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**Facilitating Innovation in SMEs:
The Case of Public Intermediaries in South Korea**

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Doctor of Philosophy
The University of Edinburgh
2015

Declaration

I hereby declare that this following thesis is my own work and that, to the best of my knowledge, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institutes of higher learning, except where due acknowledgement is made in the text.

February 2015

Eun Sun KIM

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Abstract

This study addresses public sector intermediaries and their role in facilitating innovation in Small and Medium Sized Enterprises (SMEs) in South Korea. The primary aim is to understand and address the informational and relational barriers that SMEs face during the innovation process and how these are resolved through interaction. Although the government has been implementing SME support policies for several decades, the Korean National Innovation System (KNIS) has been characterised with six words: ‘strong large firms, weak small firms’. Korean Government policies for R&D have not been effective in enhancing the economic performance and innovative capabilities of SMEs and the ‘low level of competitiveness’ of SMEs obstructs knowledge interaction between firms. Policies directed at SMEs mainly focus on direct support and do not reflect the interactive nature of the innovation process. This mismatch between policy and desired outcomes has led this study to go beyond examining the informational and relational constraints. It analyses the factors influencing successful (or less successful) innovation and asks whether public intermediaries have provided an effective mechanism in resolving innovation barriers (i.e. system failures).

Yet, there has been a lack of research into public intermediaries and SMEs within the National Innovation Systems (NIS) framework. The NIS approach is a loosely configured framework and the intermediary literature is fragmented and has rarely been integrated with the NIS literature. Research has tended to focus on specific functions of private intermediaries and far less on the public intermediaries, which have been playing a crucial role in facilitating innovation in Korean industry for several decades. The central focus of this study is on the knowledge interaction process between public intermediaries and SMEs occurring at multiple levels of interaction in the Korean NIS. This study therefore attempts to integrate the NIS concept and the intermediary approach to provide a robust way to explore the knowledge interaction process at meso- and micro-levels. Four functions of the intermediary are constructed to explore how they might influence SME innovation: knowledge facilitation, learning facilitation, knowledge enabling and managing interfaces.

Through in-depth analysis of five case studies encompassing firms in mechatronics and IT, this study explicates the knowledge interaction process and influential factors of successful innovation. The analysis addresses a series of issues that the generic NIS concept cannot fully explain: (1) knowledge interaction at meso- and micro-levels; (2) multiplicity of relationships and their evolving nature; (3) the role of public intermediaries in a specific cultural context; and (4) the heterogeneity of SMEs with their pre-existing resources and routines. Sociological perspectives especially provide insights for investigating not only the dynamic nature of interactions but also micro-level factors that determine successful interactions and innovation that are largely neglected in both NIS and intermediary studies; e.g. productive combination of competing rationalities, social learning, and the importance of reflexive individuals. Focusing on a modulated NIS concept for public sector intermediaries and SMEs in a Korean context, the study opens the ‘black box’ of knowledge interaction and learning that resolves the barriers, shapes the successful innovation environment and hence strengthens the innovation system.

The findings have implications for policy, including the need to establish new policy measures aimed not simply at achieving a set goal but rather at facilitating the interaction process with a long-term view. The study recommends that public intermediaries need to focus on monitoring activities that integrate and support the knowledge interaction process by facilitating ‘associativeness’ among actors. Furthermore, the heterogeneity of the local contexts and SMEs in the innovation process need to be taken into account in designing the programmes, moving away from one-size-fits-all type services.

Acronyms

BIC	Business Incubation Centre
CEOs	Chief Executive Officers
COSTII	Composite Science and Technology Innovation Index
CTOs	Chief Technology Officers
DUI	Learning by Doing, Using and Interacting
ETRI	Korea Electronics and Telecommunications Research Institute
EBWS	Electrolysis Ballast Water-Management System
GDP	Gross Domestic Profit
GRI	Government Research Institutes
GSBC	Gyeonggi SME Business Centre
HFOEs	Wholly foreign-owned enterprises
HVV	Hongneung Venture Valley
IF	Innovation Foundation
IMD	International Institute for Management Development
IMO	International Maritime Organization
IPO	Initial Public Offering
ITRI	Industrial Technology Research Institute
KAIST	Korea Advanced Institute of Science and Technology
KARI	Korea Aerospace Research Institute
KBSI	Korea Basic Science Institute
KETI	Korea Electronics Technology Institute
KIET	Korea Institute for Industrial Economics and Trade
KIOST	Korea Institute of Ocean Science and Technology
KIST	Korea Advanced Institute of Science and Technology

KISTEP	Korea Institute of S&T Evaluation and Planning
KISTI	Korea Institute of Science and Technology Information
KNIS	Korean National Innovation Systems
KOSDAQ	Korea Securities Dealers Automated Quotations
KTVF	Korea Techno-Venture Foundation
LCD	liquid crystal display
LGLS	LG Life Science Co., Ltd.
MITI	Ministry of International Trade and Industry
MOST	Ministry of Science and Technology
MSIP	Ministry of Science, ICT and Future Planning
NFRI	National Fusion Research Institute
NIS	National Innovation Systems
OECD	Organisation for Economic Cooperation and Development
PCNIS	Plan to Construct a National Innovation System
PCSME	Presidential Commission on Small and Medium Enterprise
PDU _s	Power Distribution Units
R&D	Research and Development
RSI	Regional Systems of Innovation
S&T	Science and Technology
SI	Systems of Innovation
SLTI	Social Learning and Technology Innovation
SMBA	Small and Medium Business Administration
SME _s	Small and Medium Sized Enterprise
SPIE	Semiconductor Packaging Inspection Equipment
SPIS	Science Policy and Innovation Studies
SSI	Sectoral Systems of Innovation

SST	Social Shaping of Technology
STEPI	Science and Technology Policy Institute
STI	Science and Technology Innovation
STS	Science and Technology Studies
TAME	Industrial-sized thickness analysis and measurement equipment
TF	Technology Foresight
TFT	Task Force Team
TLO	Technology Licensing Office
TRT	Technology Round Table
WFOEs	Wholly Foreign-Owned Enterprises

1 Chapter 1. Introduction

1.1 *What is This Research About?*

This study concerns the issue of public-sector intermediaries and their role in facilitating innovation in Small and Medium Sized Enterprises (SMEs). The primary aim lies in understanding and addressing the informational and relational constraints that SMEs face during the innovation process and how these are resolved through interaction. SMEs in South Korea constitute 99% of businesses and 98% of employment (Hong, 2005); thus, fostering innovative SMEs has been a major policy issue, linked to the creation of jobs as well as achieving economic growth. Despite the importance of SMEs in the Korean economy, the Korean National Innovation System (KNIS) has been characterised with six words: ‘strong large firms, weak small firms’.

Recognising the weakness of SMEs that only have limited access to the various resources needed for successful innovation, such as technologies, human resources, information, and knowledge, compared to large corporations (D. Cho, 2005), the Korean government has put great effort into building a support mechanism. As a result of sustained effort, the number of innovative SMEs has been growing; however, some mismatches remain in the innovation system in several ways. For example, a mismatch exists between research and development (R&D) investment and performance, a low level of cooperation among firms, and weak SMEs. Unlike the government’s successful experience in fostering large corporations, the SME policy that has been implemented seems to be unsuccessful. It neither links to economic outcomes nor to enhancing innovative capabilities of SMEs.

Notwithstanding the increasing attention on fostering innovative SMEs in the KNIS, SME policy does not, in general, seem to be effectively incorporated in the National Innovation System (NIS) framework. Rather, SME policy has been criticised due to its standardised forms of services based on one-way knowledge flow, ignoring heterogeneous demands of innovative SMEs. Innovation is a spiral, complex process that takes place through interactions among an array of actors and institutions involved and affected (Williams and Edge, 1996, p867), but this view has been

largely overlooked in SME policy. One can speculate that policymakers do not understand the dynamic process or that the mechanism been ineffective.

In this vein, the role of the public intermediary as an external linkage of SMEs has attracted policy attention (Y. B. Kim, 2005), because they have been the mechanism in recent Korean S&T history to facilitate the rate of innovation by linking policy to the SMEs and large corporations. Although other issues must be considered when discussing ways of facilitating the innovation of SMEs in Korea, the focus of this study is the bridging mechanism to overcome barriers between SMEs and other entities in the innovation process.

Stakeholders know little about the interaction process between intermediaries and SMEs. Few research studies attempted to understand the role of intermediaries as linkage organisations in the KNIS. In this research into the Korean context, I define a public intermediary as a publicly funded intermediary that promotes innovation between two or more parties without pursuing profits from their services. The framework for this study was constructed to investigate the case of Korean SMEs and the role of public-sector intermediaries in facilitating innovation. In particular, this study seeks insight into how barriers at the early stages of innovation can be resolved by answering the following research questions:

- Why do public intermediaries interact with SMEs? How do the relationships and interactions affect the innovation process of SMEs?
 - How do relationships form and evolve between public intermediaries and SMEs?
- How does knowledge get interpreted and knowledge flow take place between public intermediaries and SMEs in Korea?
 - Do public intermediaries decrease the barriers to innovation of SMEs in South Korea? If so, how do mechanisms effectively work for SMEs and how do they enhance the firm's innovative capability?

- What are the distinctive patterns of interactions and relationships among firms and how are they different?
 - What are the factors that determine and differentiate the patterns of interaction and the innovation process? How do these factors affect the innovation process?

Emphasising relationships and interactions in the innovation process between public intermediaries and SMEs, this study will broadly investigate the social aspects at the meso- and micro-levels.¹ To provide a detailed explanation, I explore intermediary perspectives, while also applying the NIS concept to show how interactions with intermediaries affect the shaping of innovation processes. I will draw insights from these processes to build on existing theories of social learning in technology innovation (SLTI), to offer improved understanding of learning processes during interactive innovations. I also provide an account of how significant knowledge and relational barriers (or gaps), described as system failures in the KNIS, and uncertainties may be overcome through interactions between intermediaries and SMEs with a specific focus on how public intermediaries facilitate the innovation process.

1.2 Objective of the Study

The study aims to contribute to the understanding and practice of innovation facilitation for SMEs on three different levels. Considering the contribution of public intermediaries in the S&T history of Korea, I examine how they interact with SMEs to resolve the barriers during innovation processes on a case-by-case basis for further policy development.

First, on the national level, I propose important factors that may resolve the obstacles entailed in the complex innovation process by analysing the nature of successful or less successful innovation processes of SMEs. Therefore, I contribute to establishing an appropriate policy framework that focuses on the knowledge-interaction process

¹ Meso-level actors are innovation service providers such as intermediaries and the micro-level actors are firms, public and private institutes, etc. (Seidel et al., 2013). The meso- and micro-level analysis will be further explained in Section 2.3.2.

between SMEs and other entities, overcoming the linear view of innovation prevalent in Korean S&T policy.

Second, on the intermediary organisational level, this paper will contribute to establishing SME policy tools, based on the interactive model, by reflecting heterogeneous demands of SMEs and different patterns of interaction of each SME. Furthermore, the study attempts to contribute to redefining the role of public intermediaries by examining their hidden role as an innovation facilitator for SMEs in Korea.

Last, on the research level, I brought together separate bodies of literature—NIS and Innovation Intermediaries—whereas extant research has rarely made those connections.

Separately, the study proposes a conceptual framework to analyse the interactions between public intermediaries and SMEs. By reviewing the intermediary literature, I develop four functions—(a) knowledge enabling, (b) facilitating relations, (c) facilitating learning, and (d) managing interfaces, that allow a systemic approach to analyse the knowledge-interaction process and how the process decreases the barriers on a specific level. Based on the framework, I analysed forty-five interviews with CEOs, policymakers, and staff from intermediaries, indicating the usefulness of public-sector intermediaries as innovation facilitators of SMEs; two factors considered in analysis of the empirical data.

First, while acknowledging the complex interaction in the innovation network, incorporating firms, social, and technical factors, this study does not endeavour to consider all factors that shape and influence innovation processes of all SMEs to the same degree. Instead, the study seeks to examine how intermediaries interpret heterogeneous knowledge requirements in the innovation process and perform those roles to bridge the knowledge and relational barriers from firm to firm.

Second, whereas the main interest of this study lies in gaining insight into the interaction and relationships that affect innovation processes of SMEs, and finding determining factors, it tries to capture the evolving nature of relationships and

multiplicity of interactions among heterogeneous individuals and other entities during the innovation process.

1.3 Theoretical Motivation

This study responds to a theoretical challenge embodied by a lack of research into public intermediaries and SMEs in the NIS framework. On the one hand, stakeholders have questioned whether the knowledge-interaction process between public intermediaries and SMEs can be explained in the loose NIS framework. Previously studies making use of the NIS framework largely focused on national comparisons of innovative performance with relatively few focusing on intermediaries and SMEs in a specific setting (Lundvall, 2007a; OECD, 2002; Woolthuis, Lankhuizen and Gilsing, 2005). On the other hand, the intermediary literature is fragmented, and scholars rarely integrated it into the NIS literature (Watkins et al., 2014). The intermediary literature further remains biased towards supply-side functions showing one-way knowledge flow from intermediaries to firms, ignoring microsociological factors such as the interactive nature of innovation and preexisting resources and routines of SMEs (Howells, 2006). This apparent lack of concepts (or framework) in explicating the knowledge-interaction process between two actors is the concern of this study.

Although I do not aim to provide all-encompassing new concepts or tools to facilitate innovation of SMEs, I aim to elicit insights and ideas that might be useful for operationalisation of the NIS framework, focusing on the specific actors (i.e. public intermediaries) and SMEs, which face heterogeneous barriers in the innovation process. Throughout the journey towards analysis of the knowledge interaction in the uncertain innovation process, I was motivated by several aspects of the research: the NIS concept, intermediary studies, and more broadly by the interdisciplinary field of science and technology studies. As previously indicated, this study addresses several interesting theoretical challenges.

The first challenge is how much the loose NIS framework can convey country-specific characteristics. Dodgson (2009) indicates that Korean technology-based firms had great advantages in economic institutional support afforded by the

government, which possesses key technological standards, skills, capital, and markets. Also, patriotic entrepreneurs (Dodgson, 2009) and the high level of urgency² towards economic growth are distinctive features in Korean S&T development history. In this regard, Dodgson (2009) contends that cultural and social specifications cannot be ignored because attitudes to risk, hierarchy, trust, and social relations impact innovation (i.e. relationships between suppliers and customers). In addition, many Asian nations—especially, Korea, Japan and Taiwan—possess country-specific characteristics such as non-market modes of coordination, whereas those three countries have different industry structures that result from different political, economic, and social influences. In Korea, industry–government research institutes’ (GRIs’) interaction has been a common form of cooperation (Yusuf, 2008) rather than industry–university interaction. However, to the best of my knowledge, no references explain or visualise the differences at micro-levels, such as the role of strong governments in the NIS framework. The NIS literature making use of static indicators does not yet fully recognise or explore the significance of nation-specific legacies (Balzat and Hanusch, 2004; Mahroum and Alsaleh, 2012).

The second theoretical challenge is whether the ‘degree of abstraction’ of the framework can act as a comprehensive guide to analyse ‘what is happening’ in the system. The KNIS has grown in size and sophistication and, as a result, the scope to analyse and identify the barriers in the simplified concept is more complex and difficult. Yet, no indication exists of barriers (i.e. system failures) and levels of complexity in the NIS framework. Consequently, SMEs and linkage organisations, so-called public intermediaries, and their interaction process cannot be explored in the vaguely designed framework. It is difficult to know whether SMEs’ needs are met by public intermediaries through knowledge interaction and if so, how the process can decrease the barriers. This difficulty gave this study momentum. I recognised that the applicability of the NIS concept at a specific level is questioned, despite its popularity in the policymaking sphere³. I attempt to demonstrate that the

² Urgency comes from the memory of deprivation and hard times under Japanese occupation and during the Korean War (L. Kim 1993).

³ The policymaking sphere is defined as supranational organisations (e.g. OECD) and single nation-states that formulate innovation and technology policies (Sharif, 2006). The academic sphere refers to

simplistic NIS concept needs to be revised at an appropriate level and the object of experimentation, especially targeting the interactive approach to analyse ‘what is happening’ during the innovation process and to apply the policy at an appropriate level.

These challenges led to calls for operationalisation of the NIS concept at meso- and micro-levels, linking the NIS concept with practical approaches such as intermediary functions and sociological perspectives to the interaction process. By adopting meso- and micro-level approaches, I am able to reveal dynamic interplay between public intermediaries and SMEs. Four intermediary functions developed for this study provide an analytical tool for the knowledge-interaction process and how it decreases the diverse barriers in the complex and uncertain innovation process. These functions do not interact with SMEs in a ‘knowledge vacuum’; their role can be different between regions, technology fields, actors involved in interaction processes, innovative capabilities of SMEs, and experiences and resources of intermediaries. The microsociological perspective on innovation helps describe ‘a range of factors: organisational, political, economic and cultural’ that may determine the pattern of interaction and relationships among intermediaries, SMEs, and other actors and non-actors (Williams and Edge, 1996).

1.4 Contribution to Knowledge

The focus of this study is on the interaction between public-sector intermediaries and SMEs during the innovation process. Involving a set of case studies, I attempted to elicit insights that can be used to build on the NIS framework, focusing on the nexus of the barriers and institutional influences on innovation. The study extends previous works by focusing on several critical influences in the innovation process of SMEs: the knowledge and relational barriers, uncertainties at the early stage of innovation, and interaction between public intermediaries and SMEs. Unlike previous studies that examined knowledge flows among idealised actors at macro-levels, the conceptual framework developed for this study indicates that knowledge interaction between intermediaries and SMEs occurs at interactive and multiple levels to

universities, research institutes, and centres where the study of innovation systems is central to scholarly research programmes (Sharif, 2006).

decrease the heterogeneous barriers that each SME faces, leading to evolution of different patterns of relationships and interactions.

Innovation scholars (Lundvall, 1992, 2010; Nelson, 1992, 1993) have studied knowledge flow, competence building, and learning in a limited social context, but undertook little empirically-based research in mainstream NIS studies to understand learning by interaction at multiple levels in the innovation process in a specific setting (Lundvall, 2007a).⁴ Similarly, the mainstream of intermediary research has rarely addressed the role of innovation facilitators as interactionists in the complex innovation process. Rather, intermediary studies tend to focus on specific functions of private-side intermediaries and far less on public intermediaries (Dalziel, 2010; Howells, 2006; Watkins et al., 2014). From this point, an innovative aspect of this study can be the integration and focus on constructs of the multiplicity of interaction and intermediation processes that received little attention, either in the theoretical or empirical literature on the NIS and intermediary studies.

In addition to emphasising the importance of multiplicity of interaction and relationships in collectively addressing the barriers in the innovation process, this study demonstrates, through analysis of the empirical evidence, the necessity of closely assessing microsociological factors. By adopting social dimensions of the interaction process, microsociological aspects in the interaction process in the analysis provide a more systematic and interactive approach to understanding the knowledge-interaction process (Lankhuizen and Gilsing, 2005; Lundvall, 1996). Although these constructs have been identified separately in different traditions or domains, researchers rarely treat them together as potential factors in the innovation process, nor are they addressed in depth in the mainstream NIS or intermediary research. This more comprehensive approach provides a robust way to explore the knowledge-interaction process between intermediaries and SMEs and among individuals, especially when the loose NIS framework at the macro-level has limitations to open the black box of interactive learning, knowledge flow, and the

⁴ Lundvall (2007a) criticised the distortion of the NIS concept, which was biased towards science-based innovation that focused on the formal technological infrastructure and on policies aiming almost exclusively at stimulating R&D efforts in high-technology sectors; limitations of encompassing individual, organizational, and interorganisational learning in the innovation process.

evolving nature of relationships (Balzat and Hanusch, 2004; Russell and Williams, 2002).

The study also contributes to elicit the role of public intermediaries in facilitating the innovation of SMEs at the early stage of innovation. The four functions, if effectively organised by intermediaries, do appear to have the potential to influence the innovation process of SMEs. The investigation of functions draws from the innovation intermediary literature and then, linking it to knowledge-interaction process, represents a conceptual contribution, which also helps to generalise the findings of this study to a certain extent. In particular, this study illustrates the role of public intermediaries as reflexive actors encapsulating particular experiences and applying these to other settings, so-called social learning, which has been a relatively understudied in the NIS framework.⁵

1.5 Structure of the Thesis

This thesis consists of eight chapters. Chapter 2 presents the theoretical background of the NIS which relates to key questions of the knowledge-interaction process among actors. The chapter describes the barriers, based on the systems-failure perspective emerging in the interaction process. In particular, this chapter emphasises the loose nature of the NIS which brings disagreement between policymaking and academic spheres, highlighting two different approaches to innovation. In this regard, the chapter also raises theoretical issues in relation to the limitation of implementing the NIS framework, drawing attention to the involvement of a multiplicity of relationships and their evolving nature.

Chapter 3 concerns the theoretical context of intermediaries, focusing on the four functions in knowledge interaction developed for this study. The chapter examines how intermediaries resolve the barriers emerging in the innovation process of SMEs through knowledge enabling, facilitating relations and learning, and managing interfaces. I argue that knowledge interaction is more complex than the roles and

⁵ Several scholars (Mazzoleni and Nelson, 2007; Watkins et al., 2014; Woolthuis, Lankhuizen and Gilsing, 2005) indicated the neglected part of the NIS; that is the bridging institutions. Williams, Stewart, and Slack (2005) highlighted the role of intermediaries in social learning but not in the NIS framework.

activities explained in the related literature where the role of the intermediary is merely static and conceptual. On that basis, I attempt to delineate dynamic entities of innovation intermediaries, highlighting public-sector intermediaries acting as innovation facilitators at the early stages of innovation.

Chapter 4 covers the research design and methodology, describing the field work, the procedures for selecting SMEs, which provide the empirical data for the thesis, and the methodology for data collection and analysis. I adopted the case-study approach in cooperation with semi-structured in-depth interviews, given that little has been studied in this area and the need existed to contribute to theory building. The primary data collection involves in-depth interviews at three levels: four intermediaries, 26 SMEs and an observer, to obtain a more objective and accurate picture of the knowledge-interaction process. I selected five SMEs for a second in-depth interview to obtain more detailed information about the process and the factors that hinder or facilitate the innovation process. Interviews at firms provided an opportunity to check the veracity of statements made by intermediaries.

Chapter 5 reviews the history of science, technology, and innovation policy, focusing on SME policy and innovative SMEs in Korea. In particular, the chapter highlights the role of the government and public intermediaries as non-market mechanisms to deliver government policy to SMEs. Then I examine weaknesses of the KNIS, characterised as ‘strong large firms and weak small firms’, explore the definition of innovative SMEs in Korea, critically review policy implemented for SMEs, and figure out mismatches between input and output. I emphasise the low level of interaction among firms (e.g. large corporations and SMEs), which hinders interactive learning and knowledge flow, and the lack of capability of SMEs, as problems of the KNIS.

Chapters 6 and 7 provide the main field research, examining how the evidence from the knowledge interaction between the public intermediary and SMEs differs from the NIS concept presented in the previous chapter. In the empirical discussion, Chapter 6 presents five case studies examining the knowledge-interaction process between the public intermediary and SMEs through the lens of the four intermediary functions developed in Chapter 3. It includes the different history and capability of

SMEs, how each SME interacts with intermediaries to bridge the heterogeneous barriers emerging at the early stages of innovation, and the outcomes of multiplicity of the knowledge-interaction process.

Chapter 6 analyses successful and less successful factors, identifying differences and similarities among the five cases. It focuses on the variety of factors incorporated in the interaction process such as the capabilities of SMEs and intermediaries, the existence of reflexive individuals, quality of knowledge, the level of trust, and the multiplicity of interaction and relationships. Emphasising the role of public intermediaries linking all the services and actors in the knowledge-interaction process, I afforded special attention to the evolving characteristics of relationships of each SME, which differs from case to case. The chapter shows the difference between the NIS framework and empirical findings that entail constellations of actors and interactions at multiple levels. It raises issues in relation to sociological micro-level factors embedded in multiple levels of interaction, which are mostly neglected in NIS and in intermediary studies.

Chapter 7 provides the rationale for the involvement of public intermediaries that facilitate the innovation process and lower barriers of innovation in the KNIS. The chapter highlights the concept of innovation as a process that involves a number of failures and constraints, and covers a wide range of activities. Therefore, a need exists to maintain durable, satisfactory relationships with multiple actors during knowledge interaction and constantly negotiate acceptable solutions to remove barriers. In this regard, this chapter emphasises how and why public intermediaries facilitate innovation at the innovation systems level: it is characterised as a constant process of interaction, multiplicity of relationships, and mutual learning. This chapter further presents some dilemmas between the role of public intermediaries and their need to meet performance indicators, which may overlook activities in the innovation-facilitation process, arguing they are often hard to measure and quantify.

Chapter 8 presents insights and findings of the study, including implications for the NIS concept and intermediary theories, policies, and SMEs. I discuss the possibility of generalising the results and their effects on different contexts, followed by reflections on the study that address its strengths and limitations and

recommendations for future research. Concluding the main theme of the study, the chapter argues that the simplistic and loosely descriptive NIS framework has shortcomings in explaining different patterns of interaction and relationships that are evolving over time; this outlook emphasises the lack of attention paid by NIS to the social dimensions embedded in the process. With emphasis on the crucial role of public intermediaries in the KNIS, this chapter concludes that the loose NIS framework needs to be operationalised at a more appropriate level (i.e. public-sector innovation intermediaries and SMEs), and incorporate other disciplines of study to identify the barriers and resolve the problems relating to the KNIS.

2 Chapter 2. National Innovation Systems: Towards a Conceptual Framework

2.1 Introduction

The NIS concept, which first appeared in the mid-1980s in Europe, has been enjoying currency in academic and policymaking contexts (Sharif, 2006) in many countries. Along with Freeman's (1987) book on Japan, the concept has been widely diffused through Europe and Asia, with a growing literature and influence on policymaking in the last few decades. Rejecting the linear view of innovation, the NIS emphasises firms in interaction with other firms and with a knowledge infrastructure at the core of the system, arguing that the most important resource in the economy is knowledge, and the most important process is learning (Lundvall, 1992). However, it is not just firms but the role of government that is crucial in achieving a high level of competitiveness in a global market, considering Japanese success.

Many scholars have positively welcomed the concept, but the generic NIS model has brought disagreement to the policymaking and academic spheres (Sharif, 2006), questioning whether the loose concept is useful as a policymaking tool. Most of all, the ambiguous nature of the concept does not allow for how governments intervene and where support should go to enhance the innovation capacity of firms and nations. The system-failure concept can be applied to identify barriers to innovation and a rationale for public support. However, some limitations in implementing NIS remain: the role of governments in a specific nation as a mechanism to resolve barriers, and the knowledge-interaction process at specific levels (i.e. public intermediaries and SMEs), and its evolving process.

This chapter presents the theoretical background to the NIS, its emergence, development, and surrounding debates in policymaking. Section 2.2 illustrates the emergence of the NIS as an interactive model of innovation and its historical background, followed by two different approaches to the NIS concept. Section 2.3 examines the developmental direction of the NIS concept towards policymaking and academic spheres. In particular, I analyse the limitations of such a nebulous concept

as a policymaking tool. Then, I investigate types of system failures as barriers to innovation in Section 2.4, which provides a rationale for government intervention. Adopting a broader notion of knowledge flows, this section highlights the knowledge interactions and important role of public intermediaries as innovation facilitators in the NIS. The conclusion, in Section 2.5, addresses theoretical issues in relation to the limitation of implementing the NIS framework due to its ‘loose concept’.

2.2 Genesis and Development of the NIS

2.2.1 Its Origin: Refutation of the Linear-Based Model of Innovation

Innovation in science and technology has been an economic factor since the time of the classical economists, and modern discourse on innovation management tends to trace its roots to the work, in particular, of Schumpeter (e.g. Roberts, 1998). Schumpeter (1939) considered innovation to be a fairly linear process that moves through the gathering of commercially practicable ideas (invention) by entrepreneurial figures who stimulate product development and diffusion (innovation). In criticising the neoclassical and Schumpeterian notions of linearity (Mytelka and Smith, 2002), evolutionary studies start to highlight learning feedback (Kline and Rosenberg, 1986), heterogeneity, environment, differences between firms themselves (Nelson and Winter, 1982), and the unpredictable nature of innovation (Freeman, 1988; Kline and Rosenberg, 1986).

Evolutionism offers a holistic view that innovations, ‘far from being isolated’, are a complex learning process across firms and sectors intertwined with technological and nontechnological aspects. Emphasising the complex array of factors in the innovation process, researchers have moved away from a single linear model to investigate heterogeneous factors including firms, specific industries, or regions and nations, at a system level, since the 1980s. Partly, this movement is a response to the failure of economists to integrate institutions into theories and econometric models (Edquist, 1997; Freeman, 1987; Lundvall, 1992; Nelson and Rosenberg, 1993). These institutions are firms, institutes, universities, governments, and others that interact with each other at a systems level.

