## Rice cracker industry

**One-Sample Kolmogorov-Smirnov Test**

| | | Financial support management | IP management | Info about partners | Facilitating | Access to external resources | Technical services | R&D utilisation | In-house R&D | knowledge circulation |
|---|---|---|---|---|---|---|---|---|---|---|
| N | | 6 | 6 | 6 | 6 | 6 | 11 | 10 | 9 | 11 |
| Normal Parameters[a,b] | Mean | 3.17 | 3.50 | 3.83 | 3.33 | 3.33 | 3.36 | 3.40 | 3.44 | 3.36 |
| | Std. Deviation | .408 | .837 | .753 | .816 | 1.033 | 1.027 | 1.075 | 1.014 | .924 |
| Most Extreme Differences | Absolute | .492 | .392 | .254 | .293 | .293 | .275 | .245 | .336 | .380 |
| | Positive | .492 | .392 | .246 | .207 | .293 | .275 | .245 | .336 | .380 |
| | Negative | -.342 | -.275 | -.254 | -.293 | -.207 | -.180 | -.155 | -.219 | -.256 |
| Kolmogorov-Smirnov Z | | 1.205 | .959 | .623 | .717 | .718 | .911 | .775 | 1.008 | 1.261 |
| Asymp. Sig. (2-tailed) | | .110 | .316 | .833 | .682 | .681 | .377 | .585 | .261 | .083 |

a. Test distribution is Normal.

b. Calculated from data.

**Test of Homogeneity of Variance[a,b,c,d,e,f,g,h,i,j]**

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| IP management | Based on Mean | 4.623 | 1 | 7 | .069 |
| | Based on Median | 3.370 | 1 | 7 | .109 |
| | Based on Median and with adjusted df | 3.370 | 1 | 6.945 | .109 |
| | Based on trimmed mean | 4.641 | 1 | 7 | .068 |
| info about partners | Based on Mean | 1.937 | 4 | 61 | .116 |
| | Based on Median | 1.208 | 4 | 61 | .317 |
| | Based on Median and with adjusted df | 1.208 | 4 | 57.769 | .317 |
| | Based on trimmed mean | 2.403 | 4 | 61 | .059 |
| facilitating | Based on Mean | 1.375 | 4 | 61 | .253 |
| | Based on Median | .913 | 4 | 61 | .462 |
| | Based on Median and with adjusted df | .913 | 4 | 49.605 | .464 |
| | Based on trimmed mean | 1.419 | 4 | 61 | .238 |
| access to external resources | Based on Mean | 1.753 | 4 | 59 | .150 |
| | Based on Median | .998 | 4 | 59 | .416 |
| | Based on Median and with adjusted df | .998 | 4 | 46.951 | .418 |
| | Based on trimmed mean | 1.868 | 4 | 59 | .128 |

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| technical services | Based on Mean | 1.383 | 4 | 66 | .249 |
| | Based on Median | 1.114 | 4 | 66 | .357 |
| | Based on Median and with adjusted df | 1.114 | 4 | 62.885 | .358 |
| | Based on trimmed mean | 1.491 | 4 | 66 | .215 |
| R&D utilisation | Based on Mean | 1.320 | 4 | 62 | .273 |
| | Based on Median | 1.024 | 4 | 62 | .402 |
| | Based on Median and with adjusted df | 1.024 | 4 | 55.989 | .403 |
| | Based on trimmed mean | 1.394 | 4 | 62 | .246 |
| in-house R&D | Based on Mean | 1.186 | 4 | 51 | .328 |
| | Based on Median | .542 | 4 | 51 | .706 |
| | Based on Median and with adjusted df | .542 | 4 | 45.978 | .706 |
| | Based on trimmed mean | 1.167 | 4 | 51 | .336 |
| knowledge circulation | Based on Mean | 5.928 | 4 | 66 | .000 |
| | Based on Median | 2.750 | 4 | 66 | .035 |
| | Based on Median and with adjusted df | 2.750 | 4 | 48.109 | .039 |
| | Based on trimmed mean | 5.792 | 4 | 66 | .000 |

a. There are no valid cases for financial support management when Industry = 4.000. Statistics cannot be computed for this level.