During the 1980s, some nations that made profits from innovation policy expanded economically at firm and government levels. Japan in particular emerged as a new global powerhouse that called for governments of many countries to learn from the Japanese Ministry of International Trade and Industry (MITI). This phenomenon led a variety of commentators to conduct research into national capabilities; their research strongly connected innovation to national performance, collectively recommending government intervention in the innovation process to pursue national competitive advantage (Roberts, 1998).

Amid the climate of analysing ‘developmental gaps’ among nations, discussions of the NIS arose to frame international comparative studies particularly of Japan, Europe, and the United States. Scholars Freeman, Lundvall, and Nelson performed the majority of studies. However, Freeman (1987)⁶ first used the concept of national innovation systems, analysing the increasing economic dominance of Japan as a result of policies in the Japanese system pursued over many decades (Sharif, 2006). Although no single definition or boundary of the NIS emerged (see Appendix 1), one widely quoted definition follows:

The set of institutions that (jointly and individually) contribute to the development and diffusion of new technologies. These institutions provide the framework within which governments form and implement policies. ... It is a system of interconnected institutions to create, store, and transfer knowledge, skills, and artefacts which define new technologies. (Metcalf, 1995, as cited by OECD, 1999, p24)

Focusing on the knowledge, learning, and interactivity among actors that gives rise to ‘systems of innovation’ (Freeman, 1988) draws attention to the ‘national environment where institutional developments have produced conditions conducive to the growth of interactive mechanisms on which innovation and diffusion of technology are based’ (OECD, 1992, p238). The NIS approach rests on the interactive model of the innovation process, which emphasises market and nonmarket knowledge transactions among firms, institutions, and the human resources involved (OECD, 2002) in the innovation process. This provides a ‘richer

⁶ Although the NIS concept came from several scholars (Freeman, 1987; Lundvall, 1992; Nelson, 1993), Freeman (1995) indicated that the idea goes back to Friedrich List’s conception of ‘The National System of Political Economy’.

picture' of the innovation process, thereby overcoming the weaknesses of the neoclassical approach. In this approach, the firm was conceived as a 'learning organisation' embedded in a broader institutional context (Lundvall, 1988). By paying greater attention to the mechanisms that shape the system, instead of viewing the system as a market with anonymous players, the NIS approach (Lankhuizen and Woolthuis, 2003, p13) carries the potential to provide effective mechanisms.

In parallel with the above phenomenon, the OECD looked for conceptual frameworks⁷ to draw the attention of policymakers and averred the NIS could do the job, providing better understanding of differences among member nations (Godin, 2009). The OECD started to produce a number of reports on many countries' NIS, comparing systems in various aspects and components (Dodgson, 2009) and encouraging member nations to use the concept (OECD, 1997).⁸ In particular, an Industry and Technology Scoreboard of Indicators published by the OECD provided a readily understandable story by generalists and the press (Godin, 2006; OECD, 1998).

The publication included a series of economic and science and technology indicators, graphically ranking countries on different dimensions with a brief analytical text (Godin, 2009). It soon became a popular analytical tool for policymakers in many countries who wanted to more firmly grasp the interaction processes underlying a country's technological and economic development (Balzat and Hanusch, 2004; Edquist, 2005; Lundvall, 1992; Nelson and Rosenberg, 1993). Freeman especially played a crucial role in stimulating the concept centred on the Science Policy Research Unit at Sussex University, and the concept has been adopted as an intellectual agenda for theory building, occupying economists, sociologists, and political scientists for several decades.

For example, Porter emphasised the importance of managing technological change as a means of gaining economic advantage from a perspective of innovation

⁷ The OECD entrusted the programme on NIS to Lundvall (who used to be a deputy director of the OECD from 1992 to 1995) to develop the conceptual framework (Godin, 2009).

⁸ The concept has become the international standard with the adoption of the OECD Frascati Manual by member countries in 1963.

management. Sociologists also attempted to widen the innovation process. Williams and Edge (1996) attempted to broaden policy discussions by introducing new theoretical approaches that examined the sociopolitical context of innovation. Meso-level patterns of the NIS across firms and industries aligned with the idea of Social Shaping of Technology (SST; MacKenzie and Wajcman, 1985) in the tacit and cumulative character of knowledge, path dependency in directions of change, and choices between contradictory pressures (Russell and Williams, 2002). However, these scholars criticised the NIS concept as it only focuses on ‘revealed performance of organisations and systems’, remaining a black box of the dynamic interaction process and learning nature of innovation⁹.

Along with the growing body of the NIS knowledge, produced by a group of leading scholars and policymakers who had specific agendas, disagreement emerged about ambiguities or uncertainties relating to the concept or usage of the NIS (Sharif, 2006). Although the NIS concept was defined differently by various scholars and policymakers, it can be regarded as an analytical tool to explain economic growth and competitiveness of a nation—as briefly mentioned above—and a synthesis of analytical results produced by scholars (Lundvall, 2007a). This topic will be examined further in the following section.

2.2.2 Key Concepts and Different Approaches to Innovation Systems

Although the NIS concept is quite broad and loose, basic characteristics of the NIS can be set-up¹⁰ institutionally, related to innovation and emphasising relationships and interaction between components that can be the ‘semantic core’ implied in most definitions. Interactions and linkages are key ingredients of the interactive model that assumes that growth in interactions leads to improved innovative performance.

Hence, ‘innovation systems may grow through complementary interactions at three

⁹ Lundvall (2010) argued the international organisations distorted the original concept of the NIS, which tended to focus on science-based innovation without encompassing individual, organisational, and interorganisational learning. Edquist (2001) criticised the SI approach as largely neglecting individual learning.

¹⁰ The building blocks of the NIS are a set of institutions, organisations, routines, rules, norms, linkages, and flows that regulate relations between actors and shape interaction. Firms are at the centre of the NIS, and effective interaction between firms and the knowledge infrastructure affect economic performance (Lundvall, 2007c).

levels' (OECD, 2002, p16): first, firms and knowledge institutions; second, interactions among different markets; and third, interactions between market and nonmarket mechanisms (interactions through networking and collaboration; Figure 2-1).

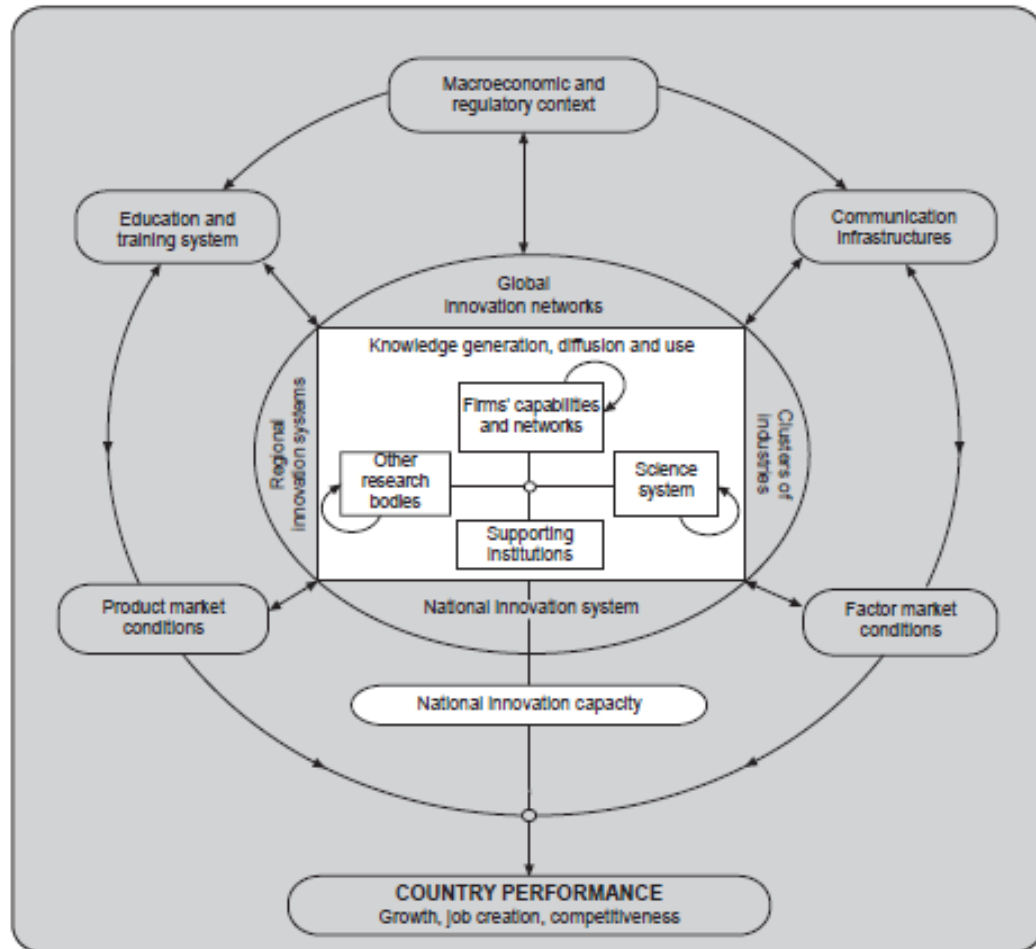


Figure 2-1 Actors and linkages in the innovation systems.

Source: OECD (1999, p23).

Interactive learning can be viewed as a leitmotif of the NIS because it is the learning system of national economies (Lundvall, 1992, 1998, 2005, 2007c). Thus, understanding the interactions that facilitate knowledge creation, diffusion, and utilisation are crucial for analysis and development of the NIS. Lundvall (2007a, 2007b) distinguished two modes of innovation, arguing that this distinction is fundamental in analysing innovation systems. The first is the DUI-mode of innovation, which refers to learning by doing, using, and interacting (so-called

experience-based learning). The second is the STI-mode of innovation, which refers to use and development of science-like understanding and explicit knowledge (know-what type) rather than tacit or experience-based knowledge.

The DUI-mode emphasises organisational learning, representing that firms have closer relationships with customers and may have structured and tacit elements of communication involved in interaction. Because Lundvall (1996) conceptualised innovation as learning, creating novelty in capabilities as well as knowledge, which contributes to developing innovative technology, user–producer interaction has been an important learning process, with information and knowledge flow, and feedback between actors. Although a variable reflecting the level of relationships of firms with customers can measure the DUI-mode, it has a strong focus on organisational learning as well as on user needs (Jensen et al., 2007). The DUI-mode of innovation also involves organisational frameworks and relationships between employees that facilitate creating implicit knowledge and promoting interactive learning (Jensen et al., 2007; Lundvall, 2007a, 2007b).

In this regard, Lundvall et al. (2002) highlight knowledge interaction among constellations of actors.¹¹ Organisations where individuals follow a different kind of rationality, characterised by a shared understanding of new phenomena, technologies, and knowledge, would be successful in innovations through learning-by-interaction (Lundvall, 1996). In other words, interactions with individuals with different rationalities can be seen as the process of combining competing rationalities towards successful innovations: so-called ‘productive combination of competing rationalities’.

The second mode of innovation, the STI-mode, focuses on science-based learning such that science is seen as the first step towards technology and innovation, and knowledge may reach users in the form of disembodied codified knowledge (Lundvall, 2005, 2007b). Inspired by the S&T tradition in the United States, the STI-mode considers the NIS an expanded concept of earlier analysis of national science

¹¹ These constellations can provide a space with mixed rationalities to enable interactive learning and new knowledge creation. If instrumental rationality completely dominated the interaction between engineers from R&D labs belonging to different firms, very little knowledge would be gained and very little learning would occur (Lundvall et al., 2002).

systems and national technology policies (Mowery and Oxley, 1995). Because mapping indicators of national performance regarding R&D efforts, S&T specialisation, and innovation has been the major issue, the related policy is likely skewed towards the S&T domain, ignoring considerations of wider dimensions of the NIS.¹²

From this point, the DUI- and STI-modes of innovation reflect two major studies on the NIS, published in the early 1990s. The first is a major extension of Lundvall and collaboration in Aalborg (Lundvall, 1992); the second is the national comparative study of Nelson (1993). Lundvall distinguished these two approaches as a narrow and a broad definition of the NIS:

The narrow definition would include organisations and institutions involved in searching and exploring—such as R&D departments, technological institutes and universities. The broad definition ... includes all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring—the production system, the marketing system and the system of finance present themselves as subsystems in which learning takes place (Lundvall, 1992, p12).

Nelson's NIS follows a narrow definition focused on the core of the NIS approach in partial ways (STI-mode), whereas Lundvall highlighted conceptual characteristics of the NIS and interactive learning (DUI-mode). Martin (2012b) further claimed that Schumpeter defined innovation in a broader way and innovative activities may not always be visible: so-called 'dark innovation', which could be design, software, or intangible investment. The narrow definition of innovation tends to focus on systemic relationships between R&D efforts in firms, S&T organisations, universities, and public policy, and as a result, the analysis focuses on interactions between supply and demand (Freeman and Soete, 2009).

However, the development of the NIS is not a technical achievement but a web of society, politics, and economics engineered by actors responsible for its conception (Sharif, 2006). For this reason, the broader concept is more appropriate to analyse the

¹² This tendency may affect production of many quantitative survey-based innovation studies that overlook DUI-mode learning in favour of innovative performance based on their narrow view of innovation.

nation, where specific sociocultural factors and groups co-construct formulating the concept.¹³ A country's competitiveness can be interpreted flexibly, having different meanings for different concepts through a wider approach (Sharif, 2006) where different mechanisms or bridging arrangements for knowledge flows and interactive learning exist. For example, the NIS concept perceived in Asian countries (e.g. Japan, South Korea, and Taiwan) may differ from that perceived in Western countries (the UK, United States, and Scandinavia) or other developing countries.

In this vein, Fransman (1990, 1991, 1992) analysed the role of the Japanese government, showing how the long-term vision was shaped by an interactive and coordinated process. In Japan, the MITI became the spearhead coordinating innovation activities in the 1970s and 1980s. In the case of Brazil and South Korea, which were known as the most successful industrialising economies (Viotti, 2002), a sharp contrast arose in education, firm level R&D, telecommunication infrastructure, and the diffusion of new technologies, in addition to R&D activities in the early 1980s. Although South Korea has grown fast since the 1980s, the GNP growth rate of many Latin American countries fell to less than 2%.

What are the systemic features driving success and causing differences between countries? It seems other factors than R&D investment or capability of firms explain the contrast. Looking into Japanese success and the role of innovation in national economies, it is not just individual firms, but coordinated efforts by government that achieve the high level of competitiveness. In other words, creating novelty and attaining competitive advantage in a rapidly changing global market intensifies the firm-specific and nation-specific pressures that highlight the broader context in the development of the NIS concept.

However, a strong tendency exists among policymakers to consider innovation processes largely as aspects connected to formal processes of R&D (Jensen et al.,

¹³ The NIS concept has been popular especially in the early 2000 in Korea. It seems that the popularity of the concept did emerge at a single moment in South Korea, precisely when a financial crisis attacked the Korean economy in the late 1990s. At that time, the government needed legitimacy to intervene and the NIS, as a policymaking tool recommended by well-known organisations (OECD and Science Policy Research Unit), played a crucial role in providing a rationale for government intervention.

2007), although the wider approach emphasises interactive learning with customers, suppliers, and knowledge institutions (Freeman, 1987; Kline and Rosenberg, 1986; Lundvall, 1988, 1993). This tendency may affect production of many quantitative survey-based innovation studies that overlook DUI-mode learning in favour of innovative performance (Jensen et al., 2007) based on a narrow view of innovation. Emphasising the STI-mode of innovation, policymakers demonstrate huge investment in S&T systems and develop statistical analyses¹⁴ on science and technology use to manage the efficiency of policy (national commitment) and learn about performance. In this regard, Lundvall (2007a, 2007b) and Freeman and Soete (2009) expressed concern that an STI focus may result in weak organisational learning and a weak focus on user needs that has limited positive impact on innovation. Often, in contrast to *Frascati Manual's* R&D focus, a more routine use and new combination of knowledge base without a particular leap in S&T facilitates innovation; so-called innovation without R&D (Freeman and Soete, 2009).

Along with the different approaches to the innovation system, the loose nature and flexible interpretations of the NIS bring debate on the meaning of the concept (Figure 2-2). On one hand, Edquist has been undertaking a major comparative study to build a 'theory-like' concept. On the other hand, Lundvall emphasised the importance of a broader concept in policymaking, although Lundvall (2004, 2007c) proposed the NIS needs help from other disciplines with more insight into human societies and social interaction. This discourse will be further analysed in Section 2.3.

¹⁴ Indicators have weaknesses, and are inadequate to describe the dynamic system of knowledge development, acquisition (OECD, 1995), and diversity across innovation systems (Smith, 2001). The OECD (1995) report further argued that feedback loops between markets and R&D were often overlooked. Describing subsystems where long-term relationships and trust for innovation shape different forms of innovation is insufficient. However, traditional indicators, based on a linear view of innovation, still dominate S&T measurements that are far from the concept of interactive learning, considered as the most important factor in a knowledge-based economy. Although some made efforts to reflect characteristics such as tacit knowledge, the results are not yet fruitful (Godin, 2006).

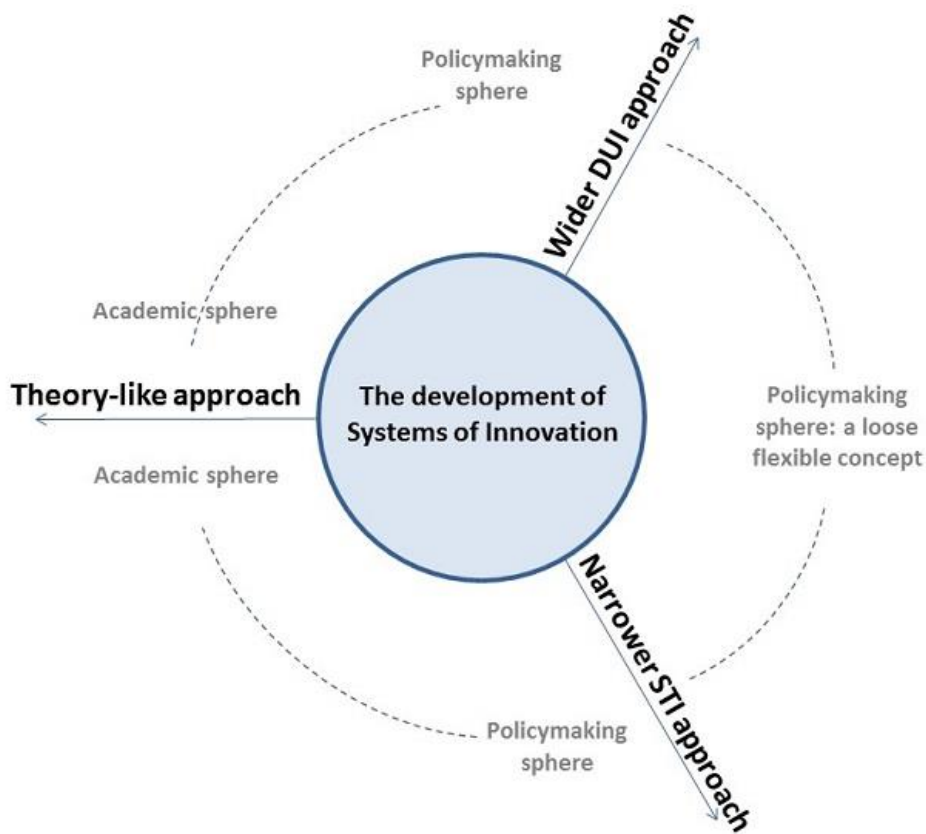


Figure 2-2 Different meaning of the NIS concept.

Source: Elaborated by the author

2.3 The Debates: Academic Sphere vs. Policymaking Sphere

2.3.1 Consistency and Adequacy

Since its appearance as a new conceptual framework, the NIS has drawn the attention of academics for more than two decades. Two groups of NIS research programmes exist: one group argues that the concept should be theorised and needs to be applied in greater detail (i.e. Edquist, Metcalfe, and Fagerberg); the other concedes its usefulness as a loose and flexible concept (i.e. Lundvall, Nelson, Rosenberg, Sharif, and Viotti).¹⁵

In the former group, Edquist (1999, 2001) criticised the systems approach due to a lack of functions that can describe causes and determinants of components in the system. This led Edquist and some other scholars to put effort into theory building

¹⁵ There is no clear consensus on whether the NIS concept is purely academic or policy related (Sharif, 2006). Godin (2009) considered Lundvall's approach to be more theoretical than Nelson's in focusing on knowledge and the process of learning itself.

and sharpening the concept by overcoming the vagueness of the functional boundaries of the system (Table 2-1). They considered that the fuzziness of the concept is why the systems approach does not deserve theoretical status. Yet, Edquist consented that policymakers might appreciate the fuzzy concept of the NIS, especially in the policymaking sphere (interview with Sharif, 2006, p758) because the policymaking sphere and academic sphere have different user groups with different requirements for the NIS concept. The loose concept helps policymakers sell their ideas to the public because the analytical reports based on quantitative data are sufficiently objective.

Instead, Edquist (2005) developed ten activities (functions or determinants) influencing innovation to provide rigour and specificity, criticising lack of clarity of the NIS concept, and delineating where to draw the lines around the innovation system. Edquist (2001) argued that Lundvall and Nelson seemed to neglect what actually happens in the system, which can be questioned at a more specific level. In the same vein, Liu and White (2001) identified five activities highlighting how fundamental functions (or determinants) of the system are organised and coordinated. A. Johnson and Jacobsson (2000) further emphasised assessing the functionality of the system in the way functions are provided. This group of scholars contributed to theory building by identifying ‘determinants of innovation’ that can be important attempts to increase the theoretical status of the systems approach.

Lundvall, Freeman, Nelson, and Smith emphasised the importance of the abstract nature of the NIS as a policymaking tool. From this perspective, the definition of the NIS must be flexible for a wider application as an analytical tool, as well as a policy tool in different contexts, and thus no sharper guide is necessary to explicate what should be included and what could be left out of the innovation system (Lundvall, 1992, 2007a; Nelson and Rosenberg, 1993). Lundvall (2004) especially, as a proponent of the NIS approach, argued that Edquist’s approach lacks consistency in the list of functions, that is, the heterogeneous character of the elements that make the approach less theoretical. Moreover, some functions (e.g. R&D and competence building) can be organised differently in different national innovation systems, and

some activities (e.g. formation of markets and articulation of user needs) cannot be organised by any specific types of organisations.

Table 2-1 The Different Research Focus of the NIS Concept

	Research focus	Keywords (or functions)	Authors
Towards flexible concepts	Interaction	Innovation as an interactive process	Freeman (1987)
	Interactive learning	Interactive learning (DUI and STI modes of innovation). The NIS as a socioeconomic formation	Lundvall (1992, 2004)
	STI modes of learning	The NIS as a science and technology system concentrating on institutions that promote the acquisition and dissemination of knowledge	Nelson (1992, 1993)
	Interaction	Socioeconomic dimensions Broader innovation systems where qualified institutions and organisations exist	Smith (1995, 1999)
Towards more rigorous and theoretical concepts	Developing functions	1. R&D, 2. Competence building, 3. Formation of new product markets, 4. Articulation of user needs, 5. Creation and change of organisations, 6. Networking around knowledge, 7. Creating and changing institutions, 8. Incubating activities, 9. Financing innovation, 10. Consultancy services	Edquist (2005)
		1. Research (basic, developmental, engineering), 2. Implementation (manufacturing), 3. End-use (customers of the product or process output), 4. Linkage (bringing together complementary knowledge), and 5. Education	Liu and White (2001)
		1. To create 'new knowledge', 2. To guide the direction of the research process, 3. To supply resources (i.e. capital or competence), 4. To facilitate the creation of positive external economies (in the form of an exchange of knowledge and vision), 5. To facilitate the formation	A. Johnson and Jacobsson (2000)
	Measuring capabilities	Factor analysis (innovation system, governance, political system, openness) in data for 24 indicators	Fagerberg and Srholec (2008)

Source: Compiled by the author.

Instead, Lundvall (2004, 2007a) claimed that the theory behind the innovation system is the combination of innovation and learning, emphasising that ongoing activities may result in innovation that comprises understanding of the learning process. This leads to further arguments on STI and DUI modes of innovation in

policymaking discussed in a previous section (2.2.2). For example, the concept needs a socioeconomic dimension (Gu, 1996; Lundvall, 1992, 2005, 2007c) and real structure to become a useful framework, such as quality of institutions, different contexts of firms and economies (Sharif, 2006), social capital, loyalty, and a mix of trust (Adler and Kwon, 2002; Anderson and Jack, 2002; Lundvall et al., 2002).

Edquist is undertaking a major comparative study and invoking the scientific principle partly to unify the meaning of the concept. On the other hand, Lundvall questions the value of taking a rigorously scientific approach in social science, defending a broader attitude and conceiving of the NIS concept as a loose umbrella approach. (Sharif, 2006, p760)

Although, theoretical efforts contribute to building a strict definition with general applicability, the approach may mislead policymakers to focus on static factors and functions at a specific time. Statistical analysis of the NIS has been popular among policymakers, but only shows the linear and static nature of innovation capacity in different nations (Bergek et al., 2008; Edquist, 2005). Furthermore, developing a general theory for the NIS may limit time and space, which changes over time, and the heterogeneity of functions (or determinants) differ across contexts.

In that sense, the wider approach has an advantage, notwithstanding the conceptual flexibility and subsequent diversity in the literature (Lankhuizen and Woolthuis, 2003). As a 'focusing device' (Lundvall, 1992), the broad concept (Lundvall, 2007a; Sharif, 2006, 2010) may play an important role in interpreting cases and organising the flexible NIS framework. The wider context of the NIS approach may show how the sociocultural and political situation shapes norms and values of the NIS and how the NIS affects them conversely (Sharif, 2006), along with its powerful impacts on the internal organisation of firms, and on firm interrelationships. However, the combination of approaches may provide a focus for analysis, explaining what happens and what is going to happen by linking inputs to outputs (Lundvall, 2007a, 2007b), and identifying the conditions (functions) determining innovation and economic growth (Lankhuizen and Woolthuis, 2003). The combination allows policymakers to drive an appropriate strategy for government intervention in innovation (Edquist, 1999; Lankhuizen and Woolthuis, 2003).

2.3.2 Its development as a Policy Tool and Limitations

Building on work performed by OECD explained in Section 2.2.1—the NIS concept, as ‘a name or label’ for policymakers to coordinate the political agenda—the conceptual approach of the NIS contributes to expansion of the literature¹⁶ (Balzat and Hanusch, 2004; Lankhuizen and Woolthuis, 2003), emphasising the systemic characteristics of innovation but with a focus on other levels of the economy than the nation (Lundvall, 2007c). These approaches are technological systems (Bergek et al., 2008; Carlsson and Stankiewicz, 1991), regional systems of innovation (RSI; Cooke, Uranga and Etxebarra, 1997), and sectoral systems of innovation (SSI; Malerba and Orsenigo, 1997). Some crucial ideas inherent to the innovation system concept appear in other literature (Lundvall, 2007c): regional industrial systems (Saxenian, 1994), industrial clusters (Porter, 1990), and the Triple Helix concept (Etzkowitz and Leydesdorff, 2000). For example, the Triple Helix concept is the related notion of systems of innovation that highlight the crucial role of ‘entrepreneurial universities’ in the knowledge economy (Martin, 2012a).

Although the NIS concept is useful to examine institutional characteristics for further development of innovative capacity, there are still concerns in the policymaking community that the NIS approach has too little operational value and is difficult to implement (Carlsson et al., 2002; Mahroum and Alsaleh, 2012; OECD, 2002; Viotti, 2002). It may need other policy frameworks to anchor its ‘loose concept’ (Song, 2009). In this regard, the NIS, RSI, and SSI may complement each other rather than exclude each other (Edquist, 1997). Lundvall (2007c) claimed that expanded concepts are not an alternative analytical tool for national systems, and may well be applied in a supranational or regional context, or an industry (technology) context, or some combination (Lankhuizen and Woolthuis, 2003). Martin and Johnston (1999) further portrayed that Technology Foresight has been used as a process to achieve effective organisational learning and system-wide learning, and thereby innovation in

¹⁶ Influenced by evolutionary theories, the systems-of-innovation (SI) approach emphasises determinants (functions) of innovations, not their consequences. The main emphasis was initially on national SIs; regional and sectoral SIs emerged and were used in addition to the national one (Edquist, 2001). Edquist (1997) argued that these three approaches can be addressed as variants of a generic system of innovation approaches, whereas Lundvall (2007c) considered that technological systems, regional systems of innovation, sectoral systems of innovations, and national systems of innovation have systemic characteristics of innovation.

the NIS. In spite of its contribution to the expansion of literature and usefulness as a policy tool, the conceptual framework has actuated several discourses.

First, although the systems concept can be applied in various regions and sectors, it is questionable whether the framework explains a nation's specificity. Lundvall claimed that this "kind of theory must have a very strong historical dimension. ... Some people want to abstract from both dimensions of space and time [miss] that the system of innovation has different meanings in different historical periods and different locations" (Sharif, 2006, p759). The nation is the arena where cultures and institutions are rooted, and furthermore, a specific national focus helps governments intervene (Gu, 1996; Lankhuizen and Woolthuis, 2003).

For example, striking differences arose among global semiconductor businesses in Japan, Korea, and Taiwan (Nelson and Rosenberg, 1993) such as the different national R&D systems and their role in economic performance, different roles of institutions such as the Industrial Technology Research Institute (ITRI) in Taiwan and Korea's Advanced Institute of Science and Technology (KAIST), and different national histories and cultures defining development paths and reifying the NIS. The Japanese government targeted strategic areas and orchestrated resources, firms, and cooperation programmes that shaped efficient innovation systems (Fransman, 1990, 1991; Freeman, 1995; Nelson and Rosenberg, 1993). Most of all, innovation policy concerns important consequences that innovations have for socioeconomic and political matters (Borrás and Edquist, 2013).

However, member nations tend to use OECD indicators to measure innovative capacity and its comparison among nations, although Lundvall, Freeman, and other leading scholars emphasised the importance of a nation and a wider institutional framework that should include socioeconomic factors and institutions. In other words, stakeholders employed the NIS concept for comparisons that were locked into homogenised views of the NIS in different nations. From this viewpoint, one may question whether the loose concept provides specificity of a nation along with popularity in policymaking or scholarly work. Also this view is inconsistent with the view of leading scholars, who suggested the search for solutions suitable for each

nation¹⁷ rather than depending on best practices (Godin, 2009; Lundvall, 2010; Viotti, 2002). For example, Lundvall (2010) contended that interactive learning is the most important process, which cannot be generalised because uneven access to knowledge and barriers for interaction might reflect different nation-specific arrangements.

Second, the heuristic and fuzzy concept or focusing device may be applicable in different contexts by offering the broad utility of the concept as an analytical tool. However, the concept does not have any indicators that can explain the patterns of interaction and learning process, although it emphasises the evolving aspects of the system. Interaction and learning still remain a black-box (Balzat and Hanusch, 2004; Mahroum and Alsaleh, 2012; Russell and Williams, 2002) and other disciplines may need to explain the micro-behaviours of individuals. Although leading scholars such as Lundvall and Metcalfe insist on the importance of firms, knowledge, and interactive learning, little literature describes how interaction and learning occur at specific levels (e.g. firms and firms or firms and research institutions). Furthermore, the concept has limits in identifying specific problems that may hinder innovation (e.g. the existence of knowledgeable individuals).

What drew the above criticism in applying the NIS to the policymaking sphere? Criticisms can be summarised as two major limitations in applying a flexible concept to the policymaking process. First, whereas other systems approaches may be useful as complementary policy tools, the NIS and related approaches in the policymaking sphere still lack an explanation of interactions between specific actors and their relationships. Although some researchers worked to identify regional, sectoral specificities, or local varieties, these approaches tend to analyse the system as a whole at the macro-level rather than unpicking underlying processes within the system (Kastelle, Potts and Dodgson, 2009; Lundvall, 2007c). Notwithstanding calls,

¹⁷ David and Foray (2005, as cited by Godin, 2009, p5) argued “A system of innovation cannot only be assessed by comparing some absolute input measures such as R&D expenditures, with output indicators, such as patents or high-tech products some absolute input measures such as R&D expenditures, with output indicators, such as patents or high-tech products.”

notably from Lundvall (2004, 2007c) to integrate macro and micro analyses¹⁸, research conducted within the NSI framework still largely fails to address interactions among specific actors at the meso- and micro-level (e.g. SMEs and public intermediaries).

The meso-level approach refers to analysing the NIS at the level of support for institutions and innovation programme. Typical meso-level actors include innovation service providers that encourage the innovative capability of firms; such as innovation-support institutions and programmes (Seidel et al., 2013). The micro-level encompasses support at the level of developing specific innovation capacity, overarching support for the main actors such as large firms and SMEs, universities, and public and private institutes (Seidel et al., 2013).

Most current NIS research tends to focus on macro-level analysis (Kastelle, Potts and Dodgson, 2009) and does not adequately consider intermediary institutions that solve the problems of firms (Watkins et al., 2014). Lack of empirically-based research using meso- and micro-level approaches (or guidance) may mislead policymakers to focus on measuring the system at a static level. This phenomenon can be one of the reasons the NIS concept is widely used to measure nations' innovation capacity rather than to facilitate interactive learning and knowledge flow as a policymaking tool.

In this regard, several scholars (Lankhuizen and Woolthuis, 2003; Lundvall, 2007a; Sharif, 2010; Viotti, 2002; Watkins et al., 2014) highlighted the need to address areas that had been neglected in the NIS literature. Lundvall (2007a) suggested that could not develop effective institutions at the meso- and macro-level without understanding micro-structure—what goes on inside and between firms, engagement of people in competence building, and learning. However, firms are treated as if they are identical in the NIS framework and it does not show how firms generate innovation (Lankhuizen and Woolthuis, 2003; Sharif, 2010). Therefore, it is important to understand innovative action undertaken by actors in many different contexts: in

¹⁸ Lundvall (2004, 2007c) suggested four steps of macro- and micro-level analysis: what takes place inside firms, analysing interactions among firms, explaining international differences, and explaining competitive and growth performance of the innovation system.

large firms, small firms, universities, and research institutes (Kastelle, Potts and Dodgson, 2009).

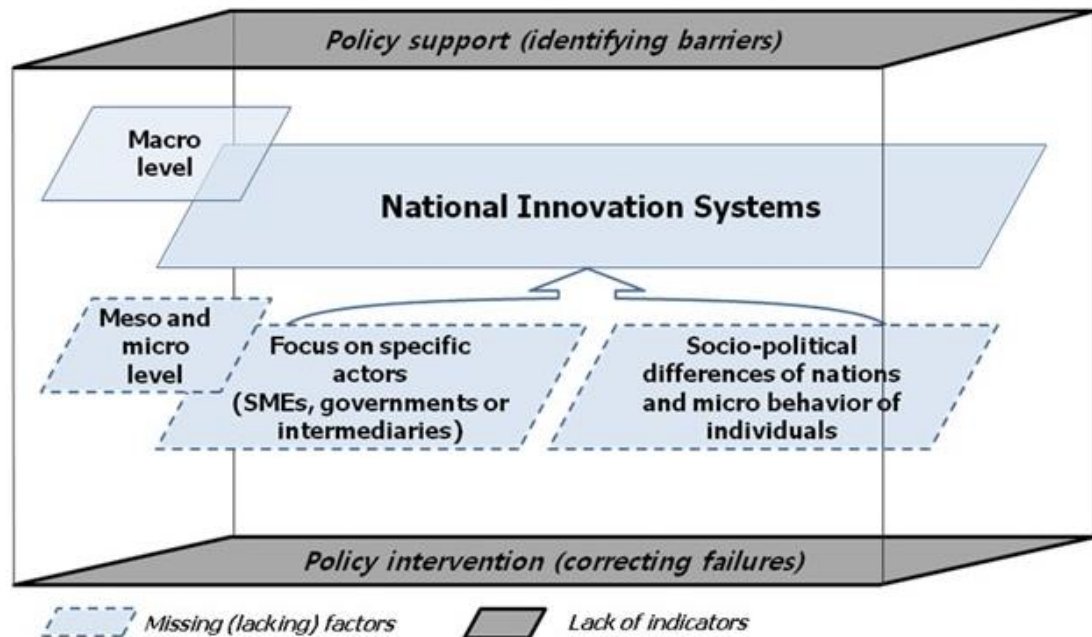


Figure 2-3 The NIS approach and its weaknesses as a policy tool.

Source: Author.

Second, the NIS concept as an analytical framework can be useful to explain the current status (or policy goals) of the NIS in nations. As Lundvall (2010, p23) put it,

innovation thrives in a context where there are few barriers for interactive learning among diverse agents. This has to do with the uneven access to knowledge and with the fact that barriers for interaction will reflect nation-specific arrangements that shape agents and the way they interact.

The problem is that the loose framework does not indicate what innovation barriers are and how to identify the barriers in the system. Edquist (2001) suggested identification of a problem should be supplemented with an analysis of the innovation system. As a consequence, the framework does not guide governments in how to support actors or functions and enhance the efficiency of the innovation system (Edquist et al., 1998). This mismatch can be explained (or resolved) in some theoretical approaches. I examine the system-failure rationale in the following section.

2.3.3 System Failures: Types and Issues

The previous section described the NIS approach, offering policymakers the potential to derive more appropriate avenues for intervention than the neoclassical approach¹⁹ (Lankhuizen and Woolthuis, 2003), followed by a brief discussion of the limitations that still remain in implementing the NIS concept in the policymaking process (i.e. where to intervene). In this regard, this section presents where system weaknesses arise and how the systems-failure approach can capture barriers or weaknesses of the NIS for policy intervention.

From the NIS perspective, innovations take place in a complex and dynamic context, using and generating new knowledge, and consequently coordinating groups of organisations and actors in an important systemic dimension (Metcalf, 2005), as examined in Section 2.2.1. However, the overall function of the system does not imply that all actors work to provide the function of the system. Actors are likely to have different goals, which may bring conflicts and tensions into the innovation system, and interactions may be weak or develop in an unintentional manner (Bergek et al., 2008, p408), resulting in system failures in the NIS, where elements of systems are not functioning effectively.

In criticising the loose nature of the NIS as a policy tool, and lacking the clarity towards a theoretical concept of the NIS, as indicated in Section 2.3.2, the systems-failure approach provides an opportunity to identify where public support should be provided, which actors to address, and when innovation is obstructed, and helps policymakers from a practical and specific point of view (Edquist et al., 1998). The approach captures specificity, such as the array of components and relations, and the boundaries of the system. Hence the approach helps identify specific barriers to innovation that the loose NIS approach could not address. In other words, well-functioning systems create and distribute knowledge, and collective efforts at a system level facilitate innovation in firms (Edquist, 1999).

¹⁹ The neoclassical market-imperfections approach suggests a rather linear process of innovation where R&D spending underpins innovation and stimulates invention, and the connection between R&D and innovation is a matter of investment (Metcalf, 2005). The approach does not show how to capture key elements of technological progress (OECD, 1992) and lacks precision such as entrepreneurship phenomena, competition, and innovation as a coupled dynamic process, and the ability to exploit knowledge in the innovation process (Metcalf, 2005).

Various system-failure literature addresses deficiencies in the functioning of the system: problems, weaknesses, or deficiencies that block flows of information and knowledge, and thus learning in the innovation system. Several authors (Carlsson and Jacobsson, 1997; Metcalfe, 2005; Niosi, 2002; Smith, 1995, 2000; Tödting and Tripl, 2005) looked into the nature of system failures (Table 2-2) focusing on weaknesses of the system, and Woolthuis, Lankhuizen and Gilsing (2005) classified them into four types: infrastructural failures (physical and S&T infrastructure), institutional failures (hard and soft institutional failures), interaction failures (soft and strong network failures), and capability failures (transition and learning failures). Regarding capability failures, Smith (2000) attributed the weakness of firms in innovation to their limited experience and resources; firms are constrained to access knowledge from outside, and even if they could take in information, huge gaps arise between acquired knowledge and the ability to integrate it into their innovation process.

Edquist (2001) defined four main categories of system failures²⁰ that led to problems or deficiencies in the functioning of a system, arguing that identifying a problem should be supplemented by policy analysis. Later, Bergek et al. (2008) criticised the four types of failures as lacking structural and process foci, and developed so-called blocking mechanisms²¹ that might hinder specific functions in an innovation system. Tödting and Tripl (2005) identified three types of ‘innovation barriers’ as system failures in their Regional Innovation Systems research: organisational thinness (underdeveloped organisational set up), lock-in (lack of cooperation or too tightly joined), and fragmentation (poorly developed external links). Niosi (2002) observed failures related to institutions and to systems: sources of institutional inefficiencies and ineffectiveness, and sources of system inefficiencies.

As can be seen in Table 2-2, concepts of system failure vary, lacking consensus.

Various scholars name similar concepts differently and describe system failures as

²⁰ System failures are inappropriate or missing functions, organisations, institutions, and interactions or links between those elements in the system of innovation (Edquist, 2001).

²¹ Blocking mechanisms are uncertainties of needs among potential customers, inadequate knowledge of relations between investments and benefits, lack of capability and articulation of demands, lack of standards, few university programmes, and weak advocacy coalitions (Bergek et al., 2008).

functional weaknesses, barriers, blocking mechanisms, or inefficiencies of the system.

Table 2-2 The Taxonomy of System Failures

Level	Types	System imperfections	Authors
Infrastructure	Infrastructural failure	Lack of physical infrastructure and S&T knowledge Lack of appropriate internal and system resources	Niosi (2002) Smith (2000)
Firms	Transition failure or capability failure	Lack of capabilities in adapting new technologies and markets Organisational inertia	Niosi (2002) Smith (2000)
	Path-dependence and lock-in	Lack of learning routines Inefficiencies and ineffectiveness caused by dependence on a historical process	Niosi (2002)
Interactions	Network failure	Strong or weak network failure that leads to a lock-in situation	Carlsson and Jacobsson (1997)
	Lock-in barrier	Situations of lock-in caused by strong ties	T ödtling and Trippel (2005)
	Fragmentation	Lack of interaction and network	T ödtling and Trippel (2005)
	Interaction failure	Inappropriate or missing interactions between elements in the system	Edquist (2001)
Institutions	Institutional failure	Hard or soft institutional failure	Smith (2000)
		Missing organisations or institutions (including rules)	Edquist (2001) Niosi (2002)
		Weak coordination among units and lack of knowledge flows	Niosi (2002)
	Organisational thinness	Low levels of clustering and a weak endowment with relevant institutions	T ödtling and Trippel (2005)
Functions	Functional failure	Missing functions	Edquist (2001)

Source: Compiled by the author.

Metcalf (2005) criticised supply-side measures of the system-failure approach directed at the invention system, overlooking the wider context of the innovation process. Innovation is a complex social activity: “a spiral process that takes place through interactions among an array of actors and institutions involved and affected” (Williams and Edge, 1996, p867). Therefore, several system failures may intertwine and cannot be addressed directly or by a single actor consisting of a complex amalgam of causes and effects, and involve multiple actors and institutions

(Woolthuis, Lankhuizen and Gilsing, 2005). From this point, the meso- and micro-level approaches are crucial to understand what takes place inside firms and analyses interactions among firms (Lundvall, 2004, 2007c). In other words, analysing the NIS needs to be centred on understanding firms as they are positioned at the heart of the NIS—what type of failures they face in the innovation process, and how failures can be overcome through interactions with other institutions. This analysis will be described in following section.

2.4 The Usefulness of the NIS as a Policy Tool: Identifying and Removing the Barriers in the NIS

2.4.1 Firms and Innovation Barriers

As previously indicated, firms are playing a central role in innovation (Edquist, 1999; Lundvall, 2004, 2007c; OECD, 1999, 2002) and interactions between firms and in interaction with the knowledge infrastructure (Lundvall, 2005) are at the core of the system. In this vein, the term knowledge interaction, rather than knowledge flows, could be appropriate to understand a broader spectrum of knowledge flows and learning between firms and other entities that may interactively affect the whole system.²² Firms need to participate in the knowledge-interaction process with external organisations because complementary knowledge produced by other firms, universities, and research institutes is the most important resource to facilitate interactive learning, create novelty, and maintain competitiveness of firms (Smith, 1995). In this vein, identifying and resolving the barriers in knowledge-interaction processes, and thus effective learning among actors, is crucial for practical use of the NIS framework and successful innovation.

However, firms are often unable to find innovation opportunities or create new knowledge. For example,

²² Five types of knowledge flows (see Appendix 2) suggested by OECD (1997) seem to conjure up the image of bilateral interaction or public-sector transfer of information or technology to private sectors unidirectionally. As Rothschild and Darr (2005) argued, know-how, information, and knowledge flow back and forth through social networks in a complex process. The interaction process, characterised by reciprocity and interactive mechanisms, affects the success of innovation (e.g. Edquist, 1997; Freeman, 1988; Lundvall, 1992; Nelson and Rosenberg, 1993).

innovation capabilities of most firms are limited. There are both market and systemic failures that lead to significant weaknesses, e.g. the ‘low capability trap’ in which firms with low capabilities and learning performance have problems in entering virtuous circles of knowledge accumulation and innovation. (OECD, 2002, p19)

What, exactly, does innovative capability mean? Innovative capability takes an important role in innovation studies (Mart ínez-Rom án, Gamero and Tamayo, 2011). Edquist (1999) also argued that a well-functioning NIS underpins the innovative capability of firms. Dodgson and Bessant (1996) defined innovative capability as features of firms and their management that enables them to define and develop their competences in ways that provide distinctive and sustainable advantages over their competitors. Innovative capabilities include learning capability, organizational capability, resource-exploiting capability, and strategic capability (Guan and Ma, 2003). Innovation capability relates to innovative organizational culture, internal processes, the capability to respond properly to changes in environment (Akman and Yilmaz, 2008), and the ability to understand that the environment could be part of the innovative capability (Neely et al., 2001). It is a dynamic concept allied to the ways firms change (Dodgson and Bessant, 1996).

This view aligns with the dynamic capability of firms, defined as “the capacity to renew competencies so as to achieve congruence with the changing business environment” by “adapting, integrating, and reconfiguring internal and external organizational skills, resources, and functional competencies” (Teece, Pisano and Shuen, 1997, p515). Dynamic capabilities could come from outside the firms; for example, CEOs could use external organisations that have experience transforming other firms, or strategic change consultants. In using external organisations, innovative capabilities also highlight linkage capabilities, networking capabilities, and resource-exploiting capabilities to capitalise on external sources of knowledge (Forsman, 2011; Guan and Ma, 2003; Kroll and Schiller, 2010).

As indicated in Section 2.3.2, the NIS concept does not fully explain meso-level actors (i.e. firms and intermediaries) and in this vein, the various capability-based approaches might contribute to understanding capabilities and problems of firms. Ideas from the dynamic capability of firms have tacitly informed this study: capacity and search. However, the focus of this study is the challenges each SME faces and

intermediaries rather than explaining performance of firms; the frameworks derived to understand performance of big firms may not track well onto small firms (Ambrosini, Bowman and Collier, 2009).²³ Individual differences are often downplayed in big firms whereas background and experiences of individuals have a huge impact on preferences and arguments between players that shape the routines in small firms. OECD and the NIS literature refer to innovative capability of firms in a broader context. Some scholars (Li and Kozhikode, 2009) considered dynamic capabilities to be part of innovative capabilities. In this vein, this study adopted the wider definition of capability of firms: the innovative capability of firms.

What is missing in the capability-based approach is a focus on learning capabilities related to the DUI-mode of innovation: different kinds of learning are taking place in different contexts as a result of firm-specific learning and different kinds of interaction between firms and other organisations (Lundvall, 2004). Learning capabilities enable firms to align resources, competences, and capabilities, in the short term and in a dynamic over the long term (Dodgson and Bessant, 1996). Capability building involves interactive learning by individuals and organisations in diverse innovation processes. Therefore, what needs to be understood is how and to which extent firms are geared to achieve innovation through interactive learning with diverse institutions and actors to address diverse problems (Lundvall, 2004).

2.4.2 Why is Public Support Needed?

The system-failure approach helps identify specific barriers that block flows of knowledge and learning in the system.²⁴ This viewpoint implies two factors: on one hand, barriers are not automatically resolved and need public support; for example, the government can organise cooperation and collaboration between firms to facilitate knowledge flows, regulation, and the creation of incentives (Smith, 1999). On the other hand, although various types of failures accrue, correcting the failures (or overcoming the barriers) may refer to enhancing ‘effective interactions between

²³ Ambrosini, Bowman and Collier (2009) argued the performance of dynamic capabilities would not lead to positive performance outcomes only when the firm actually had the required order of dynamic capability; the approach may not be well-suited to small firms that do not have existing resources.

²⁴ Woolthuis, Lankhuizen and Gilsing (2005) criticised system-failure displays as a loosely configured framework.

actors in the system' (Martin and Johnston, 1999, p50) where knowledge flows freely and learning can be stimulated among actors.

From an innovation-systems perspective (innovative-capability perspective), the accessibility of external knowledge and managing it to be internally applicable to the firm is the foundation: "the external organisation of the firm and the management of its internal processes are essential elements" (Metcalf, 2005, p50) to overcoming the barriers. Muller and Zenker (2001) argued that accessing qualified interfaces between technological and business expertise and localised knowledge and capabilities plays a crucial role in allowing firms to overcome weaknesses and generate innovations. Thus, the ability to access different sources of knowledge such as firms of different sizes, consultancies, research organisations, and universities, and to apply these to their own needs becomes crucial (Dodgson, 2009) in pursuit of shared visions towards innovation. In other words, firms must have capabilities (Caloghirou, Katelli and Tsakanikas, 2004; Lundvall, 2004; Shu, Wong and Lee, 2005) to interact with knowledge agencies because firms seem to be crucial actors in defining and resolving problems in the innovation system.

The problem is that only innovating firms can access and combine these different aspects into a plan for innovation (Smith, 1995). Especially in a newly emerging context, small individual firms (or SMEs) found difficulties in accessing the knowledge developed by research institutes, universities, or large corporations that they need for innovation, and produce competitively, due to their weak capabilities described as various types of failures in the previous section (Sharif, 2006). Most SMEs hardly interact with external knowledge providers such as universities and research institutes and often SMEs are not well aware of the importance of the knowledge sources as means to overcome the barriers (Kaufmann and Tödting, 2002). In certain circumstances, access to technical knowledge is restricted not only by the weak capability of firms, but also by global corporations that protect intellectual property (Lundvall, 2007c).

In this regard, several scholars (Kaufmann and Tödting, 2002; Nooteboom, 1994; Sawers, Pretorius and Oerlemans, 2008) indicated limited capabilities of SMEs, described in Section 2.3.3 (i.e. capability failure). SMEs lack human, financial, and

knowledge resources, and technological capabilities; they are less engaged in R&D and less able to shape external environment than large firms. One of the serious weaknesses of SMEs may be lack of interaction with external organisations and a limited number of relationships (mostly user–producer) restricting the innovative activities of firms. It may not be possible to provide exhaustive lists of weaknesses of SMEs but the general aspects are summarised in Table 2-3.

Table 2-3 Weaknesses of SMEs

	Lack of capability
Internal	<ul style="list-style-type: none"> - Technological capabilities - Developing and managing intangible resources (codified and tacit knowledge) - Absorptive capabilities - Experts (human resources) and expertise (accumulated skills or knowledge) - Means for growth (e.g. management skills or strategies)
External	<ul style="list-style-type: none"> - Relationships with external knowledge sources - Accessing external knowledge source (technology, know-how, and tacit knowledge) - Managing network relations - Accessing partners - Means for growth (e.g. funding)

Source: Adapted from Kaufmann and Tödting (2002), Nooteboom (1994), and Sawers, Pretorius and Oerlemans (2008).

At this point, SMEs should deserve policy attention because they generally have a low propensity to network and gain knowledge, and as a result may face obstacles to facilitating DUI—as well as STI—modes of learning and innovation (OECD, 2002). Policy can be implemented proactively through nonmarket mechanisms to address the situation (Edquist, 1999) where interaction and interactive learning can be intentionally fostered to promote knowledge use by building structures and relationships (Lundvall, 2007b). Therefore, the government has a role to ensure that rich knowledge is available (Metcalf, 2005) from which interactive learning facilitates innovation of firms and thereby strengthens the NIS. The nation is particularly important because external relations are more confined to the nation and the exact nature of national support for the innovation process of SMEs heavily

depends on the specific institutional setting, such as GRIs, universities, technology centres, and transfer agencies (Kaufmann and Tödting, 2002).

For example, developed Asian nations traditionally have nonmarket modes of coordination as mechanisms to correct failure and thereby improve the overall efficiency of the NIS (Dodgson, 2009; Gu, 1996). These mechanisms often take the form of intermediary institutes that can be part of public intermediaries (Dodgson, 2000); their role in resolving the barriers to NIS will be illustrated further in the following section.

2.4.3 Supporting Mechanisms to Overcome System Weaknesses

Dalziel (2010) defined innovation intermediaries as single organisations or groups in organisations that enable innovation either directly, by enabling the innovation of firms, or indirectly, by enhancing the innovative capacity of regions, nations, or sectors.²⁵ Dalziel (2010) further argued that intermediaries may or may not be involved in technology innovation, adopting Schumpeter's definition of innovation as new or improved goods, a new method of production or distribution, the opening of a new market, the use of new supplies or engagement of new suppliers, or a new mode of industrial organisation (Schumpeter, 1934).

In the NIS literature, the role of the public sector can be found in public–private interactions for knowledge flows that seem to focus on generation of patents or publications, based on bilateral interactions between industry–university or industry–research institutes. However, knowledge interactions involve more than co-patenting and co-publication (Appendix 1) involving more than two parties. The facilitation of connection and integration processes is not designed to generate passive knowledge flows but to encourage the engagement of all parties in the knowledge-interaction process (Coombs, Harvey and Tether, 2004); the interaction creates new knowledge and enables firms to master various types of knowledge necessary for innovation (e.g.

²⁵ Specifically, Dalziel's (2010) definition confines innovation intermediaries to public-sector intermediaries such as industry and trade associations, science parks, business incubators, and research institutes; Dalziel does not classify intermediaries who seek the interests of individuals or firms as innovation intermediaries.

technology development or opening of a new market) and, in doing so, may overcome the barriers.

From an innovation-systems perspective, production and knowledge exchange are not the only prerequisites for innovation; several additional factors play a key role, such as policy, legislation, infrastructure, funding, and market developments (Woolthuis, Lankhuizen and Gilsing, 2005). In other words, the innovation process may require complex knowledge and relationships, capabilities of organisations, heterogeneous actors, regulations, and infrastructure; that is, more than just technology. This complexity implies not only the importance of accessing external knowledge sources, as mentioned in the previous section, but also of garnering a wide range of interactions and relationships with knowledge agencies. The form of knowledge can be intertwined with the technological and sociopolitical process, taking the form of experience, skills, or routines embedded in individuals, organisations, and industries.

Accordingly, the various types of barriers relating to different kinds of knowledge and relationships may emerge in a complex and iterative process, and the innovation may be hindered by several system failures, as noted in Section 2.4.1, particularly in areas such as the complex knowledge base, relationships, and the know-how needed to be adequately shaped or deployed for the new business. Considering that the NIS does not emerge naturally, these problems have to be organised at the system level, highlighting the necessity of supporting mechanisms for innovation or a new business to gain success that may be very complicated, requiring not only actions and deliberate efforts by firms, but also the actions of supporting organisations (Nelson, 1994). Providing effective bridging mechanisms between organisations and institutions, but ultimately between individuals, is crucial for the government to organise a rich knowledge ecology in the system (Metcalf, 2005). Public intermediaries, as nonmarket modes of collaboration, have to be active for two reasons, as it may be difficult for market mechanism to simultaneously address complex problems adequately and improve system efficiencies.

First, public intermediaries can build necessary infrastructures by identifying new rules and emerging buyers, configuring in favour of actors and technologies, and

providing additional support for innovation trials. Second, public intermediaries might address system failures by pushing a country to organise and implement policies that would contribute to linking actors for the new knowledge infrastructure or enhance skills required by the new business areas. In this regard, researchers emphasised the role of public research organisations²⁶ that support firms to resolve the problems of innovation and move into a new generation of technologies and products by enhancing the level of knowledge and capability of domestic firms (Malerba and Nelson, 2011). Yet, a tendency remains to neglect those kinds of institutions that support and mould innovation, and correct failures of firms in the NIS literature (Mazzoleni and Nelson, 2007). This tendency leads to further analysis of the interaction process at specific levels that may provide insights into how public intermediaries facilitate the dynamic interplay among actors and thereby decrease barriers to innovation. The following chapter explores specific roles of intermediaries in the innovation process, to further develop the conceptual framework.