b. IP management is constant when Industry = 1. It has been omitted.

c. There are no valid cases for IP management when Industry = 4.000. Statistics cannot be computed for this level.

d. info about partners is constant when Industry = 1. It has been omitted.

e. facilitating is constant when Industry = 1. It has been omitted.

f. access to external resources is constant when Industry = 1. It has been omitted.

g. technical services is constant when Industry = 1. It has been omitted.

h. R&D utilisation is constant when Industry = 4. It has been omitted.

i. in-house R&D is constant when Industry = 4. It has been omitted.

j. knowledge circulation is constant when Industry = 4. It has been omitted.

# Appendix 9

# ANOVA for H2(II)

**Descriptives**

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| Financial support management | 1 | 3 | 2.33 | 1.155 | .667 | -.54 | 5.20 | 1 | 3 |
| | 2 | 4 | 2.50 | 1.291 | .645 | .45 | 4.55 | 1 | 4 |
| | 3 | 6 | 3.17 | 1.329 | .543 | 1.77 | 4.56 | 1 | 5 |
| | 4 | 0 | . | . | . | . | . | . | . |
| | 5 | 5 | 3.60 | .894 | .400 | 2.49 | 4.71 | 3 | 5 |
| | 6 | 6 | 3.17 | .408 | .167 | 2.74 | 3.60 | 3 | 4 |
| | Total | 24 | 3.04 | 1.042 | .213 | 2.60 | 3.48 | 1 | 5 |
| IP management | 1 | 3 | 3.00 | .000 | .000 | 3.00 | 3.00 | 3 | 3 |
| | 2 | 4 | 2.75 | 1.500 | .750 | .36 | 5.14 | 1 | 4 |
| | 3 | 5 | 3.20 | .837 | .374 | 2.16 | 4.24 | 2 | 4 |
| | 4 | 0 | . | . | . | . | . | . | . |
| | 5 | 3 | 3.67 | 1.528 | .882 | -.13 | 7.46 | 2 | 5 |
| | 6 | 6 | 3.50 | .837 | .342 | 2.62 | 4.38 | 3 | 5 |
| | Total | 21 | 3.24 | .995 | .217 | 2.79 | 3.69 | 1 | 5 |
| Info about partners | 1 | 1 | 4.00 | . | . | . | . | 4 | 4 |
| | 2 | 22 | 3.32 | .646 | .138 | 3.03 | 3.60 | 2 | 4 |
| | 3 | 16 | 3.56 | .512 | .128 | 3.29 | 3.84 | 3 | 4 |
| | 4 | 7 | 3.14 | .378 | .143 | 2.79 | 3.49 | 3 | 4 |
| | 5 | 15 | 4.13 | .915 | .236 | 3.63 | 4.64 | 2 | 5 |
| | 6 | 6 | 3.83 | .753 | .307 | 3.04 | 4.62 | 3 | 5 |
| | Total | 67 | 3.60 | .740 | .090 | 3.42 | 3.78 | 2 | 5 |
| Facilitating | 1 | 1 | 3.00 | . | . | . | . | 3 | 3 |
| | 2 | 22 | 3.05 | .785 | .167 | 2.70 | 3.39 | 1 | 4 |
| | 3 | 16 | 3.44 | .964 | .241 | 2.92 | 3.95 | 1 | 5 |
| | 4 | 7 | 3.14 | .378 | .143 | 2.79 | 3.49 | 3 | 4 |
| | 5 | 15 | 3.73 | .799 | .206 | 3.29 | 4.18 | 2 | 5 |
| | 6 | 6 | 3.33 | .816 | .333 | 2.48 | 4.19 | 2 | 4 |
| | Total | 67 | 3.33 | .824 | .101 | 3.13 | 3.53 | 1 | 5 |
| Access to external resources | 1 | 1 | 2.00 | . | . | . | . | 2 | 2 |
| | 2 | 20 | 2.60 | .940 | .210 | 2.16 | 3.04 | 1 | 4 |
| | 3 | 17 | 3.29 | .849 | .206 | 2.86 | 3.73 | 2 | 5 |
| | 4 | 7 | 2.86 | .378 | .143 | 2.51 | 3.21 | 2 | 3 |
| | 5 | 14 | 3.57 | .852 | .228 | 3.08 | 4.06 | 2 | 5 |
| | 6 | 6 | 3.33 | 1.033 | .422 | 2.25 | 4.42 | 2 | 5 |
| | Total | 65 | 3.08 | .924 | .115 | 2.85 | 3.31 | 1 | 5 |
| Technical services | 1 | 6 | 3.00 | .000 | .000 | 3.00 | 3.00 | 3 | 3 |
| | 2 | 22 | 3.23 | .922 | .197 | 2.82 | 3.64 | 1 | 5 |
| | 3 | 17 | 3.59 | .795 | .193 | 3.18 | 4.00 | 2 | 5 |
| | 4 | 4 | 3.25 | .500 | .250 | 2.45 | 4.05 | 3 | 4 |
| | 5 | 17 | 3.76 | .664 | .161 | 3.42 | 4.11 | 2 | 5 |
| | 6 | 11 | 3.36 | 1.027 | .310 | 2.67 | 4.05 | 2 | 5 |
| | Total | 77 | 3.43 | .818 | .093 | 3.24 | 3.61 | 1 | 5 |

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| R&D utilisation | 1 | 6 | 3.17 | .408 | .167 | 2.74 | 3.60 | 3 | 4 |
| | 2 | 19 | 2.79 | .855 | .196 | 2.38 | 3.20 | 1 | 4 |
| | 3 | 16 | 2.94 | .998 | .249 | 2.41 | 3.47 | 1 | 5 |
| | 4 | 4 | 3.00 | .000 | .000 | 3.00 | 3.00 | 3 | 3 |
| | 5 | 16 | 3.69 | .704 | .176 | 3.31 | 4.06 | 3 | 5 |
| | 6 | 10 | 3.40 | 1.075 | .340 | 2.63 | 4.17 | 2 | 5 |
| | Total | 71 | 3.15 | .889 | .105 | 2.94 | 3.37 | 1 | 5 |
| In-house R&D | 1 | 6 | 3.33 | .516 | .211 | 2.79 | 3.88 | 3 | 4 |
| | 2 | 18 | 2.72 | 1.018 | .240 | 2.22 | 3.23 | 1 | 4 |
| | 3 | 14 | 2.93 | .829 | .221 | 2.45 | 3.41 | 1 | 4 |
| | 4 | 3 | 3.00 | .000 | .000 | 3.00 | 3.00 | 3 | 3 |
| | 5 | 9 | 3.78 | .667 | .222 | 3.27 | 4.29 | 3 | 5 |
| | 6 | 9 | 3.44 | 1.014 | .338 | 2.67 | 4.22 | 2 | 5 |
| | Total | 59 | 3.12 | .911 | .119 | 2.88 | 3.36 | 1 | 5 |
| Knowledge circulation | 1 | 6 | 3.17 | .408 | .167 | 2.74 | 3.60 | 3 | 4 |
| | 2 | 20 | 3.10 | .553 | .124 | 2.84 | 3.36 | 2 | 4 |
| | 3 | 17 | 3.24 | 1.200 | .291 | 2.62 | 3.85 | 1 | 5 |
| | 4 | 3 | 3.00 | .000 | .000 | 3.00 | 3.00 | 3 | 3 |
| | 5 | 17 | 3.76 | .752 | .182 | 3.38 | 4.15 | 2 | 5 |
| | 6 | 11 | 3.36 | .924 | .279 | 2.74 | 3.98 | 2 | 5 |
| | Total | 74 | 3.32 | .846 | .098 | 3.13 | 3.52 | 1 | 5 |

# Appendix 10

# Spearman Correlation for H2(III)

## HDD industry

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| ALLLINK * TECHCAP | 7 | 100.0% | 0 | 0.0% | 7 | 100.0% |