2.5 Conclusion

This chapter illustrates the NIS as an influential concept, how it has developed, and how the institutional framework shapes current national systems. The chapter also describes the constituents of the NIS—the importance of knowledge flows and interactive learning—as ways to build effective innovation systems. Section 2.3.1 explains the nature of two different approaches to innovation—a broader and a narrower approach—and argues that many policies have been worked out on the basis of the narrow definition of innovation systems focused on science-based innovation (STI-mode). The section emphasises interactive learning as one of the core foundations of innovation systems (Lim, 2008; Lundvall, 1988, 1992; Martin and Johnston, 1999) and in this vein, the wider setting (DUI-mode) has a major impact on interactive learning and on the performance of the innovation system. Section 2.3.2 analyses limitations in implementing the NIS framework in the policymaking process, highlighting the lack of meso- and micro-level approaches.

²⁶ Edquist (1999, p11) added, “research institutes and company-based research departments may be important organisations in one country (e.g. Japan) while research universities may perform a similar function in another (e.g. the United States).”

The section further indicates that the framework does not indicate what innovation barriers are, how to identify them, and where public support should go in the system.

Then Section 2.3.3 highlights the emergence of the systems-failure literature. The section addresses how the systems-failure approach provided a new rationale for government intervention by identifying innovation barriers and correcting them. Section 2.4.3 briefly illustrates that the government has been playing a crucial role in some Asian countries in enhancing national performance through policy intervention. In this regard, Lundvall, Intarakumnerd, and Vang (2006) argued that the static descriptions of the NIS produced by international organisations have shortcomings in explaining the intrinsic capabilities of nations, thereby inferring the need for more qualitative analysis of the dynamic responses of Asian innovation systems.

In the case of the literature review, the following issues were raised. First, the analysis of innovation systems may be seen as an analysis of how knowledge evolves through processes of learning and innovation (Lundvall, 2007c, p106). Learning is local and specific to individuals (Lundvall, 2005) and interactive learning among knowledgeable individuals is crucial for productive combinations of competing rationalities towards innovations. Lundvall (2004) further highlighted different kinds of interactions and the DUI-mode of learning in different contexts. However, knowledge and learning are presented as a 'black-box' concept (Lundvall, 2004; Russell and Williams, 2002) because the loose NIS concept does not seem to provide an adequate tool (Sharif, 2006) to examine knowledge interactions at specific levels and contexts. Researchers have not addressed how institutions and actors interact and co-evolve, shaping learning and innovation and driving the process of development (Lundvall, 2007c).

In this regard, several scholars (Balzat and Hanusch, 2004; Godin, 2006; Lankhuizen and Woolthuis, 2003; Mahroum and Alsaleh, 2012) indicated the little operational value²⁷ of the NIS framework and indicated the unit of analysis needs to be changed. In other words, the NIS framework tends to focus on the macro-level analysis that

²⁷ The SI framework has not been operationalised sufficiently to enable policymakers to develop policy tools and guidelines (Alsaleh, 2010; Carlsson et al., 2002; Lundvall, 1992)

does not specify meso- and micro-level actors; how intermediary institutions solve the problems of firms has not yet been fully explained (Watkins et al., 2014).

Therefore, this study argues to modulate the NIS at meso- and micro-levels to understand the co-evolution process of the NIS. This will be further examined in Chapters 6 and 7, and discussed in Chapter 8.

Second, this chapter highlights the importance of public-sector intermediaries who support the joint-learning process, making connections among different types of new knowledge (Choung, Hwang and Song, 2014), and thus facilitate innovation.

However, in spite of the importance of public-sector intermediaries as mechanisms to correct failures, knowledge interaction between firms and intermediaries has drawn relatively little policy attention in the NIS literature. Rather, researchers have failed to study public-sector intermediaries and SMEs in the NIS framework, and the intermediary literature has rarely been integrated with the NIS literature. It seems that the loose nature of the NIS has shortcomings in uncovering interaction processes at a specific level (Lankhuizen and Woolthuis, 2003; Watkins et al., 2014)—public intermediaries and SMEs—and thus the concept needs to be operationalised to explicate the knowledge interaction between them. The following chapter examines public intermediaries, what they do, how they interact with firms, and how knowledge interaction decreases (or resolves) innovation barriers.

3 Chapter 3. Intermediaries and Intermediation in the Innovation Process

3.1 Introduction

The previous chapter analysed the literature on the NIS and the rationale of government intervention (i.e. supporting mechanisms) in overcoming the barriers of innovation and thereby facilitating innovation in firms. Because intermediary organisations have been regarded as innovation facilitators, understanding innovation intermediaries is useful as it draws attention to an aspect that has previously been somewhat overlooked in studies of national innovation systems (Lundvall, 1992; Nelson and Rosenberg, 1993). Interest in intermediaries has featured prominently in innovation studies, where the discourse linking intermediary activities to competence building, knowledge transfer, and diffusion of knowledge amongst communities of organisations emerged (Bessant and Rush, 1995).

Faced with bridging the barriers in the innovation process explained in the previous chapter, it is very likely that various intermediaries will coalesce to enable knowledge *de novo*, providing the platform for learning/knowledge creation, and shaping the new innovative environment. Furthermore, intermediaries may also become involved in ‘indirect’ activities such as organising an innovative environment, facilitating social interactions, or networking that will allow SMEs to share information, knowledge, and experience with each other and, possibly, share personnel such as technicians, scientists, and producers. However, literature on intermediaries seems to be fragmented, mainly addressing limited roles and activities at a specific point of time that are often broadly conceptualised in an innovation process. I argue that knowledge interaction is more complex than currently explained in the literature.

Bearing this in mind, researchers must investigate better conceptual frameworks and methodological tools to adequately address the wide and complex mix of dynamic entities of innovation intermediaries. One contribution of this dissertation is an attempt to synthesize the fragmented literature on intermediaries from multiple levels of knowledge interaction and the evolution of relationships in which innovation

intermediaries exist. In this chapter, I examine activities of innovation intermediaries regarding their roles and activities in the innovation process. I begin by examining the existing literature on innovation intermediaries in Section 3.2. In Section 3.3, I review the function of innovation intermediaries, particularly focusing on four functions: how intermediaries enable knowledge, facilitate learning and relationships, and provide interfaces based on multidirectional interaction and relationships. This format delineates how intermediaries resolve the barriers for SMEs that lack knowledge and resources and facilitate innovation during the interaction. Section 3.4 puts forward the role of public-sector intermediaries acting as innovation process facilitators in the NIS.

3.2 *Theoretical Approaches to Intermediaries*

3.2.1 Overview of Intermediaries

Over the last few decades, interests in intermediary studies has undergone considerable development, emerging from a number of different research fields in innovation studies (Nilsson and Sia-Ljungström, 2013). Intermediaries in the innovation process have not yet been well-grounded theoretically and little cross referencing exists between intermediary studies in different fields of study: technology transfer, innovation research, systems of innovation research, and service organisations (Howells, 2006).

Bessant and Rush (1995) considered intermediaries to be primarily facilitators in the innovation process, whereas others highlighted the more interactive and diagnostic role of intermediaries. Hargadon and Sutton (1997), for example, emphasised the proactive role of intermediaries, who not only scan and store information, but also retrieve it through brainstorming, social interaction, and informal conversation. They also stressed the role of individuals in making analogies between past problems and current solutions, and bridging capabilities through ‘cross-pollination’. These scholars emphasised the role of brokers who act as individual knowledge repositories and provide customers with solutions based on new combinations of knowledge.

From an innovation-system perspective, intermediaries often connote public-sector innovation intermediaries contributing to the shaping of the overall innovation

system, facilitating knowledge flows between policymakers and actors in the system (Watkins et al., 2014). Van der Meulen and Rip (1998) identified a wider institutional role of intermediaries (e.g. research councils or research organisations, funding bodies, and government agencies); how they shape an ecology of influence on other actors in the system between policy and institutions. Clarke and Ramirez (2011) also emphasised the role of intermediary organisations that promote knowledge flow between two or more parties among firms and contribute to the learning process among the firms or regional clusters with whom they work. Although these studies concentrate on policymaking, their important role is managing complex networks.

As mentioned above, the different roles that intermediaries play in the innovation process have been described as service organisations, brokers, bridge builders, science parks, etc. Therefore, analyses of intermediaries include a variety of organisations (Table 3-1). Howells (2006) distinguished intermediaries as organisations and intermediation processes²⁸ whereas Winch and Courtney (2007) distinguished between different types of intermediaries based on whether their primary aim is to undertake an intermediary role or perform intermediary activities as a by-product of their main activities. Examples of the former can be innovation centres such as science parks, industry associations, and knowledge-intensive business services while examples of the latter are consultancies, technology-transfer offices, and technology brokers. These are innovation intermediaries although some activities do not relate specifically to innovation (Howells, 2006).

What can we conclude from this review? The underlying metaphor most used in intermediary studies is bridging between unrelated groups; these bridging activities are increasingly involved in complex relationships and interactions whereas some limit their roles as transformers of information or knowledge. Whether acting as bridges or undertaking other mediating services, intermediaries have, on the whole, been considered useful to augment the competencies of firms, but ultimately play a

²⁸ Howells' (2006) comprehensive taxonomic review of the different kinds of innovation intermediaries reflects a new and more diverse division of labour in the knowledge economy that leads to focusing on the nodes and brokers through which knowledge flows among heterogeneous organizations.

subsidiary function as one external linkage to SMEs, considered to be principal performers in business (Clarke and Ramirez, 2011). By reviewing these intermediary studies, it is possible to have a wider holistic view of intermediaries in the innovation process. The next section will attempt to unpack what functions and types align with innovation intermediaries.

Table 3-1 A Typology of Intermediaries

Term/Ownership	Description	Examples
Service organisations /Private	Supporting innovative change; Providing knowledge or expertise about specific disciplines	KIBS, consultancy firms
Technology brokers/Private	Creating new products by making connections between existing solutions in other sectors or technologies	Consultancy firms
Consultants as bridge builders /Private	Independent consultants as bridge builders in the innovation process (e.g. bridging managerial gaps, technology transfer)	Innovation consultants
Funding bodies /Private or government	Bringing together those economic agents with surplus funds who want to lend (invest) to those with a shortage of funds who want to borrow	Banks, Venture capital
Innovation Centres /Government	Providing knowledge or services that are complementary to the firm and facilitate the exchange of information	Innovation brokers
Governments (or government agencies) /Government	Facilitating collaboration involving multiple organisations and providing direct and indirect support	GRI, not-for-profit organisations
Regional institutes/ Government	Providing surrogate ties by serving as functional substitutes for a firm's lack of bridging ties in a network; Networking with local firms to facilitate economic development	GRI, public research institutes
Industry Associations /memberships	Allowing firms to accomplish specific organisational objectives	Trade associations, lobbying groups
Universities/ Universities	Promoting technology licencing and new venture formation; Undertaking innovation activities on behalf of local firms	Technology-transfer offices
Science parks/ Government	Increasing the wealth of communities by promoting innovation and the competitiveness of associated businesses and knowledge-based institutions	Research parks, technology parks, science towns
Business Incubators/ Government	Accelerating the growth and success of firms through an array of business support resources and services	Innovation labs, innovation incubators
Network-based intermediaries	Emerging actors who bridge gaps in newly forming networks and facilitate contacts; Creating new knowledge and relationships	Formal, informal actors emerging in the technology innovation process

Source: Adapted from Howells (2006), Dalziel (2010), Wu and Dalziel (2012), Van Lente et al. (2003), Klerkx and Leeuwis (2009), and Stewart and Hyysalo (2008).

3.2.2 Innovation Intermediaries: Types and Functions

Several authors (Howells, 2006; Klerkx and Leeuwis, 2009; Van Lente et al., 2003) distinguished traditional intermediaries, innovation intermediaries, and systemic intermediaries by roles or functions (Table 3-2). Traditional intermediaries provide services on a one-to-one basis without involving third parties and play a major role in initiating and developing an innovation (Klerkx and Leeuwis, 2009). For example, traditional intermediaries may provide services (e.g. providing information or testing services) to customers,²⁹ which can be seen as sources of innovation (playing a major role in initiating and developing innovation) or carriers of innovation (transferring innovation that does not originate from particular knowledge providers; Van Lente et al., 2003).

Traditional intermediaries have been criticised in several ways. First, they are unlikely to reshape innovation processes, overlooking interaction between different parties and ‘reconfiguring, translating, and redesigning’ to meet with the new demands of heterogeneous actors (Van Lente et al., 2003). Second, they do not seem to align with different ‘choices’ in the innovation process from the context of multiple relationships in complex systems. Another criticism is that they design their services for large organisations with ‘standard solutions’, based on the assumption that users are homogeneous and that standard solutions to problems can be applied (Howells, 2006), although the solutions may not work for SMEs (Bessant and Rush, 1995).

When it comes to innovation intermediaries, Howells’ (2006, p720) definition is ‘an organisation or body that acts as an agent or broker in any aspect of the innovation process between two or more parties.’ Klerkx and Leeuwis (2009) argued innovation intermediaries are system builders that enable organisations to innovate and facilitate innovation processes. Dalziel (2010) confined innovation intermediaries to public-sector intermediaries who work towards the economic success of firms and create

²⁹ Banks and for-profit firms such as consultancy firms can be considered as traditional intermediaries (Bessant and Rush, 1995; Grabner-Kraeuter, 2002) as they deliver services as sources of innovation. Wu and Dalziel (2012) argued universities and technology-transfer offices were not dedicated innovation intermediaries because they undertook innovative activities (e.g. contract research) on behalf of firms as carriers of innovation.

socioeconomic benefit in regions and industries, not for their personal success. In a similar vein, Van der Meulen and Rip (1998) indicated not-for-profit organisations are innovation intermediaries that link basic science to socioeconomic objectives. Thus, the functions of innovation intermediaries can be ‘targeted at individual firms, and clusters or network of firms, but also can be targeted at higher system aggregation levels in innovation systems that involve complex constellations of business, government, and societal actors, dealing with complex problems’ (Klerkx and Leeuwis, 2009, p851).

Systemic intermediaries are the new types of innovation intermediaries that facilitate and accelerate complex interactions in the multi-level structure of the innovation process where there is sociotechnical co-evolution (Van Lente et al., 2003).³⁰ The systemic approach to intermediaries (Backhaus, 2010; Boon et al., 2008; Klerkx and Leeuwis, 2009; Van Lente et al., 2003) seems to focus on ongoing changes in innovation systems and functions in networks during long-term and complex transitions in the innovation system. Smits and Kuhlmann (2004) distinguished three major trends in systemic intermediaries: the end of the linear model and the rise of interactive model, a reinforcement of the systems approach, and the increasing importance of the learning process. Under these trends, they provide five systemic functions: including knowledge interaction at multiple levels (not limited to bilateral contacts), building systems that align consensus and facilitate involvement of all actors, providing learning space, providing an infrastructure, and stimulating demand articulation. Limiting themselves to examining how intermediaries contribute to the learning process, some authors (e.g. Van Lente et al., 2003) seemed to assume that systemic intermediaries may replace traditional ‘hard’ (knowledge transfer, technical services, or R&D related services) and ‘soft’ (management or organisational services) function intermediaries.

³⁰ Several case studies (e.g. Moss, 2009; Moss et al., 2009; Van Lente et al., 2003) also illustrated that systemic intermediaries in system transitions operate interfaces on a multi-level structure, different scales or levels of action, and further interaction between technologies and social contexts. They described how intermediaries facilitate and translate a process of reshaping technologies into different sociotechnical contexts during the system transition.

Table 3-2 summarises three different types of intermediaries, functions, and levels of interaction. While traditional intermediaries carry innovation, which focuses on one-to-one interactions, innovation and systemic intermediaries can be seen as innovation facilitators, involved in more complex interactions and relationships. Innovation intermediaries and systemic intermediaries do more than carry innovation engagement in unilateral and bilateral activities.

Table 3-2 Functions of Intermediaries

Types	Definition	Functions	Interaction
Traditional intermediaries (Howells, 2006; Smits and Kuhlmann, 2004; Van Lente et al., 2003)	Carriers or sources of innovation	Supplying services on a one-to-one basis, which involves no interaction with other organisations (e.g. knowledge processing and combination; testing and valuation; knowledge transfer)	one-to-one interaction (mainly bilateral)
Innovation intermediaries (Howells, 2006)	Facilitators of innovation	Foresight and diagnosis (demand articulation); scanning and information processing; knowledge processing and combination; gatekeeping and brokering (facilitating negotiation); testing and valuation; accreditation; regulation; protecting the results; commercialisation; evaluation of outcomes	One-to-one interaction or multiple-level interactions in (distributed) innovation systems
Innovation intermediaries (Klerkx and Leeuwis, 2009)	Innovation brokers that function in networks and systems	Demand articulation; network formation; innovation-process management (can be aggregated as detailed functions presented by Howells)	Multiple-level interactions
Innovation intermediaries in the public-sector (Dalziel, 2010; Inkinen and Suorsa, 2008; Nilsson and Sia-Ljungström, 2013)	Facilitators of innovation funded in a specific national or regional system	Direct and indirect funding support; networking and collaboration (partnership building and knowledge dissemination); other supportive functions that align with functions of innovation intermediaries	Multiple-level interactions in specific innovation systems
Systemic intermediaries (Moss, 2009; Moss et al., 2009; Van Lente et al., 2003)	Intermediaries that function primarily in networks and systems	Demand articulation; alignment; organising discourse; managing of complex, long-term innovative projects; learning; creating conditions for learning by doing, using, interacting and searching; feeding actors with tailor-made information	Multiple-level interactions

Source: Elaborated by the author.

Although a systemic approach attempts to introduce the changing characteristics of intermediaries in innovation systems as new types of intermediaries (e.g. Van Lente, et al., 2003), this approach may overlook traditional or innovation intermediary roles. In reality, no clear boundary of roles exists between traditional intermediaries and innovation (or systemic) intermediaries, or between innovation intermediaries and public-sector innovation intermediaries. Overlap exists in the roles of innovation intermediaries and public-sector innovation intermediaries, and of innovation intermediaries and systemic intermediaries (Table 3-2). Many functions of innovation intermediaries provided by Howells (2006) can be linked to systemic functions in the innovation-system literature, whereas some focuses on supporting firms (Nilsson and Sia-Ljungström, 2013).

For example, contract research and technical activities are often the most prevalent role of traditional intermediaries but can be the one of the roles of innovation intermediaries (Howells, 2006). Traditional intermediaries may develop functions towards innovation or systemic intermediaries through interaction with customers. Therefore, care is needed to classify their roles into traditional and innovative (or systemic) intermediaries. Rather, innovation intermediaries cover a wide range of functions carried out by traditional intermediaries (e.g. knowledge processing and combining, testing and valuation, and knowledge transfer) as well as systemic intermediaries (e.g. demand articulation and managing innovation process). Howells (2006, p725) stated,

Innovation intermediaries were often not only involved in providing mediated innovation services linking their clients with other organisations, but also supplying services direct to their clients on a one-to-one basis, which involved no other interaction with other organisations. Intermediaries therefore can, and do, provide other functions within an innovation system, such as contract research, testing or training work, which have no third-party or brokerage function whatsoever. The role of innovation intermediation may therefore be only one amongst a number of other roles an organisation may undertake in terms of its strategic remit.

In this vein, this study does not limit the role of innovation intermediaries to the specific activities listed in Table 3-2, but is rather flexible in accordance with barriers or opportunities firms face in the innovation process. In terms of the various types of

innovation intermediaries, I distinguish public-sector innovation intermediaries, whose primary purpose it to enhance socioeconomic benefits, from other types of innovation intermediaries for further analysis. As public-sector innovation intermediaries are the central focus of this study, discussion centres on the interactions between public-sector innovation intermediaries and SMEs.

3.3 Functions of (Public-sector) Innovation Intermediaries

As indicated in the previous section, ‘innovation intermediaries’ cover a wide range of functions³¹ not traditionally required, ranging from translating basic research and technologies into different levels of practice and markets, to encouraging greater resources to enhance knowledge flow in networks and scanning new knowledge, to articulating customer needs in innovation processes. Among these, Van Lente et al. (2003) categorised three major systemic functions as articulation, alignment, and learning, whereas Klerkx and Leeuwis (2009) categorised them as demand articulation, network composition, scanning, scoping and matchmaking, and brokerage in established networks (aligning actors and mutual learning).

The roles of innovation intermediaries may be evolving based on social and political systems of specific regions or countries, as policies align with characteristics of innovation systems that differ from other systems of innovation. Van der Meulen, Nedeva and Braun (2005, as cited by Klerkx and Leeuwis, 2009, pp851–852) explained: “the establishment of an intermediary organisation is often contingent on the specific political context or on typical opportunities and needs within research and innovation sectors.” Nonetheless, innovation intermediaries have emerging important roles at the NIS level that include demand articulation, learning facilitation, and networking. By engaging in these activities, innovation intermediaries may mitigate the gap (or barriers), thereby facilitating relations and learning through the complex innovation process, whether or not intermediaries fulfil traditional

³¹ In this context, the different roles of intermediaries that facilitate innovation processes have been studied (Backhaus, 2010; Howells, 2006; Klerkx and Leeuwis, 2008; Moss, 2009; Van Lent et al., 2003). This study does not distinguish between the role of innovation intermediaries and public-sector innovation intermediaries, as their roles often overlap (see section 3.2.2).

functions.³² Thus, to avoid proliferation of roles and activities, I categorise the following roles as key elements in the ongoing innovation process: enabling knowledge, facilitating relations, facilitating learning processes, and providing interfaces (Table 3-3).

Table 3-3 Roles and Activities of Innovation Intermediaries in the NIS

Roles	Activities	Supporting literature
Knowledge enabling	Demand articulation Knowledge generation and combination configuration Customising knowledge to a specific context	Boon et al. (2008), Brown and Duguid (1991), Clarke and Ramirez (2011), Howells (2006), Smits and Kuhlmann (2004)
Facilitating relations	Bridging links and aligning actors Facilitating interpersonal communications and relationships Building trust	Howells (2006), Klerkx and Leeuwis (2008), Moss et al. (2009), Smits and Kuhlmann (2004), Van Lente et al. (2003)
Facilitating learning	Stimulating interaction and enhancing mutual adaptation Building new routines and skills through interaction (feedback mechanism)	Backhaus (2010), Boon et al. (2008), Smits and Kuhlmann (2004), Stewart and Hyysalo (2008), Van Lente et al. (2003)
Managing interfaces	Providing facilities and other knowledge infrastructures Providing access to human resources	Clarke and Ramirez (2011), Hargadon and Sutton (1997), Howells (2006), Van Lente et al. (2003)

Source: Elaborated by the author

Specifically, I try to emphasise the role of knowledge enabling and managing interfaces for two reasons. First, many intermediary tasks initially were limited to matchmaking and brokering (Howells, 2006) although innovation intermediaries could learn and improve their competence, playing an important role in connecting, translating, and facilitating flows of knowledge in systems of innovation. Knowledge can be configured and translated during the interaction process between innovation intermediaries and SMEs and between intermediaries and potential innovation players. This can be defined as ‘knowledge enabling’ rather than knowledge brokering.

³² Traditional intermediaries may improve their competence and move out of limited roles (such as testing and knowledge generation), addressing wider and more complex functions. For example, traditional intermediaries can learn and develop those roles because, in part, they can facilitate interaction with outside knowledge much more easily, and because intermediary organisations are perceived as independent and impartial by supplier and user firms alike (Clarke and Ramirez, 2011).

Second, by emphasising a form of learning, such as learning by doing, learning by using, or learning by interacting, innovation intermediaries may also need to consider providing learning space as part of a follow-up service, defined here as ‘managing interfaces’. Because innovation through learning can be achieved through continuous interaction, it is important to bridge the gap at each stage of innovation rather than providing a one-off service that may not bring any changes. In particular, providing interfaces is an important conduit for continuous knowledge flow and interaction under high market uncertainties and demand ambiguity.

3.3.1 Knowledge Enabling

Knowledge enabling is a challenging activity, defined as providing new knowledge inputs and adapting existing knowledge to make it applicable to a different context and situation (Clarke and Ramirez, 2011). This definition closely links the roles of ‘translation’ and ‘bridging the knowledge gap’, that is, helping to transform ideas and transfer knowledge. To carry out this role, intermediaries must have knowledge infrastructure, human resources, and networks and be seen as independent and impartial by supplier and user firms.

There are three parts to this role: articulating the demands of customers, knowledge generation and combination, and customising knowledge to a specific context. Through empirical studies, several authors (Backhaus, 2010; Boon et al., 2008; Van Lente et al., 2003) averred that intermediaries articulate process, defined as an iterative, inherently creative process stimulating technological varieties and characteristics of possible futures. They argue that, at the early phase of emergent technology development, actors only have ‘vague’ ideas that should be developed further in the demand-articulation process.

These uncertainties in innovation processes include possible technologies and their application options, different legal and social settings, the definition of demands, and relationships that can be strengthened through learning by interacting. Due to uncertainties and flexibilities inherent in the innovation process, other actors than the intermediary and the firm will participate in the articulation process. Bessant and Rush (1995) indicated the articulation and diagnostic role of consultants while

highlighting intermediation as a complex activity involving multiple actors with different patterns of relationships and different sets of influential actors and issues.

The second part of the enabling role is knowledge generation and combination, developed with customers on a one-to-one basis, emphasising a deeper understanding of what customers need. Clarke and Ramirez (2011) defined this as ‘providing new knowledge inputs’ and categorise formal testing, accreditation, and standard setting as parts of related activities. However, intermediaries move on from their initial role of providing knowledge to needing to carry out more complex functions, due to the complexities inherent in new knowledge. Hargadon and Sutton (1997, p716) identified the role of broker as not just supporting a linkage role, but as a knowledge repository, whose knowledge its workers use to provide clients with solutions that are new combinations of existing ideas.

Izushi (2003) also differentiated intermediaries as ‘high information gap’ and ‘low information gap’ services. The latter covers product testing and evaluation using the institute’s equipment, offering the use of testing and evaluation equipment to individual users. The former services are characterised by technical advice and guidance, training, lecturers, and joint research; in other words, intangible services requiring skilled intermediaries and interactions. These services relate closely to the role of innovation intermediaries, the so-called ‘knowledge translation and configuration’. Interaction with potential innovation actors in specific areas plays a crucial role in generating a high quality of knowledge in the complex innovation process.

The third part of the enabling role is customising knowledge to a specific context, which may require knowledge translation and reconfiguration. Intermediaries not only must transmit knowledge, but also re-engineer knowledge, fostering several multilateral knowledge flows and adapting knowledge to a different context or a new situation. Unless recipients of knowledge understand the original recipes perfectly, intermediaries must fill the gaps in their version of knowledge (Sorenson, Rivkin and Fleming, 2006) with something suited to the specific social and technical context. Often SMEs do not know how to access the ‘original recipe of knowledge’ and are incapable of translating it for their own context. This can be the key role of

intermediaries who can adapt knowledge and frame it to fit the interests of SMEs (Brown and Duguid, 1998) so it is intelligible to them and maintains trust (Clarke and Ramirez, 2011).

Although most intermediary studies focus on their supply-side role (Howells, 2006), Stewart and Hyysalo (2008) emphasised the role of the customer. They introduced the concept of configuration, which means interpreting products and modifying projects to reflect a customer's interpretation, which can be changed when customers introduce new ideas (Stewart and Hyysalo, 2008). In this vein, knowledge enabling is an interactive and iterative process where knowledge is reinterpreted and reconfigured through interaction, rather than a one-way knowledge flow from intermediaries to customers.

3.3.2 Facilitating Relations

The second part of the intermediary role is that of facilitating relations. Relation facilitation has not attracted much attention in innovation intermediary studies thus far. It refers to organising and managing a network; a process of continuous alignment of actors in innovation networks, enhancing communication of actors and bridging cognitive difference between different knowledge domains (Klerkx and Leeuwis, 2008; Smits and Kuhlmann, 2004). In facilitating relations, intermediaries must have wide organisational and individual networks, maintain durable and satisfactory relationships with potential actors, and have the capability to negotiate mutually acceptable solutions (Klerkx and Leeuwis, 2008).

Key activities are bridging links, aligning innovation players, and facilitating interpersonal communication and relations. First, the role relates to initiating and strengthening linkages between the various parts of innovation systems, which can involve more than two parties. The activities include building and sustaining the relationship and facilitating it so potential players can co-shape the innovation environment. Intermediaries can uniquely put potential innovation players together and align the expectations of actors across different contexts relevant to a specific context (Backhaus, 2010). The capability to interact with other companies favours access to and transfer of knowledge, which in turn significantly impacts company

growth and shaping innovation (Rothschild and Darr, 2005) over time. The relationship reduces transaction costs for firms, providing the necessary resources, knowledge, and know-how required in the innovation process that is crucial for SMEs.

Through empirical study, Howells (2006) pointed out the importance of the intermediary role in providing longer term and relational innovation capabilities, whereas researchers need to study the nature of the relationships in which intermediaries are involved.³³ Criticising a linear innovation model that considers customers as passive receivers of knowledge, the study shows that interaction with proactive customers not only helps enhance their knowledge capacity to use a knowledge repository of intermediaries, but also provides learning opportunities for intermediaries. Long-term relationships between SMEs and intermediaries have the largest influence in determining the use of ‘high information gap’ services by strengthening interactions. Because intensive interaction with SMEs affects relational assets that were initially attached to physical capital, such as equipment, it gradually shifts its relational foundation to human capital, such as researchers.