**ALLLINK * TECHCAP Crosstabulation**

Count

| | | TECHCAP | | | Total |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | |
| ALLLINK | 0 | 1 | 0 | 0 | 1 |
| | 1 | 1 | 0 | 0 | 1 |
| | 2 | 0 | 1 | 0 | 1 |
| | 5 | 0 | 1 | 1 | 2 |
| | 6 | 1 | 0 | 0 | 1 |
| | 78 | 0 | 0 | 1 | 1 |
| Total | | 3 | 2 | 2 | 7 |

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Interval by Interval | Pearson's R | .587 | .215 | 1.620 | .166[c] |
| Ordinal by Ordinal | Spearman Correlation | .553 | .342 | 1.484 | .198[c] |
| N of Valid Cases | | 7 | | | |

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

## Automotive industry

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| ALLLINK * TECHCAP | 43 | 100.0% | 0 | 0.0% | 43 | 100.0% |

**ALLLINK * TECHCAP Crosstabulation**

Count

| | | TECHCAP | | | Total |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | |
| ALLLINK | 0 | 2 | 1 | 0 | 3 |
| | 1 | 1 | 2 | 1 | 4 |
| | 2 | 4 | 3 | 1 | 8 |
| | 3 | 0 | 2 | 0 | 2 |
| | 4 | 2 | 1 | 1 | 4 |
| | 5 | 4 | 3 | 2 | 9 |
| | 6 | 3 | 2 | 1 | 6 |
| | 7 | 0 | 1 | 0 | 1 |
| | 8 | 1 | 0 | 0 | 1 |
| | 9 | 0 | 1 | 1 | 2 |
| | 15 | 1 | 0 | 0 | 1 |
| | 24 | 0 | 0 | 1 | 1 |
| | 30 | 0 | 0 | 1 | 1 |
| Total | | 18 | 16 | 9 | 43 |

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Interval by Interval | Pearson's R | .298 | .145 | 2.002 | .052[c] |
| Ordinal by Ordinal | Spearman Correlation | .150 | .156 | .968 | .339[c] |
| N of Valid Cases | | 43 | | | |

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

## Ceramic industry

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| ALLLINK * TECHCAP | 30 | 100.0% | 0 | 0.0% | 30 | 100.0% |

**ALLLINK * TECHCAP Crosstabulation**

Count

| | | TECHCAP | | | Total |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | |
| ALLLINK | 0 | 4 | 0 | 1 | 5 |
| | 1 | 2 | 2 | 0 | 4 |
| | 2 | 1 | 2 | 1 | 4 |
| | 3 | 0 | 1 | 1 | 2 |
| | 4 | 1 | 1 | 1 | 3 |
| | 5 | 0 | 1 | 1 | 2 |
| | 8 | 1 | 0 | 1 | 2 |
| | 9 | 1 | 1 | 0 | 2 |
| | 10 | 1 | 0 | 0 | 1 |
| | 11 | 0 | 0 | 1 | 1 |
| | 12 | 0 | 0 | 1 | 1 |
| | 13 | 1 | 0 | 0 | 1 |
| | 20 | 0 | 1 | 0 | 1 |
| | 22 | 0 | 1 | 0 | 1 |
| Total | | 12 | 10 | 8 | 30 |

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Interval by Interval | Pearson's R | .135 | .138 | .723 | .476[c] |
| Ordinal by Ordinal | Spearman Correlation | .239 | .181 | 1.302 | .203[c] |
| N of Valid Cases | | 30 | | | |

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

## Furniture industry

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| ALLLINK * TECHCAP | 17 | 100.0% | 0 | 0.0% | 17 | 100.0% |

**ALLLINK * TECHCAP Crosstabulation**

Count

| | | TECHCAP | | | Total |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | |
| ALLLINK | 0 | 1 | 4 | 0 | 5 |
| | 1 | 3 | 3 | 0 | 6 |
| | 2 | 0 | 1 | 2 | 3 |
| | 3 | 0 | 0 | 1 | 1 |
| | 4 | 0 | 1 | 0 | 1 |
| | 5 | 1 | 0 | 0 | 1 |
| Total | | 5 | 9 | 3 | 17 |

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Interval by Interval | Pearson's R | .112 | .257 | .437 | .669[c] |
| Ordinal by Ordinal | Spearman Correlation | .226 | .254 | .897 | .384[c] |
| N of Valid Cases | | 17 | | | |