Second, facilitating interpersonal communication is an important activity, especially at an early stage of R&D where technological knowledge is not directly codified through artefacts, but is embedded in individuals and their experiences in tacit form (Howells, 2006). Technologies, knowledge, and know-how embedded in individuals flow best through informal, mainly personal, relationships (Allen, Hyman and Pinckney, 1983). Individuals’ relationships not only identify potential innovation actors but also facilitate communication to materialise various technical options and strengthen ties. In particular, science and engineering graduates are likely to be valuable in accessing knowledge developed by intermediaries (i.e. research organisations) and perhaps specifically the public science base, which can be remote from the commercial pressures commonplace in firms (Tether and Tajar, 2008).

³³ Howells (2006, p, 725) further argued “most of the discussion has been in the context of their function and not their network relationships. Simple triadic structures are mainly implied, whilst where more complex multi-actor relationships in terms of intermediation are, en passant, acknowledged they are then largely ignored.”

Relationships represents the ability of actors to secure benefits by virtue of membership of networks defined as social capital: “the aggregate of resources embedded within, available through, and derived from the network of relationships possessed by an individual or organisation” (Inkpen and Tsang, 2005, p151). From a firm level, the use of intermediaries tends to complement firms’ own internal innovation activities and to complement other external sources of knowledge (Tether and Tajar, 2008). Cooke and Wills (1999) assessed government programmes to promote collaboration amongst SMEs to improve innovation capacity by increasing social capital through networking.

Such relationships between individuals or organisations are an avenue where they exchange contextual knowledge and solve practical problems. In their IDEO case study, Hargadon and Sutton (1997) suggested intermediaries should have a more proactive and sophisticated role in innovation processes, such as ‘cross pollination’ or ‘bridging’ among unrelated groups of a particular social system to new ideas, emphasising individuals as brokers. In this vein, Stewart and Hyysalo (2008) emphasised the role of managers at cybercafés, running trials that generate new interactions, making activities visible to other actors. Friedman and Podolny (1992) highlighted the role of ‘boundary spanners’, who provide a vehicle for communications and dispute resolution for negotiations, and interfunctional relationships or other cross-group ties in organizations. According to the authors, boundary spanners carry influence between constituents and their opponents, and represent the perceptions, expectations, and ideas of each side to the other. This may be more than the role of representation; rather, they may translate the idea as well as its meaning to their own group.

In particular, innovation accompanying complex knowledge acquisition and creation will be difficult to obtain outside the firm without a tight relationship or relational capital attached to individuals. The social capital of individuals and intermediaries can facilitate the knowledge flow between firms and other organisations in innovation systems. However, the knowledge-facilitation process has limitations in showing, for example, how knowledge flows back and forth between intermediaries and potential players and between SMEs and intermediaries, bridging the gap of

social proximity and knowledge, and how intermediaries can access the knowledge repository of potential players using relational capital. These processes can be still seen as black boxes that need to be explored in a different social context.³⁴

3.3.3 Facilitating Learning

A third part of intermediary activities can be the concept of learning facilitation. Intermediaries should be able to create conditions for learning by interaction, feeding actors' tailor-made knowledge, which is highly context specific. Learning facilitation focuses on an interactive and iterative process that increases opportunities for mutual learning, stimulates creation of new knowledge, and simultaneously contributes to a firms' ability to innovate (Nielsen, 2005; Tsai, 2001). In a similar vein, Van Lente et al. (2003) pointed out that learning can be enhanced by the feedback mechanisms and by stimulating experiments and mutual adaptation. To do so, facilitators provide various kinds of learning space, contributing to the added value of the innovation system.

Williams, Stewart and Slack (2005) provided SLTI, lending insight into the role of intermediaries who mediate and bridge reciprocal social-learning processes between those whose interests, visions, and expertise differ. SLTI particularly highlights complex learning processes and knowledge flows among heterogeneous players, representation of users and uses, and the processes of appropriation by actual users (Williams, 2000; Williams, Stewart and Slack, 2005). Scholars consider brokering, configuring, and facilitating activities as central to the social-learning process, which creates new relationships and new knowledge. In this context, Williams, Stewart and Slack (2005) identified intermediaries as the key players in social learning who facilitate relations and knowledge, providing a focus of reflexivity in a social-learning process.

³⁴ Theorists on social capital emphasise the relationship between actors or organisations, undermining the barriers of building networks under certain social and cultural contexts, as shown in Bathelt and Zeng's study (2010) in China, where intermediaries provided a conduit of networks for knowledge flow. Tether and Tajar's (2008) study shows that knowledge flows more efficiently from the public science base to firms through intermediaries than it flows directly from one to another. They argued that intermediaries such as research institutes tend to be dominated by university graduates, who occupy the same social worlds as graduates in firms. The relationships of university graduates are likely to be particularly significant.

Social learning explains the processes where various actors learn from experiences and interactions; thus, social learning can be seen as a cognitive, social, and political process, emphasising negotiation and interaction among heterogeneous actors (Sørensen, 1996; van Mierlo et al., 2010). Social learning highlights the active role of actors, serving to alert policy makers to the necessity of the process and what is required to facilitate it. In this vein, intermediaries help SMEs understand and articulate demands and mediate among actors by continuously forcing them to learn about, filter, translate, and reflect on information, products, and practices of other actors to remain relevant and thus in existence.

The problem is that an important avenue for exploitation may take the form of ‘embodied knowledge’, given the complexities and difficulties in formulating and communicating social-learning experiences (Williams, Stewart and Slack, 2005, p231). In this case individuals can be key players as reflexive actors in the social learning process, and act as a conduit for knowledge flow. Because certain players may have a particularly advantageous viewpoint and a broad span of control and action, they may have special opportunities and incentives for reflection (Williams, Stewart and Slack, 2005). Intermediaries can be individuals or institutions that facilitate learning by others by transferring and translating relevant knowledge and information (Stewart and Hyysalo, 2008; Williams, Stewart and Slack, 2005).

Meagher, Lyall and Nutley (2008) also indicated the role of ‘individual knowledge brokers’ as intermediaries who influence and enhance the flow of knowledge during the process of knowledge transfer between researchers and users. In this case, individuals were allowed to ‘cross-pollinate’ their ideas between products and industries by linking otherwise disconnected domains to gain access to ideas from others in the innovation process. As shown in the IDEO case, this process was a routine that made connections between existing solutions and new problems; employees created new knowledge by learning, remembering, and retrieving them in new forms that fit a new combination (Hargadon and Sutton, 1997).

Learning by interacting may augment individual memories and written materials by sharing different point of views on specific knowledge, acting as linkages between routines in the past and those that lie ahead. Learning by interaction, remembering,

and retrieving also take time, which may require consistent and ongoing intervention to facilitate interaction of employees at all levels. The presence of legitimate facilitators who are capable of maintaining the quality of process facilitation is the crucial condition for social learning, providing specific intervention to problems that block learning and innovation (van Mierlo et al., 2010).

3.3.4 Managing Interfaces

The fourth part of the intermediary role associates activities with accessing knowledge, facilities, and human resources aimed at providing a conduit for continuous knowledge interaction. Managing interfaces means accessing the way intermediaries expose other organisations to a wide range of new sources of knowledge and how they can help assess the value of different alternatives (Clarke and Ramirez, 2011). Although the term accessing brings forth an image of one direction of interaction, managing interfaces does not merely mean supporting or brokering the activities of intermediaries, but rather connecting various infrastructures that are limited to neither one-off services nor sources of knowledge. These activities may include not only knowledge infrastructures but also human resources, networks, and other physical infrastructures such as research facilities.

Intermediaries should offer a space for continuous interactions, while linking resources and actors from different places, ‘acting as conduits for exchange of knowledge and other resources’, a *sine qua non* for early stage innovation to materialise from vague ideas and options. As explained in Section 3.3.1, the knowledge-enabling process is iterative and can be reinterpreted and reconfigured during the innovation process. One-off services and unidirectional knowledge flow cannot fill the various gaps at every stage of innovation.

Several empirical studies have offered examples of managing interfaces, ranging from brokering activities to providing a space for continuous interaction. Bessant, Kaplinsky and Morris (2003) illustrated the way intermediaries play a crucial role in providing access to important sources of knowledge, helping the South African furniture industry achieve international status. Clarke and Ramirez (2011) showed how the intermediary PROMPERU has bridged the gap between producers and

overseas buyers in the agricultural cluster in northern Peru by developing a knowledge base for producers to contact buyers.

Izushi (2003) highlighted the role of managing interfaces between the research institute and customers, emphasising access to organisational capital and human capital. Continuous interaction with staff at the research institute allows customers to know more about areas the staff research and other services of the institute. Customers learn how to use external knowledge to resolve new issues and find opportunities for collaboration. Staff of (government) institutes could constantly discuss the possible causes of problems, using their knowledge with customers, whereas private-sector intermediaries tend to be limited to one-off specialised services.

3.4 *Characteristics of Public-Sector Innovation Intermediaries*

3.4.1 *Public-Sector Innovation Intermediaries in Asian Countries*

As indicated in Section 3.2.1, innovation intermediaries often imply public-sector innovation intermediaries in the innovation system (Dodgson, 2000; Howells, 2006; Izushi, 2003; Klerkx and Leeuwis, 2008, 2009; Kodama, 2008; Van Lente et al., 2003). Public-sector innovation intermediaries—industry associations, chambers of commerce, economic-development organisations, and research institutes—are active in almost every country (Dalziel, 2010). Their activities are directed towards economic development through technology catch-up in developing countries (Mazzoleni and Nelson, 2007) and facilitating collaboration between actors, networking to resolve multidimensional problems in developed or advanced countries. In this vein, understanding public-sector intermediaries is important for two reasons: first, the NIS, SI, and RSI literature often overlooks intermediaries, although they are instrumental in addressing problems in the system; second, it is useful to examine the innovation intermediary as a single class of organisation in developing useful theories. This section further examines the types of public-sector innovation intermediaries linking their contribution to the NIS.

As briefly described in Section 2.4, the development of different types of public-sector intermediary institutions to address system failures and coordinate support in

the NIS (Dodgson, 2000) is not a recent phenomenon in developed Asian countries. Government-supported research institutes play the part of innovation intermediaries (Choung, Hwang and Song, 2014; Dodgson, 2009; L. Kim, 1993; Lim, 2008; Mazzoleni and Nelson, 2007): for example, 400 S&T institutions exist in China (Xiaoyuan and Yanning, 2011), ITRI in Taiwan, GRIs in Korea, and not-for-profit associations and institutes in Japan. In Japan, government intervention played a crucial role in leading the electrical and electronics industry. Since 1920, GRIs and universities accumulated R&D capabilities that led to the absorption of transistor and computing technologies from the United States and Europe in a short period of time (Fransman, 1991, 1992). Japanese-government investment in restructuring key industries rose significantly during World War I and the post-war period encouraging co-operation between GRIs and universities to accelerate economic development. As a result, GRIs (e.g. the Electrotechnical Laboratory administered by MITI) and universities accumulated technology capable of facing the challenges inherent in the information-technology era and transferred these technological capabilities to industry under co-operation and competition strategies.

Through a case study on central-office switches, Fransman (1991) highlighted the role of 'controlled competition', which was a uniquely Japanese form of organising the supply of complex telecommunications equipment during the mid 1980s. Government organisations in the form of Nippon Telegraph and Telephone and Electrical Communications Laboratories played a significant role in organising and managing controlled competition by initiating research, inviting suppliers to join the research, helping them specialise in various tasks, facilitating knowledge sharing amongst suppliers, and making procurement decisions. Izushi (2003) analysed the length of relationships and their effects on information gaps between research institutes and SMEs, whereas Kodama (2008) emphasised the intermediating effect of the Technology Advanced Metropolitan Area Association in Japan.

In Korea, GRIs have been a crucial mechanism to foster major industries and firms (i.e. *Chaebols* and technology-based small firms) for several decades (Dodgson, 2009; Hershberg, Nabeshima and Yusuf, 2007; L. Kim, 1993, 1997; Lim, 2008). For example, the Korean Electronics and Telecommunications Research Institute (ETRI),

played a major role in coordinating and managing the consortia in developing 16-/64- DRAM with Samsung (Choung, Hwang and Song, 2014). In this regard, Roberts (2005) described GRIs as the one of the major innovation actors in ‘Innovation Intensive Environments (IIEs)’³⁵, purported to accelerate the rate of innovation and proliferation of high-technology industries. Although the author did not name them as intermediaries, the notion seems to imply their role as innovation facilitators who linked and interacted between actors at regional or national levels. These are the public-sector innovation intermediaries whose purpose is to enable innovation in firms, industries, and nations.

3.4.2 Main Advantages in Supporting Innovation Processes

Reflecting on the conclusions of not-for-profit scholars as to why they know so little about not-for-profit organisations (Dalziel, 2010; Salamon and Anheier, 1992), previous sections explained how (public-sector) innovation intermediaries perform four functions and how public-sector innovation intermediaries influence the innovation process of SMEs. Studies on public-sector innovation intermediaries (Backhaus, 2010; Boon et al., 2008; Klerkx and Leeuwis, 2009; Van Lente et al., 2003) seem to have three main issues under the framework of NIS. The first is their role of knowledge interaction at an early stage, the second is maintaining an impartial position during the interaction process, and third is resources.

First, public intermediaries act at a precompetitive stage until actors form a network involving other knowledge providers (Klerkx and Leeuwis, 2009). The process requires deliberate efforts to create effective linkages between technological arrangements, people, and social-organisational arrangements (Geels, 2004) to embellish the vague knowledge at the early stages of innovations. Due to the high levels of uncertainties and contingent nature of innovation (Nilsson and Sia-Ljungström, 2013), it may be difficult to predict the services of intermediaries and outcomes that may hinder the participation of private intermediaries. Knowledge generation and knowledge brokerage are hard to make tangible and visible because the services take place in the early stage of innovation. Moreover, a risk associated

³⁵ IIEs are innovation spaces such as science parks, industry clusters, regional innovation systems, the technopolis, and the milieu.

with long lead times to the arrival of innovation processes makes it hard to recover the costs incurred.

Even venture capitalists are increasingly reluctant to invest in early stage firms and prefer to invest in revenue-earning firms (Branscomb, 2001; Branscomb and Auerswald, 2002). Thus, publicly funded innovation intermediaries fulfilling these roles could provide a solution to avoid the dilemmas of leaving the network-brokering phase to private consultants (Klerkx and Leeuwis, 2008). As Hansmann (1987) indicated, when the quality of a service is difficult to appraise, compare, negotiate, or verify, customers would be better served by a not-for-profit organisation than by a for-profit firm because the organisation would not be motivated to diminish the quality of the service to maximise profits. Public-sector innovation intermediaries must direct their activities towards the early stages of innovation processes, far from the commercial stage that other actors are reluctant to undertake to fulfil their mission.

A key premise of this facilitating role is an impartial and independent position (Hanna and Walsh, 2002): the second stream of study. Interaction in innovation processes involving public-sector innovation intermediaries could be better suited to provide insights regarding added value based on impartiality and to remain credible to all actors amongst whom they mediate (Klerkx and Leeuwis, 2008). A for-profit intermediary can prejudice the impartial position of an innovation intermediary by focusing on tangible and visible services to generate sufficient revenues, making them less credible in the eye of SMEs. Also, intermediaries should be able to keep a balance between short-term and long-term considerations (Klerkx and Leeuwis, 2009).

Here, the centrality of the intermediary, in that they can access suppliers and buyers as an impartial third party, will be crucial. Bathelt and Zeng's (2010) study on the Shanghai Chemical Industry Park around the Yangze Delta region shows the barriers of learning-by-interaction between wholly foreign-owned enterprises (WFOEs) and Chinese vendors. WFOEs, big chemical producers, tended to ship their products to specialised intermediaries located in Hong Kong or Shanghai. Chinese vendors did not provide WFOEs with much information on customers, markets, and opportunities

about local or national markets. Furthermore, due to insufficient market transparency, high market uncertainty and a lack of ability to stimulate *guanxi* networks, WFOEs could not develop close relationships with local companies or vendor firms. Instead, WFOEs depended on intermediaries distributing their products to learn about Chinese markets.

Third, public intermediaries have knowledge of infrastructure, networks, experts, and experience as a result of strong government support. In this regard, Izushi (2003) and Kodama (2008) argued that those public intermediaries are unique to the Japanese context as an external source of technical knowledge equipped with its own powerful ‘intellectual and material equipment’. Unlike private-sector providers, experts in the public intermediary hold discussions with their customers using the competitive knowledge that often derives from their research experiences.

Interactions with researchers in public intermediaries allow user firms to know more research areas, to develop additional contacts in industries or academia, and to access other services. A long-term relationship may result between individuals, facilitating learning by interaction. Interactions may strengthen the social capital of user firms by accessing additional contacts (Izushi, 2001). Cooke and Wills (1999) indicated that public intervention may create social capital in support of knowledge flow in interactive innovation processes where SMEs rely on good relationships with government bodies.

3.4.3 Innovation Facilitators of Firms in the NIS

Building on significant resources and their impartial position, public intermediaries facilitate knowledge interaction, which stimulates innovation of firms, increases efficiencies of the NIS, and thereby buoys economic development over time. Considering the contribution of public intermediaries in the NIS, it is important to uncover the knowledge-interaction process at an appropriate level of actors. Intermediaries interact with heterogeneous SMEs in different regions, technology fields, and sectors. However, little explanation of the dynamic interplay between actors exists due to the lack of meso- and micro-level approaches in the NIS, as explained in Chapter 2. The NIS concept is rather broad and the intermediary

literature seems to focus on some functions at a specific point in time and their contribution to technical innovation based on the suppliers' viewpoint. Furthermore, research relating to intermediaries still focuses on the private sector and far less on the public sector. Public-sector innovation intermediaries are important in the innovation process in two respects (see Sections 2.4.1 and 2.4.3): they are able to interact and resolve the diverse barriers of firms consistently throughout the innovation process, and they facilitate knowledge interaction at all levels (organisations, institutions, and individual).

First, due to the high levels of uncertainty, complexity, and ambiguity inherent in the innovation process, the NIS often carries various problems that decrease efficiencies of the innovation system. Public intermediaries, as non-market mechanisms, correct system failures and failures may not accrue from a single factor or actor but rather from a complex set of problems, as posited in Chapter 2. These barriers can be more problematic for firms that lack capabilities and resources. In the case of SMEs in Korea, not only R&D funding but also a wide range of knowledge regarding social changes, new demands, legal issues, and potential big buyers may be necessary (J.-S. Kim, 2007; Song, 2009). However, most SMEs are unlikely to have enough resources to accomplish their vision when exploring new business areas such as prospecting the future of certain technologies and potential innovation actors.

As examined in Section 3.3, intermediaries may engage in innovation processes of firms through a variety of activities, including knowledge enabling, facilitating relations and learning, and managing interfaces for continuous interaction. By engaging intermediaries, firms can explore a new business area through collective support while significantly decreasing or sharing costs involved in the innovation process. At a firm level, intermediaries provide interfaces for SMEs to achieve their goals during the innovation process in ways they are unable to undertake themselves, in a short period of time, by reducing uncertainties and costs. These activities are not merely functions that resolve a single problem at one point in time, but rather 'process facilitation' embedded in constant interaction.

Second, aligning actors' expectations around realisable objectives (Molina, 1994) or enrolling users, suppliers, and developing markets, needs to be involved (Williams

and Edge, 1996) in the innovation process. The process entails an iterative process in which SMEs interact with a range of organisations (e.g. research institutes, intermediaries, buyers, authorities, and financial organisations) and institutions such as regulations and culture (Woolthuis, Lankhuizen and Gilsing, 2005). As a result, managing a wide spectrum of collaborative arrangements of knowledge generation occurs in a systemic context, covering a multiplicity of minds and unpredictable and unintended paths (Metcalf, 2005). The innovation facilitation of intermediaries might be complicated, as individuals communicate with knowledge in the specific context of the firm to which they belong, and routines of the firm also shape the knowledge interaction between individuals, requiring specific localised information and different kinds of knowledge interaction in relation to specific innovations.

In other words, the knowledge interaction may not (simply) occur between public intermediaries and firms but rather occur around multiple individuals and organisations. These connections may change as innovation opportunities and problems evolve over time. As a result, mediating involves aligning heterogeneous actors and connecting the knowledge embedded in individuals and organisations, which are quite complex and time consuming. It is the public intermediaries that are able to organise multiple levels of interaction to overcome the barriers (refer to Section 2.4.3) and thereby shape the NIS to be the practical ‘device’ to facilitate innovations, rather than to remain a loose framework.

From this perspective, intermediary functions need to be incorporated into the NIS framework to facilitate the dynamic interplay among actors at meso- and micro-levels: how knowledge interaction between public intermediaries and SMEs occurs, decreasing the barriers, and how micro-factors relating to the specific context affect the innovation process. Examining specific cases may be helpful in understanding whether and how the four functions of the knowledge-interaction process would resolve the barriers of firms. This will be elaborated in Chapter 6.

3.5 Conclusion

3.5.1 Summary and Challenges

This chapter pursues a deeper cross-disciplinary understanding of intermediaries in innovation. It proposes a functional analysis of intermediaries to understand the area of knowledge interaction between intermediaries and SMEs. Based on a literature review of intermediaries, differentiated according to the roles they can play, this chapter has suggested four types of intermediary functions: enabling knowledge, facilitating relations, facilitating learning, and managing interfaces. This study suggests that the four functions can more effectively be understood as ‘innovation-process facilitation’ rather than merely providing services at one point of time.

After examining the general characteristics of innovation intermediaries, this study highlights the particular role of public-sector innovation intermediaries in Asian countries and their characteristics in the innovation process: facilitating innovation at the precompetitive stage; impartiality; and a vast knowledge infrastructure. At the early stages of innovation, technologies are malleable and uncertainties increase in technical options, markets, acceptability of options, and demands. Knowledge demands posed by innovating firms at this stage may be more complex, requiring long-term interaction with multiple actors to realise technological ideas more than the knowledge demands at the later stage. However, the roles of public-sector innovation intermediaries are not well defined; this raises question, in particular, about how they align resources and multiple actors to decrease the barriers at the precompetitive stage, and create new opportunities and dynamics in the system.

From the above literature review, I can present some limitations of intermediary studies that this study seeks to overcome through closer examination. First, intermediary studies lack an understanding of public-sector innovation intermediaries. What was striking about the NIS in Asian countries was that intermediaries supported national strategy with a degree of system openness, allowing industries to adopt and improve on technology and organisational practice from advanced economies (Watkins et al., 2014). The openness could be explained through understanding of intermediary functions in the interaction process between actors, as

intermediaries work in the strategic level between policy and firms to correct failures. In this vein, understanding intermediary functions in the dynamic-interaction process requires examining how they interact with SMEs and how relationships evolve around an innovation. This leads to the second issue of functions of innovation intermediaries.

Section 2.4 draws attention to the long-term cooperation and collaboration in facilitating a wide range of knowledge interactions that may be needed to resolve the barriers. A long-term perspective is needed because problems and relationships may change that may affect the activities of intermediaries. The range of services being offered does appear to be increasing over time, although intermediaries provide functions specialised around particular activities (Howells, 2006). From this point of view, the activities may not be simply categorised as activities provided by traditional or systemic intermediaries; rather, innovation intermediaries fulfil various functions for firms in the NIS. The four functions of (public-sector) innovation intermediaries may be expanded over time, covering the role of traditional intermediaries in some cases. In contrast, (public-sector) innovation intermediaries engage in networking with multiple levels of intermediaries to address diverse barriers in time.

However, most intermediary studies seems to focus on functions at a particular point in time (one-off services) perhaps because they are based on the supply viewpoint rather than offering longer term, innovation capabilities to them (Howells, 2006). Watkins et al. (2014, p6) also argued “central to the NIS concept ... relational interaction between actors and institutions is often missing.” By undertaking a critical examination of public-sector intermediaries in the innovation-facilitating process of SMEs, this study enhances knowledge about intermediary functions that resolve barriers, and may influence SME innovation at meso- and micro-levels. This calls for analysing the NIS at the support level as well as at the innovation-capacity level). The four functions of intermediaries developed in Section 3.3 will be used in developing the conceptual framework for this study, collecting and analysing empirical research.

3.5.2 Integration Intermediary Functions with the NIS Framework

This study aims to investigate the interaction between public-sector innovation intermediaries and SMEs during the innovation process. Building on the NIS framework it explores how multiple levels of interaction decrease the barriers that each SME faces, leading to the evolution of different patterns of relationships. In this regard, Chapter 2 has addressed the components of the NIS—the importance of interactive learning and knowledge interaction—highlighting the role of public-sector innovation intermediaries as an effective mechanism to facilitate interactive learning and innovation. Chapter 3 reviewed the role of public-sector innovation intermediaries: how they perform four functions to address barriers. This chapter also emphasised the role of public-sector innovation intermediaries who have provided an effective mechanism in overcoming the barriers and thereby facilitating innovation in firms.

The role of intermediaries has not yet been fully integrated into the NIS framework, although several scholars (Dodgson, 2000; Howells, 2006; Izushi, 2003; Klerkx and Leeuwis, 2008, 2009; Kodama, 2008; Van Lente et al., 2003) emphasised public-sector intermediaries in the innovation system. One consequence of the convergence of diverse analytical traditions on the concept of intermediary is that the literature is rather fragmented and tends to focus on specific functions of intermediaries, as previously indicated. These problems are augmented by the conceptual limitations of the NIS framework and its failure to engage effectively with sociocultural factors, and the diversity of actors and institutions in a wider setting. Consequently, the dynamics and evolving nature of the interaction process among them, and interactive learning (i.e. the DUI-mode of learning) occurring at multiple levels, remained a black box.

This is probably due to the macro-level focus and lack of meso- and micro-level approaches of NIS studies in which the role of intermediary institutions is largely absent (Watkins et al., 2014). As indicated in Chapter 2, the NIS framework has limitations in uncovering the interaction process at a specific level: public intermediaries and SMEs. This may be one reason why attention remains largely focused on university–industry interactions that still dominate the national

characteristics of the innovation system, overlooking other public-sector intermediaries (Lundvall, 2007c). Despite the occasional acknowledgement and the empirical observations that public-sector intermediaries do play a significant role in shaping innovation and economic outcomes, there is a dearth of studies which describe how this form of intermediary institution, which provides mechanisms for interactions among firms, might shape successful innovation processes in the NIS. As criticised in section, 2.3.2, to the best of my knowledge, no empirically grounded work has been done on the role of public-sector innovation intermediaries in enhancing innovations of heterogeneous SMEs in a specific context. Rather, the NIS tends to treat firms as if they were broadly identical actors.

However, each NIS is unique (Edquist, 1997). Firms are also heterogeneous in innovative capabilities and barriers they might face. Learning takes place in a localised context. In a similar vein, the role of intermediaries highly depends on the sociopolitical context (Van Lente et al., 2003). The NIS is a dynamic and open system where institutions and actors co-evolve, and shape the innovation system (Kastelle, Potts and Dodgson, 2009); where the different types of innovation system interact at the level of specific actors. Therefore, understanding innovation processes of firms calls for the modulation of the NIS at an appropriate level, where it is possible to investigate how interaction and interactive learning take place in a specific context and relationships co-evolve over time. In this regard, in Chapter 2, I suggested the adoption of meso- and micro-level approaches in the NIS to examine the knowledge-interaction process, highlighting the role of public-sector innovation intermediaries as effective mechanisms to resolve barriers of firms in the NIS. Integrating intermediary studies into the NIS might provide an analytical lens to observe underlying processes and dynamics in the system.

In sum, the scholarly neglect of public-sector innovation intermediaries is not limited to the issue of the facilitation of innovations. Their role as innovation facilitators, how they facilitate the DUI-mode of innovation to resolve barriers of firms, has also not been fully accounted. Given the objectives of this study to outline how public-sector innovation intermediaries might influence the successful (or less successful) innovations of SMEs, the study attempts to operationalise the NIS at meso- and

micro-levels: how public-sector innovation intermediaries interact and perform four functions to correct the failures of SMEs in the NIS. From the micro-level approach, the system-failure concept provides micro-level factors: the set of determinants that influence innovations. However, as Lundvall (2004) criticised, the concept may not be applicable to different contexts; in other words, static functions may not reflect all multifarious factors or barriers of heterogeneity SMEs may face in innovation processes.