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

# Local textile industry

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| ALLLINK * TECHCAP | 31 | 100.0% | 0 | 0.0% | 31 | 100.0% |

**ALLLINK * TECHCAP Crosstabulation**

Count

| | | TECHCAP | | | Total |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | |
| ALLLINK | 0 | 5 | 0 | 0 | 5 |
| | 1 | 1 | 0 | 0 | 1 |
| | 2 | 3 | 0 | 0 | 3 |
| | 3 | 1 | 0 | 1 | 2 |
| | 5 | 1 | 0 | 0 | 1 |
| | 6 | 1 | 2 | 0 | 3 |
| | 7 | 1 | 1 | 0 | 2 |
| | 8 | 1 | 0 | 0 | 1 |
| | 9 | 1 | 0 | 0 | 1 |
| | 10 | 0 | 0 | 1 | 1 |
| | 11 | 2 | 0 | 0 | 2 |
| | 13 | 1 | 0 | 0 | 1 |
| | 14 | 0 | 0 | 1 | 1 |
| | 15 | 1 | 0 | 0 | 1 |
| | 16 | 1 | 0 | 0 | 1 |
| | 17 | 1 | 0 | 0 | 1 |
| | 23 | 0 | 1 | 0 | 1 |
| | 59 | 1 | 0 | 0 | 1 |
| | 98 | 1 | 0 | 1 | 2 |
| Total | | 23 | 4 | 4 | 31 |

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Interval by Interval | Pearson's R | .220 | .235 | 1.212 | .235[c] |
| Ordinal by Ordinal | Spearman Correlation | .254 | .154 | 1.417 | .167[c] |
| N of Valid Cases | | 31 | | | |

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

## Rice cracker industry

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| ALLLINK * TECHCAP | 17 | 100.0% | 0 | 0.0% | 17 | 100.0% |

**ALLLINK * TECHCAP Crosstabulation**

Count

| | | TECHCAP | | | Total |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | |
| ALLLINK | 0 | 3 | 0 | 0 | 3 |
| | 3 | 1 | 0 | 1 | 2 |
| | 4 | 0 | 0 | 1 | 1 |
| | 6 | 1 | 0 | 0 | 1 |
| | 9 | 1 | 0 | 1 | 2 |
| | 10 | 2 | 0 | 0 | 2 |
| | 13 | 1 | 0 | 1 | 2 |
| | 14 | 1 | 0 | 0 | 1 |
| | 15 | 1 | 0 | 0 | 1 |
| | 19 | 0 | 0 | 1 | 1 |
| | 24 | 0 | 1 | 0 | 1 |
| Total | | 11 | 1 | 5 | 17 |

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Interval by Interval | Pearson's R | .210 | .200 | .830 | .420[c] |
| Ordinal by Ordinal | Spearman Correlation | .207 | .225 | .818 | .426[c] |
| N of Valid Cases | | 17 | | | |

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

## All industries

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| ALLLINK * TECHCAP | 145 | 100.0% | 0 | 0.0% | 145 | 100.0% |

**ALLLINK * TECHCAP Crosstabulation**

Count

| | | TECHCAP | | | Total |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | |
| ALLLINK | 0 | 14 | 5 | 1 | 20 |
| | 1 | 20 | 9 | 1 | 30 |
| | 2 | 10 | 14 | 10 | 34 |
| | 3 | 4 | 3 | 6 | 13 |
| | 4 | 1 | 2 | 2 | 5 |
| | 5 | 2 | 2 | 2 | 6 |
| | 6 | 3 | 2 | 0 | 5 |
| | 7 | 1 | 1 | 0 | 2 |
| | 8 | 2 | 0 | 1 | 3 |
| | 9 | 3 | 1 | 1 | 5 |
| | 11 | 2 | 0 | 1 | 3 |
| | 12 | 0 | 0 | 1 | 1 |
| | 13 | 3 | 0 | 1 | 4 |
| | 14 | 1 | 0 | 1 | 2 |
| | 15 | 2 | 0 | 0 | 2 |
| | 16 | 1 | 0 | 0 | 1 |
| | 17 | 1 | 0 | 0 | 1 |
| | 19 | 0 | 0 | 1 | 1 |
| | 22 | 0 | 1 | 0 | 1 |
| | 23 | 0 | 1 | 0 | 1 |
| | 24 | 0 | 1 | 0 | 1 |
| | 59 | 1 | 0 | 0 | 1 |
| | 78 | 0 | 0 | 1 | 1 |
| | 98 | 1 | 0 | 1 | 2 |
| Total | | 72 | 42 | 31 | 145 |