Instead, this study tries to examine the micro-level interaction process and meso-level institutions; linking firm-level interaction processes to intermediary functions. This study will contribute to theory building on the NIS, describing how relationships are evolving in the complex innovation process, while also providing a better empirical understanding of the role of public-sector innovation intermediaries in supporting SMEs at the early stage of the innovation process. To achieve these objectives, the study adopts a strategy that employs a case-study methodology, which is the subject of the next chapter. The following chapter will explain the methodology used to analyse the four functions described in this chapter for the empirical case studies. Using these structures in the empirical analysis, I will try to show how these functions are fulfilled through the knowledge interaction between intermediaries and SMEs, and whether certain activities during the interaction have not been highlighted sufficiently in the literature.

4 Chapter 4. Research Design and Methodology

4.1 Introduction

This chapter presents the research design and methodology I employed in this study, and indicates how I used them to address the research questions. To remind the reader, the aim of this study was to investigate the case of Korean SMEs and the role of public-sector intermediaries in facilitating innovation. In particular, I sought insight into how barriers at the early stages of innovation could be overcome through the mechanisms of knowledge interaction and relationships. Although this was the main research topic, I chose five innovative SMEs to study innovation barriers.

Following the introduction, I explain the reasons behind the choice of public intermediaries and SMEs from different fields of technologies in Section 4.2. Then, Section 4.3 presents the research strategy and design formulated at a preliminary stage and adjusted over time. The conceptual framework was constructed based on the NIS concept, intermediary studies, and STS perspectives that enabled this study to uncover the interaction process based on the specific functions developed in Chapter 3. I introduce the choice of strategies from data collection to analysis with a justification for each. This section ends with some arguments about the strengths and weaknesses of the current research design, and the methods of case selection.

Section 4.4 describes the processes of data collection and data analysis: how I collected, triangulated, and analysed data, with some reflections on the research process. Finally, Section 4.5 concludes how this chapter provides a methodological grounding to developing explanatory and exploratory contexts of the cases in the following empirical chapters.

4.2 Research Methodology and Strategy

4.2.1 Defining Key Concepts

Before moving to the analysis of S&T-development history in Korea (Chapter 5), it is useful to introduce the two main actors in the KNIS briefly, describing the role of public intermediaries in facilitating innovation of SMEs and how I defined them in

this study. In Chapter 5, I further discuss the nature of these two actors in the KNIS context: how they have interacted and what policy issues need to be resolved.

Fostering innovative SMEs has long been a major policy issue in Korea in relation to economic growth and creating employment. In the overall economy, SMEs play a pivotal role in ensuring sustainable growth by enhancing employment and national competitiveness. Therefore, since 1990s, the Korean government has been establishing support programmes³⁶ to foster innovative SMEs, for which the total budget increased from US\$2.3 billion in 2005 to US\$4.8 billion in 2008 (SMBA, 2013). In this vein, GRIs have been effective mechanisms, linking government policy to industries and contributing to enhancing the innovative capacity of industries for several decades (K-R. Lee and Song, 1998; Wong, 2004) that will be further explored in Chapter 5. In 2013, the government emphasised the role of GRIs as innovation facilitators for SMEs.

Whilst the government made considerable investments to enhance the innovation capability of SMEs, the policy seems to engender some issues: first, policy has been directing the growth of SMEs quantitatively³⁷ (i.e. the number of SMEs and increasing R&D funding), and second, delivering the standardised ‘one-size-fits-all’ programmes from the intermediary to SMEs did not solve the fundamental problems that an individual SME faced (SMBA, 2006). The programmes have been mainly one-off services that were generic and universal programmes that did not meet the various needs of innovative SMEs (Y. B. Kim, 2005).

In this connection, some SMEs that were involved in receiving intermediary services for their innovation processes showed success as a result of the knowledge interaction (KISTI, 2013). Various indirect services seem to help SMEs innovate

³⁶ The programmes include ‘Supporting R&D for Technology Innovation’, ‘Supporting R&D for Technology Commercialisation’, ‘Supporting Joint R&D among Industry-Academia-Institutes’, ‘Establishing Research Infrastructure of Industry-Academia-Institutes’ and ‘Feasibility Study of New R&D Idea.’

³⁷ The number of spin-off companies from large corporations between 1997 and 2001 reached 442 (Suh, 2002) in addition to start-ups and spin-offs from GRIs and universities. In the same period, professors and researchers left their organisations to establish venture businesses as a result of policy initiatives aimed at stimulating new firms. The initiatives included tax incentives, providing facilities and services, relaxing the requirements for establishing firms and granting temporary leave.

over time, whilst one-off services (e.g. funding) tend to provide a temporary expedient (D. Cho, 2005). To meet demands of SMEs, the Korean government recently announced its further intention to provide indirect services such as knowledge services by mediating and enhancing the service spectrum (Y. Cho et al., 2013); but a lack of understanding exists about the dynamics of interactions and relationships between the public intermediary and innovative SMEs.

Thus, I chose to examine the dynamics of interactions between two actors in the KNIS that might lead to insights for further programme development for SMEs. Following, I suggest brief definitions for key concepts that are frequently used in this study: public intermediaries, innovative SMEs, innovation, and knowledge.

- **Public-sector innovation intermediaries (Public intermediaries):** as defined in Section 3.2.3, these are not-for-profit organisations such as government research institutions (GRIs), government agencies, foundations, science parks etc. GRIs in particular are amongst the earliest form of organisations supporting Korean industries and considered important actors in facilitating knowledge creation and linking all actors and resources in the KNIS.
- **Innovative SMEs:** in this study, following the Korean context, innovative SMEs are those registered as venture firms, inno-biz³⁸ firms by the Small and Medium Business Administration (SMBA). The Technology Finance Corporation defines innovative SMEs as firms that pursue state-of-the-art technologies or new technologies in high value-added areas, and the SMBA defines them as firms pursuing innovative activities in product, process, or marketing innovations, or firms that have achieved success through these innovations³⁹.

³⁸ The SMEs which receive 700 marks out of 1000 on the technology innovation system assessment together with obtaining more than B grade on the technology assessment provided by SMBA.

³⁹ In Korea, an SME refers to firms which have up to 300 employees with a limit of gross capital of US\$3 million (SMBA, 2012).

- Innovation: as defined in Section 2.4.3, Schumpeter's definition of innovation is new or improved goods, a new method of production or distribution, the opening of a new market, the use of new supplies or engagement of new suppliers, or a new mode of industrial organisation (Schumpeter, 1934). Emphasising the knowledge production in the system, innovation also represents "something new and therefore adds to existing knowledge. The second is that innovation is a process where the innovating unit operates under uncertainty and therefore regularly is confronted with unforeseen problems" (Lundvall, 2007b, p14). These views align with the views of SMEs I have interviewed.
- Knowledge: multiple bodies of knowledge such as scientific, technological, or market based on which innovating firms need to draw (Metcalf, 2005). Knowledge is not merely technological, but also organisational and societal knowledge, which relates to the technical process integrated with skills, routines, use of equipment, training, and management systems (Smith, 1995).⁴⁰

4.2.2 Research Methodology: Case Study

The particular focus of the proposed case study centres on the relationships and interactions between the public intermediary and SMEs. Some cases of public intermediation resulted in successful innovation of SMEs, where the public intermediary and the Korean SMEs actively interacted. The impact of such intermediation and the role of intermediaries, leads to the following questions: why do interactions between some SMEs and public intermediaries yield success stories, whilst others do not? If the interactions with the intermediary affect innovations of SMEs, what are the major factors; and if not, why not? These are the important questions addressed in this study.

⁴⁰ Smith (1995) presents four characteristics of knowledge different from the neoclassic approach: a) multilayered, consisting of articulated forms of different knowledge, b) highly localised and specific, c) internally systemic, and d) interactive and externally systemic involving mutual learning and knowledge exchange processes.

The main objective of this thesis was to discern the interaction and SMEs in the complex innovation process, with a focus on the role of public intermediaries at the early stages of innovation. Because previous researchers have not adequately studied this phenomenon and thus, the topic lacks an extensive empirical base, this study focused more on discovery than verification (Adesida, 2005). Research concerned with verification tends to test established hypotheses; discovery-type research focuses mainly on unearthing new information and ideas that can be used to develop new theories or contribute to existing concepts (Alvesson, 1995). Quantitative methods are unlikely to explain the complex context of a phenomenon and related issues. Secondary data used in examining knowledge-interaction process was unavailable.

Therefore, I adopted the qualitative method in data gathering and in analysis, an approach well suited to explore, describe, and understand a phenomenon that is not well understood. This is possible because of the engagement of the *actors* as *participants* in the research process, engaged in a dialogue to uncover what public intermediaries are doing that might influence the innovation of SMEs. The remainder of this thesis described the procedures and processes used.

To answer these questions, this study applies case-study methods that allow an investigation of contemporary phenomenon when the boundaries between phenomenon and context are not clearly evident (Yin, 2003). Furthermore, the case study is “designed to produce theories” (Hammersley, Gomm and Foster, 2000, p234) that provide analytical insights and uncover underlying causal processes behind a phenomenon (Hammersley, Gomm and Foster, 2000; Yin, 2003). Orum and Feagin (1991) define a case study as a method to examine the ‘hows’ and ‘whys’ of a single phenomenon in rich detail. In this regard, the case-study method is an appropriate tool for this study for the following reasons: 1) it permits detailed examination of the knowledge-interaction process between public intermediaries and SMEs, and 2) it can help uncover insights useful in building on the NIS concept and intermediary studies through an in-depth understanding of the role of intermediaries in the NIS. Furthermore, this is a longitudinal study⁴¹ to a certain extent, as it aimed

⁴¹ Longitudinal research is more about how and why rather than length (Pettigrew, 1997).

to examine interactions between actors in the innovation process, which required the investigation to follow experiences in chronological order.

In selecting the research methodology, collecting in-depth knowledge is of paramount importance in examining the role of public intermediaries facilitating innovation of SMEs at the early stages of innovation. Uncovering information about how public intermediaries interact with SMEs to bridge the barriers in the innovation process underlines the case-study method, given that relatively little is known about the phenomenon. Case studies facilitate learning (Gomm, Hammersley and Foster, 2000). In particular, this study focuses on learning; that is, interactive learning by intermediaries and SMEs in the knowledge-interaction process.

However, generalisation from a case study is debatable, as “its findings are not generalisable, especially by comparison with those of survey research” (Gomm, Hammersley and Foster, 2000, p98). Some scholars argue the case study approach is especially applicable when complex processes need to be examined, pointing out the possibility of erroneous application of statistical notions (A. S. Lee, 1989). Also, the important issue can be analytical or logical in character, not a statistical generalisation (Hammersley, Gomm and Foster, 2000). Previously developed theory can provide a possible link between case studies when adopting the view of ‘analytical generalisation’ as an alternative to ‘statistical generalisation’ in case studies (Yin, 2003). Moreover, SST scholars rely on the case study approach as it allows them to generalise certain scopes based on in-depth analysis of cases (Russell and Williams, 2002).

Following the key questions of this study—investigating the evolving characteristics of relationships in the innovation process, and how barriers (or problems) can be resolved through non-market mechanisms—this study requires an in-depth analysis of heterogeneous cases within a certain time frame (around three years). The rationale for adopting the case study approach is that knowledge interaction between public intermediaries and SMEs in the KNIS is a unique case, observing a phenomenon in S&T history, SME policy, and the nature of interactive learning between intermediaries and SMEs in Korea. A carefully selected comparative set of cases provides an analytical lens to examine how the interaction process operates in

different contexts. The process is not composed of mechanical differences that can be proven by statistical generalisation. This study requires thick description to be able to generalise an implicit perception that emphasises reliability and credibility (Payne and Williams, 2005), although this study seeks insights rather than generalisation.

4.2.3 Research Strategy and Design Process

This study was influenced by the NIS concept, intermediary studies, and the tradition of STS, in particular SLTI. The incorporation of the NIS approach, intermediary studies, and the SLTI perspective guided this study to explicate the dynamic nature of the knowledge-interaction process, focusing on the specific level of the KNIS. I explicate different patterns of relationships that involve heterogeneous actors and different evolving patterns during the process. In particular, this study requires observation of detailed information on specific barriers that heterogeneous SMEs may face in the innovation process and how they can be resolved through the interaction.

For the study to capture how innovation occurred at a specific level of actors in the KNIS, I adopted an inductive research strategy, aimed at investigating the interactive process between the public intermediary and SMEs to garner insights into their current status and to carry out further research (Blaikie, 2000, 2010). As part of the strategy, I adopted two key features: a meso- and micro-level focus and a qualitative approach. The meso-level approach plays a crucial role in bridging macro and micro factors in mediating processes: that is, focusing on “institutions that intermediate between the firm and the market or between the individuals and the state” (Misa, 1994, p139). Meso-level institutions include public intermediaries, business associations, and consulting firms. The micro-level focus may bring insights into how the system functions, relationships between actors, heterogeneity of the system, and individual learning.

The qualitative method used for this research comprises a series of in-depth interviews in a variety of fields. The approach is attractive for social science research for many reasons including the ability to gather “rich, full, earthy, holistic, real” information about the phenomenon under study (Miles, 1979). In particular, the

qualitative approach is appropriate to unearth rich, hidden information on the interactions between the public intermediary and selected SMEs that might affect complex innovation processes. Because previous research and the empirical base are quite limited, this method is a more effective way to uncover the relationships between intermediaries and SMEs than engaging the actors and observers in a conversation. Hence, it provides “a more precise way to assess causality in organizational affairs than any arcane effort like cross-lagged correlations” (A. S. Lee, 1989, cited in Adesida, 2005 p153). The use of the in-depth interview is the best method⁴² to obtain information from players embedded in the processes.

Based on the different perspectives from the literature review, I have developed the conceptual framework to observe how public intermediaries often intervene to organise knowledge interaction in the complex and uncertain innovation process, and thereby decrease barriers. Addressing the public intermediary in Korea and the knowledge interaction with SMEs, the framework provides meso- and micro-level approaches, integrating social dimensions that go beyond examining the pattern of knowledge-interaction processes. The framework guides this study to investigate not only the nature of interaction processes and learning but also microsociological factors embedded in the relationships and interactions that may produce successful, or less successful, innovations by SMEs.

Furthermore, the conceptual framework suggests that knowledge interaction is critical for innovative SMEs to address barriers in the uncertain innovation process and in this vein, bridging mechanisms are important devices to resolve system failures and enhance efficiencies of the KNIS. For example, the complexity of innovations might require enabling knowledge, facilitating relationships and learning, and managing interfaces as a result of uncertainties and barriers entailed in the innovation process (Chapter 3). In this vein, public intermediaries at the early stages of innovation can play a crucial role in resolving the barriers that SMEs may face during the innovation process, whereas the intermediating role has comparatively

⁴² Unlike structured ones, in-depth interviews have advantages in presenting greater interests in interviewees' opinions and insights and having flexibility for interview flow (Bryman, 2004).

received little attention compared to the role of firms in the NIS framework. I elaborate on this framework in the following empirical chapters.

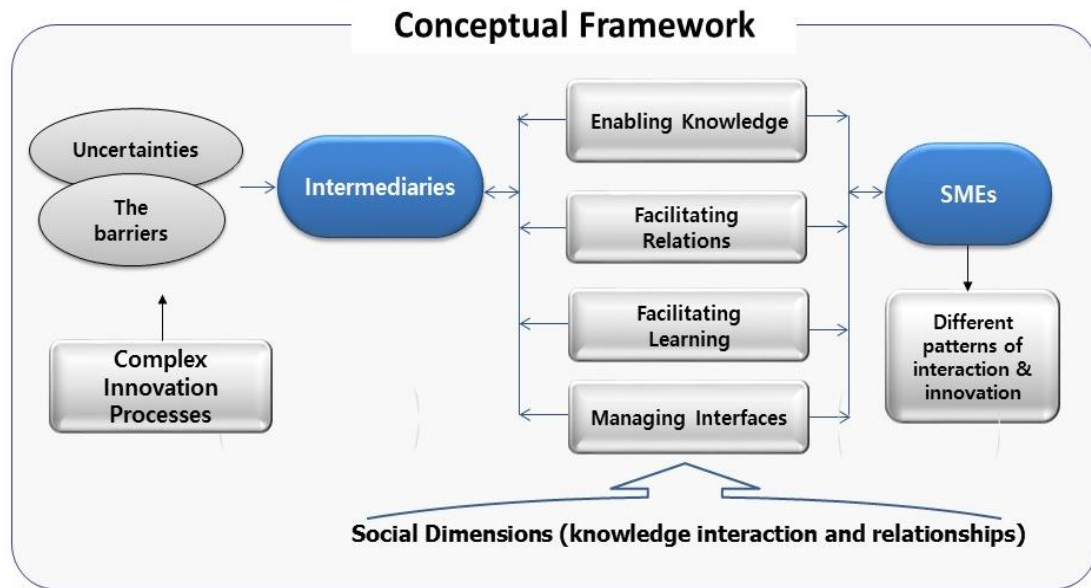


Figure 4-1 Conceptual framework.

Source: Author.

Once I designed the conceptual framework and identified the research methods, I carried out the study using the three-phase process shown in Figure 4-2. In spite of the sequential nature, the process has been rather iterative throughout the research.



Figure 4-2 Empirical research processes.

Source: Author.

During the first phase, mapping produced a broad understanding of a range of SMEs that had intermediary services, and to provide a system of classification aligned with suggestions inspired by the conceptual framework. The result was a classification of SMEs that provided the basis for the selection of 26 SMEs; I then gathered further information for analysis. These SMEs have had regular interactions with staff from intermediaries and have shown innovative outcomes for the last three years. The selection criteria appear in Section 4.3.1.

Following the mapping exercise, the second phase was the collection of information to be reviewed thoroughly: 1) 26 SMEs, their activities, interactions and relationships, 2) public and private intermediaries involved in knowledge interaction with the 26 SMEs. Carrying out semi-structured interviews with participants provided the evidence base, followed by the selection of 5 SMEs for further review and analysis. The number of in-depth interviews was a trade-off of width of knowledge against depth of knowledge that supports the findings of the study. This economical methodology, compared with structured interviews, allowed the ease of interviewing while mitigating the influence of the interviewer, which might induce biased answers (Bryman, 2004).

At this stage, I adopted the explanatory approach, employing second in-depth interviews for 5 SMEs to further develop the information obtained from the first set of interviews. I excluded cases that included a single public intermediary (i.e. KISTI) as a programme organiser when selecting the five cases, because KISTI could be biased towards the supply point of view, especially if considering successful cases. Another key challenge for qualitative research that depends on interviews is encouraging people to talk honestly or to share information. On the other hand, participants may exaggerate claims about what they achieve. To maintain objectivity, I employed triangulation of data sources to provide some assurance that the evidence gathered is close to reality.

In the third stage, I coded, categorised, and analysed the collected information. I was able to draw recommendations that may lead to solutions to overcome innovation barriers through intermediary–SMEs interactions from further analysis. The remainder of this chapter provides information on how evidence was gathered

through the case study approach and how it was analysed to provide insights into the knowledge-interaction process suggested by the conceptual framework.

4.3 Case Selection and Sites

4.3.1 Mapping the Knowledge Interaction Landscape: Case Selection

To determine the selection methods and the number of cases, I considered the data-collection processes that produce the best quality of information, along with other factors such as limitations of budget and timing or data accessibility. Obtaining in-depth and concise knowledge takes much time, thereby limiting the number of cases. Although the number of cases may be considered a small unit of evidence in support of arguments compared to large-scale surveys, I did not look at a huge range of cases due to the complexity of the interaction process and the meso- and micro-level of analysis in this study. As this study addressed several issues regarding interactions among specific actors in the KNIS, facilitating mechanisms for interactive learning and innovation, microsociological factors and different patterns of relationships made it helpful to look into selected cases, delving more deeply into the knowledge-interaction process to achieve the scope of this study.

Furthermore, considering the limited time, budget, and space for this study and doctoral research, the selected case studies in such depth and width served the purpose of this study, bringing insights and findings that provided a rationale for possible interventions in complex situations and further contributing to knowledge. Bearing this in mind, I chose cases with a certain level of variety to observe the interaction process based on the conceptual framework. As this study sought to understand the factors of knowledge interaction that distinguish successful cases from less successful cases, as indicated in Section 4.2.2, I chose successful and less successful (or failed) cases for cross-sectional analysis.

I selected five SMEs in total using the following criteria.

Table 4-1 Criteria for the Case Selection

Recognised and registered as 'innovative firms' by the SMBA
Recommended by the public (private) intermediary
Strong interaction with the public intermediary: firms that have had knowledge services that took between several months and a year-long of interaction
Firms categorised as successful or less successful
- Successful firms that achieved innovative outcomes as a result of the services
- Less successful firms that are under progress of interaction at the point of interviews or used failed experiences to develop another business opportunity
- Failure firms that reported the closure of business or were unable to yield innovative outcomes

Source: Author.

The successful (or failure) of firms, as defined by intermediaries, were firms that achieved sales growth as a result of the support. However, the definition of successful firms was changed as interviews progressed; firms that experienced any changes as a result of interaction were categorised as successful cases. In contrast, some firms failed, as they did not yield any profits relating to intermediary support. They were recategorised as less successful when experiences contributed to the firm achieving organisational changes or R&D direction.

Along with the selection of the firms by the criteria of success, I considered two technology fields: mechatronics and IT.⁴³ Mechatronics is a multidisciplinary field of engineering referring to a combination of mechanics and electronics originally, but the concept has been broadened to include areas such as intelligent robots, semiconductor and display manufacturing equipment, and other automation equipment: in other words infrastructural technology applied in various field of technologies or industries. Innovative SMEs in this area tend to have supplied large global corporations that might contribute to building technological competitiveness in global markets.

⁴³ Although I define two fields as mechatronics and IT, all firms had different technological backgrounds depending on what types of technologies they combined in producing equipment. The technological characteristics of firms were much more complex than I anticipated. Because innovative SMEs have a tendency to use a multidisciplinary field of technologies in developing new products, the complexity of classification increased. For example, members of IT firms I interviewed combine IT, software, mechatronics, electronics, and often design technology. One firm classified as mechatronics considers itself a physical chemistry firm.

SMEs are under subtle pressure from big buyers to reduce manufacturing costs as suppliers and often suffer from intensified price or technology competition with other suppliers. To avoid being crushed between price competition and technology competition, these SMEs have been seeking new business opportunities or investing in R&D to maintain technological competitiveness at a global level. The SMEs in this area require new knowledge to explore the new market or new buyers, and to exploit new innovation opportunities to enjoy their unique position as global suppliers, causing them to demand in-depth knowledge services to enhance their innovative capabilities on a mid- to long-term basis.

The Korean government has supported the IT sector as part of its S&T strategy for several decades. When the government put huge efforts into fostering innovative SMEs during the late 1990s and early 2000s, a large number of startup firms and small businesses were established. At that time, R&D investment was the main support strategy for IT firms and researchers and professors as entrepreneurs benefited from the policy. Although SMEs in this sector depend less on big buyers compared to SMEs in mechatronics or other traditional sectors, they still lack capabilities to design and produce key components, new products, or new customers. Some SMEs are technologically competitive, which can replace foreign products, whereas some try to discover new business opportunities in areas where industry or technology fusion emerge. This phenomenon might lead SMEs to look for specialised services rather than R&D funding.

Recently, the government designated the ICT sector as the infrastructure to create new industries through technology or product fusion so more firms could benefit from the national policy. As the part of efforts to create new markets, the Korean government also established a long-term S&T strategy for how existing technologies could combine with emerging technologies in different fields of technologies. The government defines the role of public intermediaries in the KNIS, and what they should do in identifying not only policy direction (where it should go) but also the capability of SMEs and their demands in exploring new opportunities (the heterogeneous nature of SMEs). This topic will be further examined in the following empirical chapters.

I conducted the entire data-collection process in Korea over the course of 1 year. Then, I analysed the collected data using qualitative methods, which took another 1.5 years.

4.3.2 Case Sites

Many other players, however, participated in innovation programmes of SMEs. The candidate space for case selection was where the interactions and relationships were formed: where policymakers, public and private intermediaries, and SMEs interacted in innovation processes. Public intermediaries promoted the fostering of innovative SMEs such as the Innovation Foundation (IF) and KISTI. The IF is one of the major organisations administered by the Ministry of Science, ICT, and Future Planning (MSIP),⁴⁴ charged with diffusing innovation and creating knowledge. The foundation, set up 1994, has operated many support programmes such as funding, networking, and consultations, in cooperation with other public and private intermediaries and global partners (Innopolis Foundation, 2014). Furthermore, the foundation has aimed to foster innovative SMEs in Daedeok Science Town,⁴⁵ linking the resources from universities and research institutes since its inception. As a result, it has extensive experience in collaborative programmes and in particular innovative SME support programmes.

KISTI has been taking an active part in SME support programmes funded by SMBA since the early 2000s, whereas other GRIs mainly focus on R&D collaboration with SMEs. KISTI has formed the Association of Science and Technology Information, which consists of 13,000 members from industry (mostly SMEs), academia, and institutes. Additionally, since 2000, policymakers have often pointed to KISTI as a linkage organisation in the KNIS. Based on a brief review of the landscape of public intermediaries, their programmes, and their roles in the KNIS, I chose IF and KISTI as major intermediaries. However, I also included the Korea Techno-Venture

⁴⁴ The IF was administered by the Ministry of Knowledge and Economy while KISTI was administered by the Ministry of Education and Science Technology until the new government took over in 2013. Now all intermediaries listed in case sites belong to the MSIP.

⁴⁵ Daedeok is the specific area where Daedeok Science Town is located. In the region, 30 GRIs, 5 universities, 1,300 firms, and 20,000 researchers reside to foster collaboration among industries, academia, and research institutes.

Foundation (KTVF), an organisation affiliated with the KIST and the Gyunggi SME Business Centre administered by Gyunggi Provincial Government to increase credibility of the collected data, based on the knowledge services that public intermediaries provided and the roles designated by the government.

However, this study aimed to understand the knowledge-interaction process, based on the views of demand side rather than supply side. I then thoroughly examined the demands and problems of innovative SMEs in the innovation process and how they resolve problems through knowledge interaction with intermediaries. I included policymakers involved in designing SME-support programmes or acting as advisors on the execution of the programmes who might provide a balanced view of the information collected. Therefore, I list in Figure 4-3 a number of players, according to their major role, categorised as policymakers, intermediaries, and SMEs. Furthermore, I updated the categories and the list of organisations, as well as their positions, as the research matured.

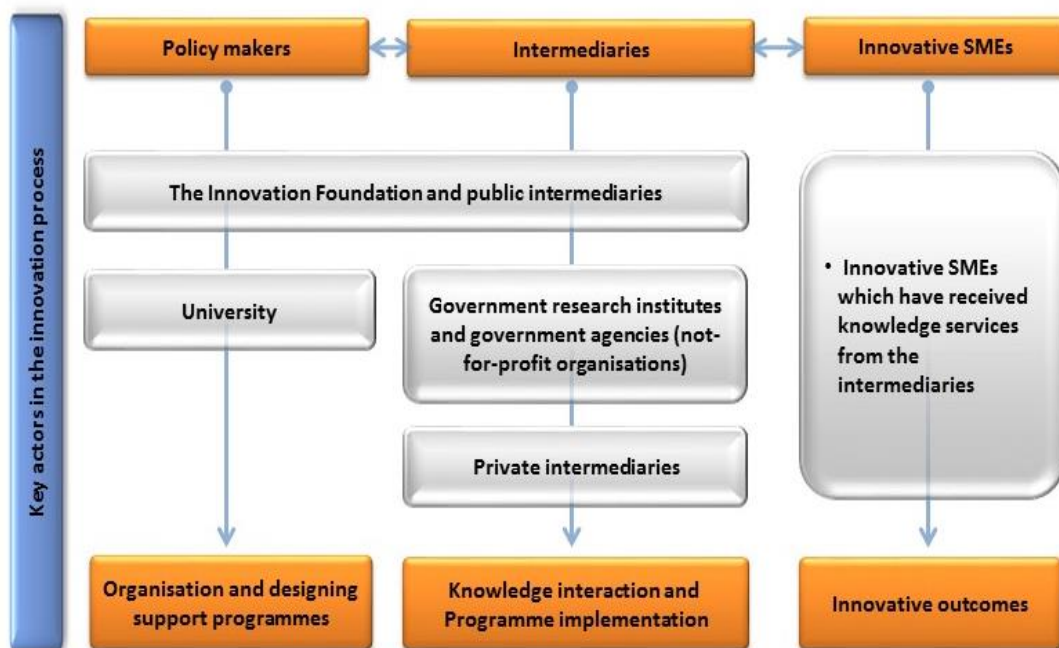


Figure 4-3 Overview of major players in interactions.

Source: Author.

4.4 Data Collection and Analysis

4.4.1 Types of Data: Documents and Interviews

For the data collection, I employed various types of data and processes to get the benefits of multiple sources of evidence (Yin, 2003). The sources included in this study were mainly in the form of documents and interviews. I triangulated the information from these data and from theories to give valid accounts of the knowledge interaction between public intermediaries and SMEs and their effects on bridging barriers to innovation.

The first type of data was a systematic review of secondary sources such as literature on the NIS concept and intermediary studies, Internet searches, and scholarly works. I collected secondary data throughout the research period to broaden the research point of view through longitudinally or cross-sectionally comparing information. These documents increased the reliability of other methods (e.g. interviews) by triangulating data sources (Yin, 2003). Hence, the secondary analysis method involves the use of existing data in order to pursue research interests which is distinct from that of the original study; this can be new or alternative perspectives on the original questions (Heaton, 1998).

I retrieved data from various sources including some major S&T policy reports in Korea, government proceedings, technical and industry reports published by research institutions and research departments in industry, technical journals, PowerPoint slides used at conferences, and other consultation reports on specific SMEs. Among multiple sources of documents, government publications were the major source of S&T history, KNIS and SME policy, from the Science and Technology Policy Institute (STEPI), Korea Institute for Industrial Economics and Trade (KIET), MSIP, the SMBA, and KISTI. The public intermediary to which I belonged held extensive information on SMEs as the national focal point of SME support in Korea, and I was able to use this resource.

For SME related information, some were not officially provided to the public and yet were traceable and accessible. In particular, those reports that included crucial information about innovative SMEs were unavailable at the beginning of the research,

although they were imperative in analysing the changes in R&D investment plans, relationships with big buyers, and marketing plans. This information could be obtained as interviews progressed. I could also contact the relevant person using personal contacts in the organisations to request a copy. This enabled the tracing of how intermediaries translate knowledge and how interactions between intermediaries and SMEs affect the development and innovation process, which was the main question for this research.

I acquired the second type of data through in-depth interviews in a semi-structured format, organised in two sessions to examine and track the interaction of actors and effects on the innovation process. In addition to the interviewees from SMEs, I interviewed experts from various organisations to increase the credibility and validity of the study phenomenon. These interviewees included experts from public and private intermediaries, policymakers from the Innopolis Foundation, and a professor from Hannam University who had been acting as an advisor on S&T policy. The data gathered from this group provided insights from different positions to define the effects of interaction between public intermediaries and SMEs in each stage of the innovation process.

4.4.2 Interviewee Guideline and Process

4.4.2.1 Interview Guideline

I designed the interview to yield a certain level of fluidity and to reflect the four functions described in the previous chapter. I prepared a preliminary interview design and tailored it where needed to bring good questions that could not be answered by going through documents, and to cover any specific issues that arose during the interviews. Based on the first interview, I revised or expanded the questions in accordance with the interviewee's expertise. This iterative process played a crucial role not only in developing the questions but also learning the innovation process in real life. As indicated in Section 4.3.1, interviewees had various concepts of successful (or less successful) innovation that required me to set aside any bias of success (or failure), even though some firms were designated as

successful firms by public intermediaries. This realization caused me to refrain from using some terms such as success factors or failure factors directly.

Table 4-2 presents the main areas of inquiry or interview themes aligned with candidate questions I asked to interviewees. A series of questions was developed around the research questions. In addition to answering the questions, questions were also included the context of knowledge interaction derived from the conceptual framework. In other words, questions were designed to seek information on the firms, their views of relationships, interaction processes, outcomes and their perceptions of innovation. The initial questions were more open-ended in order to listen to how interviewees considered experiences with intermediaries in general. Interviewees were asked to explain the history of firms and the nature of the knowledge interaction in order to identify why public intermediaries were involved in the specific types of demands from SMEs and how these differences affected on different patterns of relationships.

I presented the guideline to interview questions (Table 4-2) to interviewees prior to conducting interviews but the interviews did not follow the guidelines rigidly, as the iterative interview process led to ongoing feedback and modifications in questions. This flexibility is a peculiar aspect of semi-structured interviews where initial questions only provide guidance. I developed a series of questions around the topic and asked questions about the context regarding participants' views of particular types of intermediaries and their perceptions of experiences in the innovation process. However, when conducting interviews around the outcomes of the knowledge interaction, of foremost importance was to discern interviewees' views aligned with the meaning of innovation. Because of a certain level of expectations that support programmes and interactions might bring, questions ensued about outcomes of the knowledge interaction in the beginning: Did the support programmes generate any outcomes? What caused the low level (or high level) of sales growth? What are the effect of supporting programmes for driving successful innovation? However, participants debated the meaning of innovation and its outcomes, and some interviewees directly indicated different viewpoints about innovation between

policymakers and firms. I sensed these questions needed to be revised and should be asked directly.

Table 4-2 Guideline to Interview Questions

Categories	Sample questions
Technology	<ul style="list-style-type: none"> - What is the competitive situation for the firm's products (technologies)? - Which are your most important marketing tools? (e.g. trade shows, agents, seller- initiated relationships, buyer-initiated relationships, recommendations from existing customers, intermediaries) - Have there been any barriers to innovation that have had a negative impact on the firm? - Which individuals within the firm manage the maintenance of contact with intermediaries? (How have the relationships with them changed over time?) - Can you describe how the communication processes within the firm work? - What was the motivation to look for external expertise?
Relationships	<ul style="list-style-type: none"> - Can you briefly describe relationships that you think are the most important for the firm's activities? (Are some of these relationships with big buyers?) - Which actors were specifically involved in the creation of relationships between the firm and customers? (Were there any existing contacts or relationships between individuals in the firm's management and players in the new market?) - How did the firm communicate/work with these customers? What do you expect through communication? - Did the communication give you improved knowledge? Did the interaction improve your technological and managerial knowledge? - What would you ideally want your customer relationships to be like? How did you overcome the barriers if you have?
Knowledge	<ul style="list-style-type: none"> - What are your main knowledge sources? - What kind of knowledge existed within the firm was used to develop the new product? (How did the firm obtain the knowledge and resources needed for developing the new business area, if you did not have?) - How was previously developed knowledge about strategy development stored and transferred? (Do you use manuals, databases, etc.?) - Can you suggest any other individuals within and outside the firm who have much knowledge about the subjects that we have discussed? - Did similarities in business climates play any role in the choice of target markets? - Were there gaps between employees or between your firm and other participants in developing a new product?
Intermediary	<ul style="list-style-type: none"> - What was the motivation of using the intermediary? How did you make a choice? - What did intermediaries (your firm) provide to your firm (intermediaries)? - How did the service affect your firm? If not, what should it be? - Are you still contacting the intermediary?
Innovation	<ul style="list-style-type: none"> - What do you mean by (successful) innovation? - Has the firm used any distinctive strategies during new technology development or market expansion? - Do you believe in the support programmes provided by public intermediaries in innovation process? What should it be? - What is the role of universities and research institutes in promoting innovation? What should it be?

Source: Adapted from Lindstrand, Melin and Nordman (2011, pp210–211) and Y. S. Park et al. (2006, pp268–288).

I asked interviewees the aims behind the participating the programmes in order to understand whether (or how) firms' needs were met by public intermediaries, and whether it brought any benefits firms. Initial questions included success or failure factors which affected the innovation process but I realised questions relating success or failure (factors or outcomes) could be problematic as the research were progressed. Some CEOs argued there were no such factors which could determine success or failure of firms. Therefore, I tried not to ask directly about the outcomes of knowledge interaction with intermediaries as it is related to the notion of success or failures of firms. Instead, I tried to analyse the meaningful texts drawn from other categories of questions.

4.4.2.2 Interview Process

As Yin (2003) points out, a case-study approach relies on theoretical sampling instead of statistical sampling; the choice of interviews was influenced by conceptual questions rather than a concern with representativeness (Miles and Huberman, 1994). Because interviews are the major sources of data in a case study, well-conducted interviews may provide insights into the black-box of knowledge interaction. This insight could not be identified by statistical analysis. The information needed for the study required insiders' views and knowledge that consisted of more than information on patterns of relationships and interaction in the KNIS: these are micro-factors that determine success of innovation, different histories of SMEs, and different relational capital with external expertise.

The interviewees were chosen mainly centred on CEOs for two reasons; to explain the knowledge interaction process with intermediaries and firms' strategies which might change over time; and to explain the organisational and individual changes as the result of the knowledge interaction. Furthermore, many CEOs have also involved in the existing business area for a long time and were able to provide insights into the long-term based relationships between intermediaries and SMEs. Most of all, the CEOs were the key actors who identified problems of firms, involved in the knowledge interaction directly and maintained the contact with intermediaries. However, I also applied the 'degree of heterogeneity' of cases in selecting interviewees, when necessary. Although most interviewees from SMEs were CEOs, I

interviewed CTOs or staff from the firm if they were interacted with intermediaries to seek a holistic picture of complex innovation processes at multiple levels rather than fragments of relationships at a specific point in time.

From the intermediary side, key researchers (or directors) were identified through their involvement in the knowledge interaction process with SMEs. They had sound knowledge about which SMEs were involved in the programmes and which were successful (or less successful). Targeting 26 SMEs and 5 intermediaries, I mainly chose one key person from one organisation except two SMEs. Although the number of intermediaries seemed to be small compared to the number of SMEs, public intermediaries chosen for this study have been supporting multiple SMEs up to 26 SMEs. The researchers interviewed were actively involved in the knowledge interaction between public intermediaries and 5 SMEs, and were able to explain the 'what was happening' during the interaction processes. Furthermore, they had experiences with other SMEs in different fields and were able to provide insights into complexity and diversity embodied in the knowledge interaction process.

Through the iterative process, I interviewed 47 people during 2012 and 2013: 38 interviewees from 26 SMEs, 7 interviewees from public and private intermediaries, and 1 from a university (Table 4-3). Among them, 15 interviewees were particularly informative, as they had various experiences as CEOs or policymakers for a long period of time. Interviews with these participants took 2 to 3 hours and sometimes 5 to 6 hours at the first interview. As I had to trace whether the interaction process was successful, it was important to maintain an unbiased attitude as an interviewer. Had I let my biases interfere, interviewees may have tried to show only the good side of interactions with public intermediaries to maintain good relationships with government bodies.

I conducted the first in-depth interviews in Korea to obtain the specific details of the interaction with public intermediaries about innovation and its effects on enhancing innovative capabilities. For this stage, I interviewed CEOs who had used intermediary services. Because I have been involved in services and in regular contact with the same CEOs, I had the advantage of communicating with them without barriers. For policymakers, they had extensive knowledge of innovation of

SMEs and government support programmes. I contacted these participants as the interviews with SMEs proceeded to cross-check the information I obtained.

I took a careful approach to selecting interviewees who were well aware of the context of the innovation process of the firm. In seeking participants in SMEs, I emphasised interviewing CEOs or senior-level staff. These participants were the founders of firms and therefore knew well the history of their firm, collaboration programmes, and knowledge interactions with external organisations. Unlike big corporations, small firms often do not have clear structures (e.g. marketing, R&D, and management departments.) and CEOs have a huge impact on R&D, management, and marketing. Most of all, CEOs were key actors involved in the knowledge-interaction process with public intermediaries and big buyers, delivering feedback to intermediaries and facilitating internal communications. However, I also interviewed CTOs or other senior-level officials, if CEOs delegated roles to them or they were involved in the knowledge-interaction process. This approach was useful to explain the single phenomenon of an SME in rich detail, such as history, relationships, and capabilities of each firm, because little research has been done in this area.

This study was an ex post evaluation of the knowledge-interaction process. Learning was not monitored systematically during interactions but had to be monitored and assessed by recollection of the participants. This format might imply a greater risk of bias and selectivity by respondents (SMEs). Therefore, in addition to the CEOs of SMEs, I interviewed intermediaries as a way to corroborate the evidence collected from each SME. Intermediaries interviewed were researchers or project managers responsible for managing programmes and key activities of the knowledge interaction. Although I interviewed a small number of participants, they were the key actors who interacted with SMEs for a long period of time, managing interfaces. They provided rich evidence on the knowledge-interaction landscape, offering experiences and consultation reports in the case-study approach. In addition, as I was involved in designing SME support programmes and knowledge interaction with other types of intermediaries and SMEs, I was able to serve as a reflexive actor during the interviews.

Even though I clearly stated my position as a student, my work experiences may have limited the boundaries of interviews. However, my position had more advantages than disadvantages. Because the information I needed was often treated as confidential, it might not have been possible to access those CEOs without my background or a referee who recommended me as an analyst from the public intermediary. I was able to deliver a credible image to interviewees and my status as a student made them open their thoughts more freely. One interviewee who I met three times spent 3 to 6 hours at every meeting not only talking about interactions with intermediaries, but also his disappointing experience with the intermediary for which I worked. Some interviewees who were dissatisfied with the service seemed to be careful about giving a candid statement that could affect their potential relationships with the public intermediary, but most seemed to be open to deliver what they really wanted to say.

Following the first interviews targeting 47 interviewees, I organised a second in-depth interview process to examine the interactions that occurred between SMEs and the public intermediary, along with characteristics of successful (or less successful) innovative SMEs. I selected interviewees who were CEOs, CTOs, or staff of the five SMEs in charge of co-operation with external organisations. I visited the firm more than once to have second interviews and third interviews with the same interviewees when necessary. To maintain a 'neutral stance', one researcher from Hannam University accompanied me to two firms classified as successful cases. At the second interviews, I tried to look into the hidden nature of interaction rather than the organisational level, but also at an individual level such as individual thoughts on a certain project or relationship with analysts or consultants from the intermediaries.

Prior to interviews, I conducted document analysis and a web search to identify any participation in government support programmes, to remind interviewees of the experience of collaboration. Furthermore, I investigated additional information including innovative capabilities of CEOs, technologies, markets, networks, and outcomes for the last three years (2008–2010) with the help of public and private intermediaries involved in the programmes. Then, as previously stated, I interviewed researchers from the public intermediary who were involved in strong relationships

with those five SMEs to seek ways they interacted and transferred knowledge. As Altrichter et al. (2008, p147) insist, triangulation “gives a more detailed and balanced picture of the situation”; the data triangulation had clearly affected my preconceived notions of SMEs I interviewed and the concept of successful (or less successful) innovation, as shown in the selection criteria. In one case considered to be a good example of bilateral interaction between a specific intermediary and an SME, relationships were evolving at multiple levels, enrolling heterogeneous actors from public and private sectors. SMEs were not passive recipients of services.

The process was iterative which brought in-depth knowledge and information by building up the events related to the innovation process of SMEs. I benefitted from this study in accessing and acquiring information from CEOs and policymakers because the topic was a significant area of interest for demand and supply-side actors. Often, interviewees spent more time than they planned and some CEOs introduced key staff in case they could not deliver the interaction process in detail. Each interview was recorded after receiving the consent of the interviewee, who agreed to the use of the interview contents for the study. However, I decided to keep all names anonymous and some information confidential because the information may be critical to their relationships with big buyers. Then the interviews were transcribed with significant sections translated into English for further analysis.

The interviews conducted in the field are listed in Table 4-3. The detailed interviewee’s list is provided in Appendix 3.

Table 4-3 Interviews Conducted for the Case Study

	Fields	KISTI and IF*	KTVF	GSBC	Private consultancies	Sum
SMEs	Mechatronics	6 (10)	3 (4)	2 (2)	1 (1)	11 (17)
	Chemistry	2 (4)	—	1 (3)	—	3 (7)
	IT	6 (8)	2 (2)	2 (2)	2 (2)	12 (14)
Subtotal		13	5	5	3	26 (38)
Intermediaries		2 (4)	1 (2)	—	2 (2)	5 (8)
University						1 (1)
Subtotal		2	2		2	6 (8)
Total						32 (48) [†]

Note. Number of interviewees in parentheses; * among the 13 cases, KISTI carried two cases alone and the IF was the organiser of the support programme for the other cases. [†] The actual number of interviews was 47 because one CEO from the mechatronics firm operated a private intermediary.

4.4.3 Data Analysis

This study sought to explore, understand, and describe a particular phenomenon, with its focus on providing an understanding of how intermediaries facilitate knowledge interaction between organisations and institutions, but ultimately between individuals and how the process can resolve barriers to innovation. The study was therefore about discovery, uncovering the intermediating process based on the four functions suggested in the framework. The line-by-line review of the interview texts provided the basis to examine the research questions suggested by the conceptual framework. The analysis of the data derived insights from the case that I compared to the conceptual framework, while connecting the analytic focus to broader debates in the literature on the NIS and intermediary studies. The analysis step provided a rich description, covering theoretical and policy implications.

For the data analysis, I used an interpretive approach to analyse the narrative obtained from semi-structured interviews and linking the new ideas from thematic coding to constructs introduced in the theoretical framework (Van der Blonk, 2003). Before coding the data, I noted my thoughts related to specific comments from the interviewees, which were then used for further inquiry in the second interviews or analysis of primary-interview data. The collected data went through hermeneutic iterations of interpretation with new emerging theoretical constructs (Strauss and Corbin, 1990).

Throughout the analysis process, the conceptual framework was the basis for analysis of the data using the case study approach, but did not limit my ability to derive new properties or categories, because this process was one of the steps of the grounded-theory method. Furthermore, I had pre-established no clear direction for analysing the qualitative data (Spencer, Ritchie and O'Connor, 2003). Thus, the coding process included several iterative processes of applying new categories. I assigned concepts and labels to the meaningful transcript excerpts that could respond to research questions and then I re-categorized a number of concepts and labels into a smaller group. The iterative processes were time consuming and involved careful examination of the transcripts to gain an understanding of participants' views, which allowed segmentation of a transcript into the categories suggested by the conceptual framework.

The line-by-line review, segmentation and categorisation process provided a basis to examine the research questions, while the process also informed certain directions of the study. The aim of the analysis was not to make judgements, but rather to uncover how the knowledge-interaction process affects innovation of SMEs by decreasing barriers. Ensuring reliability of the data collected from firms, policymakers, academics, and intermediaries, I cross-checked various levels of evidence during the process, thoroughly examining ideas from the case analysis and comparison of those ideas with the expectations of the conceptual framework.

Once I categorised and analysed all interview texts, I used document data to support the validity of the analysis. Documents incorporated into the analysis included consultation reports on each SME, inside data from SMEs (e.g. strategic plans), SME policy reports, evaluation reports, and whitepapers on support programmes. In particular, inside data of SMEs and consultation reports were useful in building credibility of the findings obtained from the case study. The documents provided not only information on firms that added credibility to retrospective comments made by interviewees, but also findings on how SMEs implemented support programmes and the gaps between the programmes and expectations of SMEs. I triangulated these documents with analysed data from interviews to generalise the role of public

intermediaries in facilitating innovation of SMEs in Korea through the four functions provided in the previous chapter.

However, the analysis was not meaningful without presentation of the findings because data presentation is an integral part of research (Van der Blonk, 2003). In this vein, subsequent chapters present a rich description of the knowledge interaction between the public intermediary and SMEs in the KNIS. They cover the different innovation patterns of successful and less successful cases and how the interactions and learning influenced the innovation processes of SMEs in different directions. Furthermore, they uncover what is happening in the system, the involvement of heterogeneous actors, and evolving characteristics of relationships. The rich description and analysis of the evidence further provide theoretical and policy implications derived from interpretations of the findings.

4.4.4 Reflections

A major strength of this study is the shift from an intermediary-centred perspective towards the demand side, focusing on the shaping of mutual relationships and learning between the public intermediary and SMEs in the innovation system. In particular, the focus on the knowledge-interaction process and the role of intermediaries represents the major backbone of this research, based on the theories relating to the NIS concept and intermediary studies applying STS perspectives. During the process of analysing data, it was difficult to justify keeping the research stance away from the supplier's viewpoint of public intermediaries. It was by strengthening the framework and making it more robust through data analysis that this study could overcome the dominant discourse on the role of public intermediaries as suppliers delivering services to firms. In particular, I was interested in why some firms were successful and others were not although the group of firms benefited from the same type of knowledge services. It led to observing the view of demand side and the interaction process.

The data triangulation, applying STS perspectives, provided a rationale for the heterogeneity of relationships and actors, and the sociological factors that affect the innovation process that have rarely been explained in the NIS framework. Thus, this

study could provide adequate answers to the research questions designed to extend the existing NIS concept and intermediary studies into relationship value in the innovation processes and their influence on innovative capabilities of innovative SMEs, and thus KNIS. It might be impossible to explicate the black box of interaction and relationships without field data and theory triangulation, but it also brought disadvantages.

Sometimes, preconceptions gained by personal experience seemed to hinder the interdisciplinary field of research. As the research had been carried out as planned, I could strengthen the examining process by applying an interdisciplinary approach that provided a better framework for analysis and insights to policymakers in Korea. In particular, the processual approach to the NIS and intermediary studies elucidated the contingent and complex innovation process and interactions at meso- and micro-levels involving heterogeneous actors and factors. The relationships and interactions evolved in different ways: the innovation path and technological expertise that accumulated in the firm tended to shape the innovation environment.

For the cases selected, I had an advantage because I have been deeply involved in intermediary services as a researcher. I am well aware of policy structures, corporate cultures, and language, and at the same time have in-depth experience and relationships with SMEs in Korea. Considering that the corporate culture of SMEs is quite closed, especially in that actors depend on large corporations such as Samsung or LG, it is one of my major strengths to be able to observe the SMEs without key barriers, due to the impartial position I hold.

As I developed the study, I was able to aver my position allowed me to be open to different perspectives. I was not just a researcher but also a social scientist standing back from the situation. I needed to reflect on how interviewees might answer questions while thinking of my position, given their contexts. My neutral stance helped me overcome the local knowledge that I had at the beginning of the study. Some SMEs were defined as failure cases whereas others were not in innovation, however many interviewees consented that the innovation entailed several failure and success experiences. I could keep away from concluding the 'end-status' of

success or failure of firms by adopting the processual perspective of the innovation process.

However, the weaknesses of this research may also be found in the selected cases, due to the timeline of this study. This research required in-depth, concise, and detailed knowledge and this led to a limit to the number of cases. To overcome the limitations, information from around 47 interviewees from various levels supported the key findings from the five case studies. Most of all, the study seeks a coherent description of complex knowledge interactions and relationships rather than providing common ground for generalisation that can only be strengthened and supported by in-depth study of a specific situation. However, I shall communicate with potential readers of this study through findings and policy implications.

4.5 Conclusion

In this chapter, I explained the research methods adopted for the study. Although the case study approach influenced the research process, the empirical chapters also benefited from a grounded-theory approach. The general framework of the research design built on the NIS concept, intermediary studies, and STS perspectives, which guided examination of the complex interaction process. The research design does not aim to provide a generalisation of interaction patterns between public intermediaries and SMEs in different sectors or nations; rather, it attempts to provide insights into the role of public intermediaries in the KNIS, which facilitates innovation of SMEs by decreasing the barriers in the complex innovation process. Conducting five case studies provided width and depth to this study, enabling me to look into the complex evolving process of heterogeneous relationships during the innovation process.

Chapter 5 provides an explanatory country-specific context of innovation systems and how the government has played a crucial role in facilitating innovation, pointing out mismatches between policy support and the demands of innovative SMEs.

Chapters 6 and 7 are exploratory parts of the study, presenting the primary data obtained from the interview analysis.

5 Chapter 5. Challenging the KNIS: Its Adaptability and Flexibility

5.1 Introduction

Korea, as one of the countries that devotes relatively more of its resources to technology learning and technological processes than most others, has surpassed the leading European countries in R&D intensity (Hemmert, 2007). S&T policies and public-sector R&D appear to have grown in Korea to a level considered adequate for a technologically advanced country or ‘newly advanced economy’ (Hemmert, 2007). However, these policies, implemented for several decades, do not effectively link to economic outcomes, resulting in mismatches between institutions and actors. In particular, weak SMEs have been considered a chronic problem in the KNIS in spite of government efforts for several decades (Lim, 2008).

Many scholars (D. Cho, 2012; Chu and Cho, 2006; Chung, 2002; L. Kim, 1993; K-R. Lee, 2004; K-R Lee, Choi and Park, 2004; Lim, 2008) criticise the low level of cooperation between firms (e.g. between large and small firms) in the KNIS that obstruct knowledge flow and learning. The low level of competitiveness of SMEs (D. Cho, 2005; Chu and Cho, 2006) may hinder interaction with large corporations (Lim, 2008). In this vein, the role of the public intermediary as an external linkage of SMEs has drawn policy attention as it has been an innovation facilitator, transferring and facilitating knowledge interaction to enhance the innovation capacity of Korea (Y. B. Kim, 2005). Yet, displaying a broader framework, the KNIS has a limited grasp of the innovation process, which entails dynamic interaction with heterogeneous actors in a system where the national characteristics and institutions have strong impact on the innovative capability of firms. It is necessary to look into specific characteristics of the KNIS where institutions and actors evolve, examining the linkages and how they interact to resolve specific problems relating to the KNIS.

This chapter begins with an analysis of the KNIS. Section 5.2 addresses the history and characteristics of S&T policy and its strengths and weaknesses, highlighting the role of GRIs as bridging organisations in the KNIS. Section 5.3 investigates SME policy, focusing on its developmental direction, a move towards fostering innovative

SMEs and related programmes. Then, the section stresses policy mismatches and indicates that the programme tends to concentrate on the R&D and commercialisation stages, overlooking the process in between. I argue that the problems (e.g. weak SMEs) embedded in the KNIS may come from the linear view of innovation, missing complex interaction processes at specific levels. Section 5.4 suggests the modification of the KNIS to at an appropriate level (i.e. public-sector innovation intermediaries and SMEs) examine the interaction process, emphasising the interactive approach.

5.2 Evolution Process of the Korean National Innovation System

5.2.1 Main Historical Trends of S&T Policy in Industrial Development

The urge to build the Korean economy after the Korean War (1950–1953) created an industry infrastructure and caught up with advanced technologies in a short period of time, driving S&T policies since 1960s. This effort resulted in one of the distinctive features of Korea's capability building: the role of government.⁴⁶ The Korean government directed limited resources to targeted industries, defending its domestic markets to encourage the entry of national firms and the construction of infrastructure and efficient facilities, influencing the acquisition of foreign technology, and promoting export activities (MarketLine, 2013). Taking a leadership role in enhancing technological competitiveness, the government started to establish GRIs as effective mechanisms to provide R&D and technology infrastructure to industries. Since the Five-Year Plan of Economic Development was initiated in 1962, the continuing steady increase in the number of GRIs in South Korea had been remarkable (Chung, 2002; S. Kim, Lee and Kang, 2012; Wong, 2004).

In addition to the establishment of KIST in 1967, many GRIs were established during the 1960s and 1970s to support major Korean industries, with researchers equipped with expertise in specific technology areas. The GRIs linked the national

⁴⁶ The role of government was fulfilled through the Five-Year's Economic Development Plan, organised in five phases between 1962 and 1986. It continued to the 6th and 7th five-year plans, which ended in 1996. The Plan acted as a national blueprint that directed resources and sectoral investment plans and coordinated economic policies to implement the Plan. While Japan had the MITI to create similar kinds of conditions through guidance for developmental programs (C. Johnson, 1982), Korea had the Economic Planning Board where the deputy prime minister was in charge of the Five-Year program.

vision and policy⁴⁷ to local industries when the government pressured industries to enhance their technological capabilities by providing various incentives (H-D. Cho et al., 2011; Wong, 2004). The absence of university R&D capability in the 1960s and 1970s also affected the increase in the number of GRIs. In this period, as a backbone of building national R&D capabilities, GRIs received 90% of the research grants in new technology areas awarded by the government (K. Kim, 2003). Government support focused on industrial-technology development, taking charge of many projects from industries.

Beginning in 1980, industries showed rapid growth, and private corporations, known as *chaebols*,⁴⁸ appeared as major players in national R&D activities. Because the central role of GRIs was to support industries, the growth of *chaebols* brought controversy over the redefinition of the function of GRIs. Since the 1990s the policy had started to facilitate cooperative R&D among GRIs, universities and firms, and the role of GRIs shifted from enhancing the R&D capabilities of major industries (i.e. chemicals and heavy industries) to supporting specific actors (i.e. SMEs) and areas where high uncertainty existed and large investment was required (H-D. Cho et al., 2008). In this period, funding was seen as a major mechanism to encourage collaborative R&D and about 27% of funding was involved in information and knowledge exchange (K. Kim, 2003). While interactive learning did not seem to occur actively at this time, progress occurred in S&T policy, adopting the concept of an interactive approach: introduction of a Plan to Construct a National Innovation System (PCNIS; Lim, 2008) and the TF⁴⁹ (Technology Foresight; Schlosstein, 2007).

⁴⁷ Many GRIs were established to deal with industrial needs: the Korean Atomic Energy Research Institute in 1959, the Korean Science and Technology Information Centre in 1960, which became the KISTI in 2001, the Korea Electronics and Telecommunications Research Institute in 1967, the Korea Research Institute of Standards and Science in 1975, etc.