**Symmetric Measures**

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Interval by Interval | Pearson's R | .090 | .101 | 1.085 | .280[c] |
| Ordinal by Ordinal | Spearman Correlation | .194 | .081 | 2.366 | .019[c] |
| N of Valid Cases | | 145 | | | |

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

## H2(III) – MNC-dominated industries

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Included | | Excluded | | Total | |
| | N | Percent | N | Percent | N | Percent |
| financial support management | 7 | 14.0% | 43 | 86.0% | 50 | 100.0% |
| IP management | 7 | 14.0% | 43 | 86.0% | 50 | 100.0% |
| info about partners | 23 | 46.0% | 27 | 54.0% | 50 | 100.0% |
| facilitating | 23 | 46.0% | 27 | 54.0% | 50 | 100.0% |
| access to external resources | 21 | 42.0% | 29 | 58.0% | 50 | 100.0% |
| technical services | 28 | 56.0% | 22 | 44.0% | 50 | 100.0% |
| R&D utilisation | 25 | 50.0% | 25 | 50.0% | 50 | 100.0% |
| in-house R&D | 24 | 48.0% | 26 | 52.0% | 50 | 100.0% |
| knowledge circulation | 26 | 52.0% | 24 | 48.0% | 50 | 100.0% |

**Report**

| | financial support manage-ment | IP manage-ment | info about partners | facilitating | access to external resources | technical services | R&D utilisation | in-house R&D | knowledge circulation |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 2.43 | 2.86 | 3.35 | 3.04 | 2.57 | 3.18 | 2.88 | 2.88 | 3.12 |
| N | 7 | 7 | 23 | 23 | 21 | 28 | 25 | 24 | 26 |
| Std. Deviation | 1.134 | 1.069 | .647 | .767 | .926 | .819 | .781 | .947 | .516 |

**ANOVA**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Financial support management | Between Groups | .048 | 1 | .048 | .031 | .867 |
| | Within Groups | 7.667 | 5 | 1.533 | | |
| | Total | 7.714 | 6 | | | |
| IP management | Between Groups | .107 | 1 | .107 | .079 | .789 |
| | Within Groups | 6.750 | 5 | 1.350 | | |
| | Total | 6.857 | 6 | | | |
| Info about partners | Between Groups | .445 | 1 | .445 | 1.064 | .314 |
| | Within Groups | 8.773 | 21 | .418 | | |
| | Total | 9.217 | 22 | | | |
| Facilitating | Between Groups | .002 | 1 | .002 | .003 | .955 |
| | Within Groups | 12.955 | 21 | .617 | | |
| | Total | 12.957 | 22 | | | |
| Access to external resources | Between Groups | .343 | 1 | .343 | .388 | .541 |
| | Within Groups | 16.800 | 19 | .884 | | |
| | Total | 17.143 | 20 | | | |
| Technical services | Between Groups | .244 | 1 | .244 | .354 | .557 |
| | Within Groups | 17.864 | 26 | .687 | | |
| | Total | 18.107 | 27 | | | |
| R&D utilisation | Between Groups | .649 | 1 | .649 | 1.067 | .312 |
| | Within Groups | 13.991 | 23 | .608 | | |
| | Total | 14.640 | 24 | | | |
| In-house R&D | Between Groups | 1.681 | 1 | 1.681 | 1.952 | .176 |
| | Within Groups | 18.944 | 22 | .861 | | |
| | Total | 20.625 | 23 | | | |
| Knowledge circulation | Between Groups | .021 | 1 | .021 | .074 | .788 |
| | Within Groups | 6.633 | 24 | .276 | | |
| | Total | 6.654 | 25 | | | |

## H2(III) – SME-based industries

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Included | | Excluded | | Total | |
| | N | Percent | N | Percent | N | Percent |
| financial support management | 6 | 12.8% | 41 | 87.2% | 47 | 100.0% |
| IP management | 5 | 10.6% | 42 | 89.4% | 47 | 100.0% |
| info about partners | 23 | 48.9% | 24 | 51.1% | 47 | 100.0% |
| facilitating | 23 | 48.9% | 24 | 51.1% | 47 | 100.0% |
| access to external resources | 24 | 51.1% | 23 | 48.9% | 47 | 100.0% |
| technical services | 21 | 44.7% | 26 | 55.3% | 47 | 100.0% |
| R&D utilisation | 20 | 42.6% | 27 | 57.4% | 47 | 100.0% |
| in-house R&D | 17 | 36.2% | 30 | 63.8% | 47 | 100.0% |
| knowledge circulation | 20 | 42.6% | 27 | 57.4% | 47 | 100.0% |

**Report**

| | financial support manage-ment | IP manage-ment | info about partners | facilitating | access to external resources | technical services | R&D utilisation | in-house R&D | knowledge circulation |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 3.17 | 3.20 | 3.43 | 3.35 | 3.17 | 3.52 | 2.95 | 2.94 | 3.20 |
| N | 6 | 5 | 23 | 23 | 24 | 21 | 20 | 17 | 20 |
| Std. Deviation | 1.329 | .837 | .507 | .832 | .761 | .750 | .887 | .748 | 1.105 |

**ANOVA**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Info about partners | Between Groups | .858 | 1 | .858 | 3.756 | .066 |
| | Within Groups | 4.795 | 21 | .228 | | |
| | Total | 5.652 | 22 | | | |
| Facilitating | Between Groups | .423 | 1 | .423 | .600 | .447 |
| | Within Groups | 14.795 | 21 | .705 | | |
| | Total | 15.217 | 22 | | | |
| Access to external resources | Between Groups | .947 | 1 | .947 | 1.682 | .208 |
| | Within Groups | 12.387 | 22 | .563 | | |
| | Total | 13.333 | 23 | | | |
| Technical services | Between Groups | .370 | 1 | .370 | .648 | .431 |
| | Within Groups | 10.868 | 19 | .572 | | |
| | Total | 11.238 | 20 | | | |
| R&D utilisation | Between Groups | .013 | 1 | .013 | .015 | .904 |
| | Within Groups | 14.938 | 18 | .830 | | |
| | Total | 14.950 | 19 | | | |
| In-house R&D | Between Groups | .013 | 1 | .013 | .021 | .886 |
| | Within Groups | 8.929 | 15 | .595 | | |
| | Total | 8.941 | 16 | | | |
| Knowledge circulation | Between Groups | .141 | 1 | .141 | .110 | .744 |
| | Within Groups | 23.059 | 18 | 1.281 | | |
| | Total | 23.200 | 19 | | | |

## H2(III) – CE-based industries

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Included | | Excluded | | Total | |
| | N | Percent | N | Percent | N | Percent |
| financial support management | 11 | 22.9% | 37 | 77.1% | 48 | 100.0% |
| IP management | 9 | 18.8% | 39 | 81.3% | 48 | 100.0% |
| info about partners | 21 | 43.8% | 27 | 56.3% | 48 | 100.0% |
| facilitating | 21 | 43.8% | 27 | 56.3% | 48 | 100.0% |
| access to external resources | 20 | 41.7% | 28 | 58.3% | 48 | 100.0% |
| technical services | 28 | 58.3% | 20 | 41.7% | 48 | 100.0% |
| R&D utilisation | 26 | 54.2% | 22 | 45.8% | 48 | 100.0% |
| in-house R&D | 18 | 37.5% | 30 | 62.5% | 48 | 100.0% |
| knowledge circulation | 28 | 58.3% | 20 | 41.7% | 48 | 100.0% |

**Report**

| | financial support manage-ment | IP manage-ment | info about partners | facilitating | access to external resources | technical services | R&D utilisation | in-house R&D | knowledge circulation |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 3.36 | 3.56 | 4.05 | 3.62 | 3.50 | 3.61 | 3.58 | 3.61 | 3.61 |
| N | 11 | 9 | 21 | 21 | 20 | 28 | 26 | 18 | 28 |
| Std. Deviation | .674 | 1.014 | .865 | .805 | .889 | .832 | .857 | .850 | .832 |

**ANOVA**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Financial support management | Between Groups | .512 | 1 | .512 | 1.143 | .313 |
| | Within Groups | 4.033 | 9 | .448 | | |
| | Total | 4.545 | 10 | | | |
| IP management | Between Groups | .056 | 1 | .056 | .048 | .833 |
| | Within Groups | 8.167 | 7 | 1.167 | | |
| | Total | 8.222 | 8 | | | |
| Info about partners | Between Groups | .386 | 1 | .386 | .503 | .487 |
| | Within Groups | 14.567 | 19 | .767 | | |
| | Total | 14.952 | 20 | | | |
| Facilitating | Between Groups | .686 | 1 | .686 | 1.062 | .316 |
| | Within Groups | 12.267 | 19 | .646 | | |
| | Total | 12.952 | 20 | | | |
| Access to external resources | Between Groups | .238 | 1 | .238 | .290 | .597 |
| | Within Groups | 14.762 | 18 | .820 | | |
| | Total | 15.000 | 19 | | | |
| Technical services | Between Groups | 1.074 | 1 | 1.074 | 1.587 | .219 |
| | Within Groups | 17.604 | 26 | .677 | | |
| | Total | 18.679 | 27 | | | |
| R&D utilisation | Between Groups | .509 | 1 | .509 | .684 | .416 |
| | Within Groups | 17.838 | 24 | .743 | | |
| | Total | 18.346 | 25 | | | |
| In-house R&D | Between Groups | .500 | 1 | .500 | .679 | .422 |
| | Within Groups | 11.778 | 16 | .736 | | |
| | Total | 12.278 | 17 | | | |
| Knowledge circulation | Between Groups | 1.074 | 1 | 1.074 | 1.587 | .219 |
| | Within Groups | 17.604 | 26 | .677 | | |
| | Total | 18.679 | 27 | | | |

## H2(III) – Three industry groups

**ANOVA**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Financial support management | Between Groups | 3.865 | 2 | 1.933 | 1.924 | .171 |
| | Within Groups | 21.093 | 21 | 1.004 | | |
| | Total | 24.958 | 23 | | | |
| IP management | Between Groups | 1.930 | 2 | .965 | .972 | .397 |
| | Within Groups | 17.879 | 18 | .993 | | |
| | Total | 19.810 | 20 | | | |
| Info about partners | Between Groups | 6.297 | 2 | 3.149 | 6.757 | .002 |
| | Within Groups | 29.822 | 64 | .466 | | |
| | Total | 36.119 | 66 | | | |
| Facilitating | Between Groups | 3.650 | 2 | 1.825 | 2.840 | .066 |
| | Within Groups | 41.126 | 64 | .643 | | |
| | Total | 44.776 | 66 | | | |
| Access to external resources | Between Groups | 9.139 | 2 | 4.570 | 6.230 | .003 |
| | Within Groups | 45.476 | 62 | .733 | | |
| | Total | 54.615 | 64 | | | |
| Technical services | Between Groups | 2.833 | 2 | 1.417 | 2.183 | .120 |
| | Within Groups | 48.024 | 74 | .649 | | |
| | Total | 50.857 | 76 | | | |
| R&D utilisation | Between Groups | 7.360 | 2 | 3.680 | 5.220 | .008 |
| | Within Groups | 47.936 | 68 | .705 | | |
| | Total | 55.296 | 70 | | | |
| In-house R&D | Between Groups | 6.326 | 2 | 3.163 | 4.233 | .019 |
| | Within Groups | 41.844 | 56 | .747 | | |
| | Total | 48.169 | 58 | | | |
| Knowledge circulation | Between Groups | 3.684 | 2 | 1.842 | 2.695 | .074 |
| | Within Groups | 48.532 | 71 | .684 | | |
| | Total | 52.216 | 73 | | | |

# Appendix 11

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