⁴⁸ According to the Oxford English dictionary, *chaebols* are large family-owned business conglomerates in South Korea.

⁴⁹ TF can be defined in various ways (Martin and Irvine, 1984; Salo and Cuhls, 2003) but common traits are focusing on alternative future scenarios, drawing a common understanding of emerging social and economic issues, deriving results through superior processes and need-orientation, and distilling policy recommendations (Schlosstein, 2007). The TF was widely used in 34 countries, mostly European, and by five supranational organisations, and in Korea, technologies called Next

In 2004, the government adopted the PCNIS as the major national S&T policy. This reflected the government commitment to moving towards an innovation-driven economy, emphasising the coordination of S&T policies among ministries and monitoring according to mid- and long-term S&T strategies and planning. The Ministry of Science and Technology was in charge of coordination and monitoring activities in cooperation with the National Science and Technology Council at that time.

Along with the PCNIS, the TF framework had been used at the national level to tap decentralised knowledge resources and pool their ‘collective wisdom’ (Schlossstein, 2007). Schlossstein (2007) argued that the TF framework seemed to lend itself to the innovation-systems perspective, replacing the linear model of innovation. For example, two national R&D programmes, the Highly Advance National projects and the Frontier Research Programme were formulated under intensive interaction with academia, industry, government and civil society. This coordination drew policy attention to the concept of system failure, introduced for the first time in a third TF study along with an NIS concept. In this regard, researchers recommended to use bridging institutions to remedy the shortfall; the low level of collaboration between scientists and product developers, and large corporations and small firms (Georghiou, 2001; Schlossstein, 2007).

In early 2011, the new government reformed the National Science and Technology Council into the National Science and Technology Commission to reinforce and supervise inter-ministerial coordination, R&D spending and evaluation. Focusing on new investment avenues in the future, many policies commenced towards the development and enforcement of ‘creative and convergence-oriented R&D’. To enhance the capabilities of SMEs, the government launched the New Technology Purchasing Assurance Scheme and Procurement Programme through which opportunities are given to SMEs that can provide goods and services to public organisations. The government also considered implementing ‘a globally open innovations system’ and an inter-ministerial cooperative programme, along with

Generation Engines of Economic Growth were selected for resource allocation covering the time frame until 2015 (Schlossstein, 2007).

increasing investment in basic research areas. To implement the policy vision the new government also emphasised the role of GRIs as innovation facilitators of SMEs, supporting whole stages of the innovation process. Table 5-1 shows the history of S&T policy described above.

Table 5-1 The Direction of S&T Policy in Industrial Development

Period	Policy focus	Activities
1960s	Fostering HR	Launching the Five-Year Economic Development Plan (1962–1986) Establishing GRIs to lure Korean graduates overseas to support industrial needs Acquiring human resources and improvement in engineering skill levels
1970s	Fostering heavy industries	Legislation entitled the Technology Promotion Development Act to foster domestic indigenous technologies Establishing GRIs to address industrial needs Establishing Daedeok Science Town
1980s	Enhancing internal resources	Supporting R&D activities through the National R&D Programme Legislating Industrial Technology Association development Establishing the Korean Federation of Science and Technology Societies and Korea Basic Science Institute
Late 1990s ~ early 2000s	Increasing the number of SMEs	Establishing the Presidential Commission on Small and Medium Enterprises (1998) Promoting new venture businesses and heavy investment in R&D: Increasing the number of newly established ventures from 422 (1996) to 878 (1999; OECD, 2000) Encouraging SME-led innovation through joint research Conducting the first TF study (1993) and second TF study (1999): Formulating the HAN Project (1992) and the Frontier Research Programme (1999)
2000s ~ late 2000	Fostering innovative SMEs Facilitating cooperative R&D	Establishing the venture firms policy aiming at stimulating innovative SMEs in new and traditional industries Conducting the 3rd TF study (2003–2004) Announcing A Plan to Construct a National Innovation System (PCNIS; 2004). Shifting policy towards facilitating cooperative R&D among GRIs, universities and SMEs Increasing R&D funding and diversification of support programmes
Early 2010s ~ present	Strengthening capabilities of SMEs Encouraging Start ups	Reforming the National Science and Technology Commission (2012): Strengthening inter-ministerial coordination and designating new investment areas for the future Investing in R&D funding for SMEs, increasing the R&D budget to 18% (2018) from 12.4% (2012). Strengthening the role of GRIs as innovation facilitators for SMEs

Note. HR = human resources.

5.2.2 Current Status of the KNIS: Its Strengths and Weaknesses

The previous section described the history of S&T policy, which played an important role in shaping the current KNIS. Korea, as a full-fledged newly advanced economy⁵⁰ competing in global markets, possesses a fully developed NIS that supports its future competitiveness (Hemmert, 2007). A number of strengths of the KNIS can be summarised as follows:

- excellent innovation infrastructure; strong large corporations that have achieved global technological leadership
- competitive knowledge base in the IT sector and its high diffusion rate
- strong national propensity for education and learning
- successful experience of R&D consortia that has accumulated in firms, GRIs and ministries, along with capability of GRIs to provide a strong knowledge infrastructure based on accumulated experience

An excellent innovation infrastructure can be a key competitive advantage when led by strong government. R&D expenditures in GDP accounted for 4.03% in 2011, whereas the average of OECD countries was 2.37% in that year (OECD, 2013). According to the World Bank, high-technology exports (percentage of manufactured exports) comprised about 26% of total exports in 2011, whereas the figures for the U.S. and Japan were 18% and 17%, respectively. Additionally, Korea has large, innovation-driven corporations that are highly renowned in the international market for their high-technology products (MarketLine, 2013). Moreover, there is a highly qualified labour force, in which the number of researchers has reached 11.51 per thousand in 2011, compared to 8.29 in the U.S. and 9.96 in Japan in the same year (World Bank, 2013). In particular, the knowledge infrastructure has been accumulated by major actors through collaborative research led by GRIs.⁵¹ These factors have contributed to creating the image of Korea as a 'high-end innovation centre'.

⁵⁰ Lim (2008) defines the KNIS as a mix of advanced and developing country features in that it has advanced large corporations with weak small firms.

⁵¹ Examples of collaboration research are 4M DRAM, Electronic Switching System, optical fibre production, robotics and super-minicomputers (L. Kim, 1993).

Although Korea's development has made remarkable progress in recent decades, it has also caused a number of imbalances in its innovation system and economy. Some weaknesses⁵² that may render the innovation system inefficient (MarketLine, 2013) include:

- weakness in innovation policy; prevalence of uncompetitive SMEs
- weak science base
- lack of R&D capabilities in universities
- small pool of knowledge intensive businesses, closed networks of alumni and families (Lim, 2008)
- underdeveloped linkages for use of knowledge stock among actors (H-D. Cho et al., 2011)

Innovation policy significantly lags behind other factors in terms of capacity to conduct fundamental research, bringing a number of constraints. Universities were not regarded as knowledge sources until the government started to focus policy on increasing the R&D capability of universities in the late 1990s. Underdeveloped linkages and a low level of collaboration among major actors limit both the use of existing knowledge and the creation of new knowledge through interaction with different sectors (L. Kim, 1993). In addition, poor coordination among ministries with their own policies on research and funding, and poor cooperation, due to intense rivalries, have exacerbated the problem. Ministries organise their own activities, resulting in considerable overlap between different S&T policies in different programmes implemented by ministries (H-D. Cho et al., 2011; Hemmert, 2007).

The government has been unable to create equal business opportunity between the *chaebols* and SMEs, despite repeated efforts (MarketLine, 2013; Suh, 2004). In this regard, Lim (2008) defines the KNIS in six words: 'strong large firms, weak small firms'. For example, a huge productivity gap exists between *chaebols* and SMEs, in that the value added per worker among SMEs is 65% lower than in *chaebols*. SME

⁵² Hemmert (2007) indicates a 'lack of highly skilled technical specialists' as one of the weaknesses of KNIS, but other scholars tend to consider a 'highly educated and skilled labour force' one of its strengths.

expenditures in R&D activities is also far lower than in *chaebols* per unit of sales. Part of the reason for the dismal performance of SMEs is the high lobbying power of the *chaebols*, which are able to hinder SME reforms to protect their monopolistic trade practices (MarketLine, 2013).

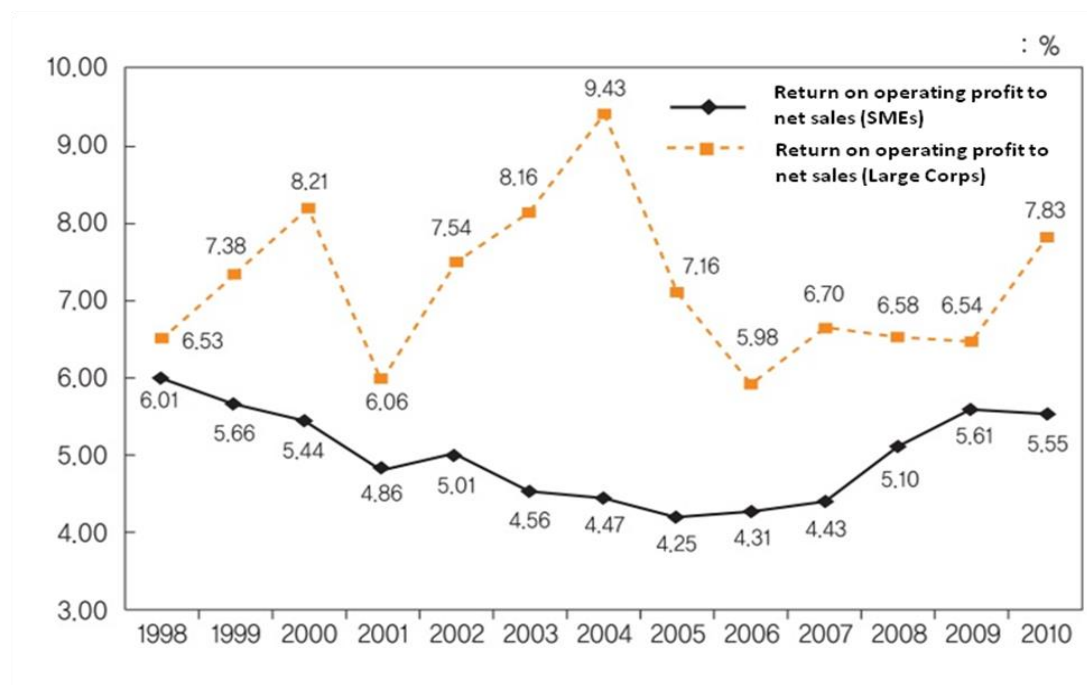


Figure 5-1 The polarization of profits between large corporations and SMEs.

Source: The Bank of Korea as cited by D. Cho (2012, p8).

Strong *chaebols* lead networks and vertical linkages with affiliated large firms that are common in the KNIS. This phenomenon may result in a lack of interaction between *chaebols* and small firms, and several authors (Chu and Cho, 2006; Lim, 2008; Suh, 2004) have indicated that networking among firms is not well developed in Korea. Networking has been ranked low, 23rd among all indicators in the COSTII index (KISTEP, 2014c),⁵³ which contrasts with the high rank of cooperation among firms, GRIs and universities (3rd). This phenomenon was closely related to the catch-up process that took place between the 1980s and late 1990s, in which large corporations actively interacted with foreign corporations to assimilate the

⁵³ Korea Institute of S&T Evaluation and Planning (KISTEP) developed the COSTII index based on OECD indicators to examine input-activities and outcomes using the NIS framework (KISTEP, 2014c).

technology, and which might have caused the low level of interaction among domestic firms. In addition, ‘clannish attitudes’ may obstruct interaction among major actors in the KNIS. Large corporations tend to interact with firms in their group and are reluctant to communicate with SMEs, while government agencies are inclined to work with their own departments or ministries.

Table 5-2 COSTII Ranking of Korea, 2013

Sectors	Subsectors	Ranking of Korea	Relative level (%)	
			Korea	Average of OECD
Resources	Human Resources	12	58.5	50.5
	Organisations	8	7.2	8.5
	Knowledge infrastructure	8	8.0	9.3
Activities	R&D investment	2	94.3	48.6
	Start-up activities	22	27.4	39.8
Network	Cooperation among firms, research institutes and universities	3	96.6	48.2
	Cooperation among firms	23	32.2	55.9
	International cooperation	18	10.0	20.1
Environment	Support infrastructure	24	39.2	60.2
	Physical infrastructure	1	100.0	70.9
	Culture	20	50.0	61.2
Performance	Economic performance	7	54.4	40.7
	Knowledge creation	16	34.7	35.7

Note. *100 = A country ranked as No. 1 in the subsector; Source: KISTEP (2014c, p26).

It is possible to speculate that the lack of capability of SMEs and low level of interaction among firms are the major impediment that needs to be resolved.⁵⁴ The problem is that knowledge-generating organisations such as universities⁵⁵ are still weak in spite of recent government efforts to upgrade R&D capabilities. GRIs still seem to be major players in knowledge generation but a lack of centralised

⁵⁴ The ranking of the level of cooperation among firms dropped to 23rd in 2013 from 16th in 2008 in COSTII index.

⁵⁵ Universities were not regarded as a knowledge source until the government started to facilitate interaction among universities, GRIs and industries in late 1990s.

organisation and poor knowledge dissemination have been indicated as weaknesses (MarketLine, 2013).

However, COSTII, OECD and IMD indicators (KISTEP, 2014a, 2014b, 2014c) give only a rigid and static picture, with no detailed insight into identify weaknesses and further resolving the imbalance between innovation input and innovation output (Table 5-2). For example, although the government has developed and implemented support programmes for several decades, economic performance and knowledge creation still appear to be below the average of OECD countries (Table 5-2), in which the rankings are 7th and 16th respectively. The analysis of KNIS at macro-levels has shortcomings when it comes to explaining why the level of cooperation among firms is low, what barriers exist, and what supporting mechanisms can be applied to overcome weaknesses. In a similar vein, the KNIS does not show whether linkage organisations facilitate knowledge flow and interactive learning among various actors (K-R. Lee and Song, 1998; Song, 2004) in the KNIS. The following section will illustrate the characteristics of public intermediaries and their role in the KNIS.

5.2.3 Unrevealed Performance: Firms and Supporting Mechanisms

In Korea, GRIs are amongst the earliest form of organisations supporting industries⁵⁶ (see Section 5.2.1), making their appearance around 1960, whereas the role of universities in economic development has been the production of well-trained graduates focusing on teaching (Yusuf, 2008). As a result of government support since the 1960s, GRIs equipped themselves with trained personnel, powerful ‘intellectual equipment and materials’, wide networks of industries, academics, policymakers and consultants, and accumulated experience as innovation facilitators, linking policies and industries for several decades.

Professor SS Seol in the Economics Department of Hannam University explained:

It is impossible to talk about the growth of SMEs without the role of the government in Korea. For example, the ranking of leading corporations

⁵⁶ Dodgson (2007, 2009) asserts that the form of collaboration has evolved from the development of intermediary institutes (i.e. ITRI in Taiwan), which was indicative of significant institutional development in the evolution of the NIS.

is the same as that of the munitions industry in the 1970s that was led by the strong government policy. [The government policies and programs still have a strong impact on industrial growth.] Korean people have been pursuing innovations to survive but the problem comes when people start looking for resources for innovations. The resources are information and knowledge. Who owns them? All the knowledge infrastructure is owed by the government related organisations.

(Interview with SS Seol at Hannam University, 27 May 2013)

The infrastructure of GRIs plays an important role in configuring the information and knowledge required in the innovation process of SMEs. Also, the accumulated history of knowledge services to SMEs that include intermediaries, provides more chances to resolve new issues. As a result, many SMEs experienced the services and facilities of the intermediaries, and the relationship with public intermediaries became a key driver to facilitate constant knowledge interaction, thereby decreasing the barriers at every stage of innovation. This history seems to shape distinct features of the KNIS such that public intermediaries, as linkage organisations⁵⁷, have been considered important actors in generating new knowledge, connecting all the actors and correcting the failures (Figure 5-2).

⁵⁷ The ITRI in Taiwan can be seen as an innovation intermediary that facilitates technology transfer, creates consortia and develops joint ventures (Dodgson, 2009) whereas intermediary institutes in Korea have been evolving centred around specific roles e.g. S&T knowledge dissemination, technology transfer, promoting SMEs, supporting the Daedeok Special Research and Development Zone, innovation clusters, etc.

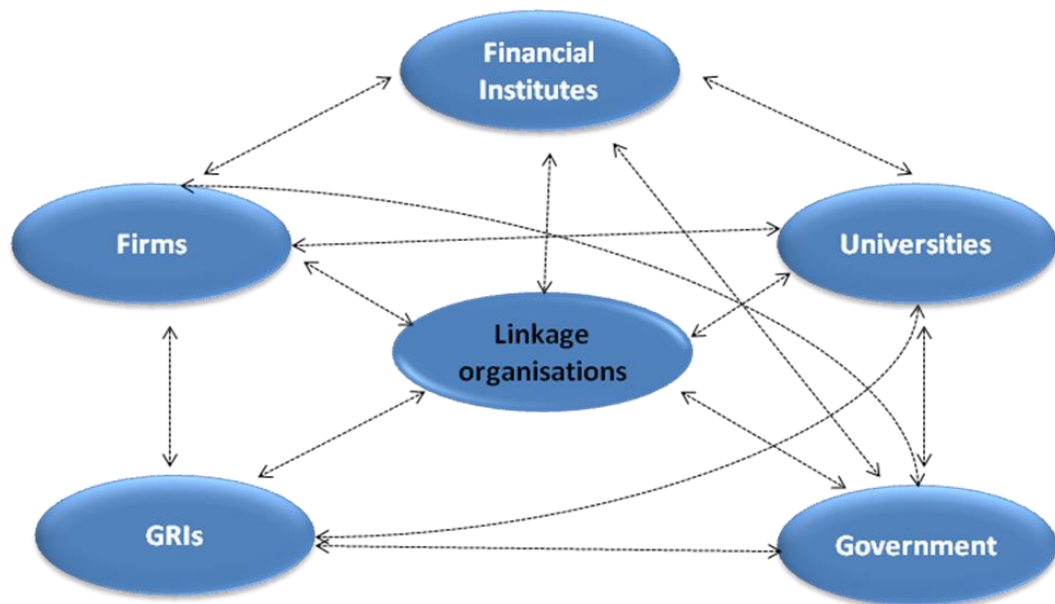


Figure 5-2 Major actors and interactions in the KNIS.

Source: K.-R. Lee and Song (1998, p60).

Whereas GRIs mostly carry out R&D and link knowledge in the KNIS to some extent, so-called linkage organisations (i.e. public intermediaries) exist independently as one of the key players generating and connecting knowledge in the system. They can be GRIs or public organisations but roles of linkage organisations are different from GRIs whose main role is the R&D activity itself (H-D. Cho et al., 2011; K-R. Lee and Song, 1998; Wong, 2004). Linkage organisations include KISTI, Korea Institute for Advancement of Technology, Technoparks, SMBA, Korea Technology Finance Corporation and National IT Promotion Agency, each entitled to bridge knowledge barriers and facilitate networking in the KNIS (K-R. Lee, Choi and Park, 2004). Among them, KISTI has played a national focal role as the S&T information centre since its establishment. These organisations can be called public intermediaries in the sense that they do not pursue profits for their services and create socioeconomic benefits over time as defined in Chapter 3.

Although other types of intermediaries exist, public intermediaries can be considered important actors in the Korean context, spending the largest part of government funding (Chung, 2002; K-R. Lee, Choi and Park, 2004) and delivering government policies to industries (i.e. large corporations and SMEs) for several decades. Often their organisational purpose is to enable innovation of SMEs by linking all the actors

and resources in the system based on their impartial position. From this point, the relationship with public-sector innovation intermediaries seems to be beneficial for SMEs to consciously seek heterogeneous and diverse sources of learning with long-term or short-term links to compensate infrastructure and to develop capabilities (see Sections 2.4.1 and 3.4.1.). Y. B. Kim (2005) highlighted the role of public intermediaries in supporting SMEs by removing the barriers during the exploration process of new businesses. K-R. Lee, Choi and Park (2004) also claimed that public intermediaries should act as knowledge brokers in the KNIS, providing necessary knowledge to SMEs, universities and researchers, interacting with CEOs to articulate demands and renew their knowledge during the innovation process.

Yet, the interaction process between the public intermediaries and SMEs has not been fully examined in spite of the perceived importance of fostering innovative SMEs. The loose KNIS framework seems too broad to examine the interaction and knowledge flow among heterogeneous actors. For example, the KNIS rarely consider (integrate) the innovative SMEs to be differentiated actors (SME policy) and consequently, it is difficult to explain why SMEs still remain weak actors though the Korean government has accumulated successful experiences in fostering industries and has been trying to impart the experiences to SMEs for several decades.

5.3 The Role of SME Policy and its Direction of Development

5.3.1 SME Policy: Trends and Limitations

As described in previous section, the KNIS has been confronted by a problem of ‘strong large firms and weak small firms’. Because the polarisation between *chaebols* and laggard SMEs made it difficult to chart the direction of the KNIS in the 1970s and 1980s (Lim, 2008), the government has been trying to solve the chronic problem. Until the late 1990s, the government directed policy at increasing the number of SMEs, facilitating cooperation among actors in the KNIS and increasing R&D funding. In the late 1990s, policy shifted to diversify programmes and foster ‘technology-based small firms’ to invigorate the economy by encouraging small-venture businesses. The effort included identifying venture businesses that should receive incentives such as financial benefits and R&D funding from the government.

At the same time, several policy tools aimed to resolve the polarisation by strengthening the capability of SMEs.

In 1998, the Presidential Commission on Small and Medium Enterprise (PCSME) was established to integrate and manage all programmes provided by ministries, the SMBA and the Korean Intellectual Property Office. The PCSME, directly responsible to the President, was in charge of drawing up SME policies and programmes, monitoring and assessing the performance of activities until 2008. In this period, PCSME created several action plans: they launched public intermediaries (e.g. the Korea Technology Transfer Centre); and the government legislated the Technology Transfer Promotion Law to foster private intermediaries to facilitate technology transfer activities (Lim, 2008).

In 2002, the SMBA designed the new-knowledge-support programme for SMEs as an attempt to expand support programmes from direct investment to indirect support. Since that time, the KISTI, in cooperation with other public and private intermediaries, has been carrying out and delivering knowledge service to thousands of SMEs. According to the PCSME, the number of experts from public intermediaries who support SMEs reached 38,369 in the mid 2000s (SMBA, 2013) and as a result, SMEs could receive various supports: funding, technical support, marketing, informatisation, linking external expertise, cooperation among firms, etc. As knowledge generation centres contributed to providing various services and developing advanced technologies through collaborative research, public intermediaries have effectively delivered government policies and programmes in support of SMEs in Korea (see Table 5-3).

Between 2008 and 2013, the government announced the ‘Science and Technology Basic Plan’, which had four objectives: achieving efficiency of national R&D investment; supporting technology innovation of SMEs; enhancing regional technology capabilities; and strengthening the science and technology infrastructure. Recently, President Park Geun-hye’s administration has announced strengthening SME policy by export financing, offering incentives to recruit a skilled labour force, and increasing R&D investment to 18% in 2017 from 12.4% in 2012 (MarketLine, 2013).

As shown in Table 5-3, various SME policies have been designed and applied to resolve problems relating to the KNIS such as insufficient cooperation among firms and a ‘weak level of competitiveness’ of SMEs for several decades. Using a qualitative approach, the policies provided indirect support through the new-technology feasibility study for start-ups, consultations diagnosis services (Im, Chung and Yang, 2005). The policy further strengthened bridging mechanisms, innovation facilitators, who could recognise and provide necessary resources required at every stage of innovation of SMEs. The recent policy report (S. Kim, Lee and Kang, 2012) asserts that the government needs to support the activities of GRIs as important mechanisms, recognising them as the backbone of the KNIS.

Table 5-3 The Trend of SME Support Policy

Period	Keywords	The development of S&T policy in Korea
1980s	Protection	Enhancing internal resources (i.e. R&D funding)
1990s	Enhancement of the SME structure	Enlargement of R&D funding and venture capital; Enhancement of cooperation among industry, academia and research institutions
Early 2000	Fostering venture businesses	Enhancement of technology transfer and commercialisation; Fostering innovative SMEs; Facilitating cooperation among industry, academia and research institutions
Late 2000s	Upgrading efficiency of SME policies	Supporting SME-led technology innovation; Fostering innovative SMEs and their innovative capabilities; Strengthening linkage among supporting programmes; Differentiation of supporting programmes
Early 2010s	Facilitating Start ups	Strengthening support functions of SMEs and establishing the role of GRIs as linkages between the policy and SMEs; Increasing R&D funding; Fostering SMEs as major actors for a ‘creative economy’

Source: Adapted from B. H. Lee and Chang (2005).

The Ministry of Science, ICT and Future Planning proposed the ‘Building Plan for Eco Systems for Government Research Institutes’ in 2013 to strengthen the SME support functions of GRIs. The plan included establishing an integrated SME support system of 25 GRIs and reinforcing their mission to support SMEs. To do so, the current government plans to invest more of the budget in GRIs; and GRIs plan to enhance support functions by restructuring organisations (i.e. Technology Licensing Offices [TLO]) and recruiting more experts. The president has emphasised the role of GRIs as innovation facilitators that support SMEs from R&D to the commercialisation stage.

In spite of sustained effort to strengthen SME capabilities, criticism arose of the policy and programmes implemented for SMEs. For example, a number of business incubators were established to support new venture businesses in the early 2000s, similar to the number in advanced countries, but their services did not seem to meet with the demand of SMEs due to the lack of experts and expertise that could satisfy the needs of new ventures (J. Kim and Lee, 2005). The recent restructuring plan to support SMEs seems to focus on R&D investment and strengthening TLOs in GRIs, which means policymakers still tend to depend on linear models of innovation where R&D input or technology transfer may result in economic outcomes (HelloDD, 2013; MarketLine, 2013; Song, 2012).

Furthermore, programmes did not seem to align with the needs of SMEs whereas the different industry characteristics, growth stages of firms and their capabilities, are considered important factors in programme design (D. Cho, 2005; Im, Chung and Yang, 2005; Y. B Kim, 2005; B. H. Lee and Chang, 2005). Scholars seem to consent to the need of indirect programmes such as enhancing infrastructure of SMEs and building the ecosystem for innovation (Hong, 2008; J-S. Kim, 2007; Y. B. Kim, 2005; B. H. Lee and Chang, 2005), but the discourse has remained at a theoretical level without detailed action plans. Rather, policies and programmes have a tendency to increase a number of programmes and deliver standardised programmes that may ignore the needs of technology-based SMEs whose demands may be different from SMEs in the 1980s and 1990s. The emergence of influential SMEs and their characteristics are discussed in the following section, 5.3.2.

5.3.2 Innovative SMEs: Who Are They and What Do They Do?

SMEs in South Korea account for 99% of all enterprises, 98% of all employment, and 50% of manufacturing output. However, most SMEs are financially vulnerable due to their dependence on bank and government loans, a cause for serious concern in the medium and long term (MarketLine, 2013). Private venture capitalists in Korea account for a marginal proportion of funding in high-risk areas, worsening financial structures, and undermining entrepreneurship. This phenomenon might lead policies to focus on constantly increasing R&D funding.

As to the internal capabilities of SMEs, they have had little chance to build a knowledge infrastructure through relationships. Section 5.2.1 described the evolution process of S&T policy between the 1960s and late 2000s, which characterised the current feature of the KNIS affecting the low level of interaction patterns among domestic firms; foreign external knowledge replaced domestic knowledge because large corporations heavily relied on foreign technology sources, resulting in a lack of interaction among domestic actors (Suh, 2004), and a lack of opportunities to accumulate knowledge resources through interaction.

This lack of interaction and cooperation limited the access of SMEs to global markets as they encounter a number of difficulties compared to larger corporations, such as the inability to explore new-knowledge sources, the level of skilled workers, and financial resources. However, high technology-based SMEs (so-called 'innovative SMEs') started to emerge in the late 1990s, as the government constantly attempted to move businesses towards higher value and technology-intensive products (Section 5.3.1). It seems that government policy⁵⁸ has had a major impact on the quantitative increase of innovative SMEs (Figure 5-3). Hemmert (2007) contended that these globally competitive independent venture firms that did not exist before would gain further importance in the KNIS.

⁵⁸ Spin-off companies from large corporations between 1997 and 2001 reached 442 (Suh, 2002) in addition to start-ups and spin-offs from GRIs and universities. In the same period, professors and researchers left their organisations to establish venture businesses as a result of policy initiatives aimed at stimulating new firms (Lim, 2008). The initiatives included tax incentives, providing facilities and services, relaxation of the requisites for establishing firms, and granting temporary leave.

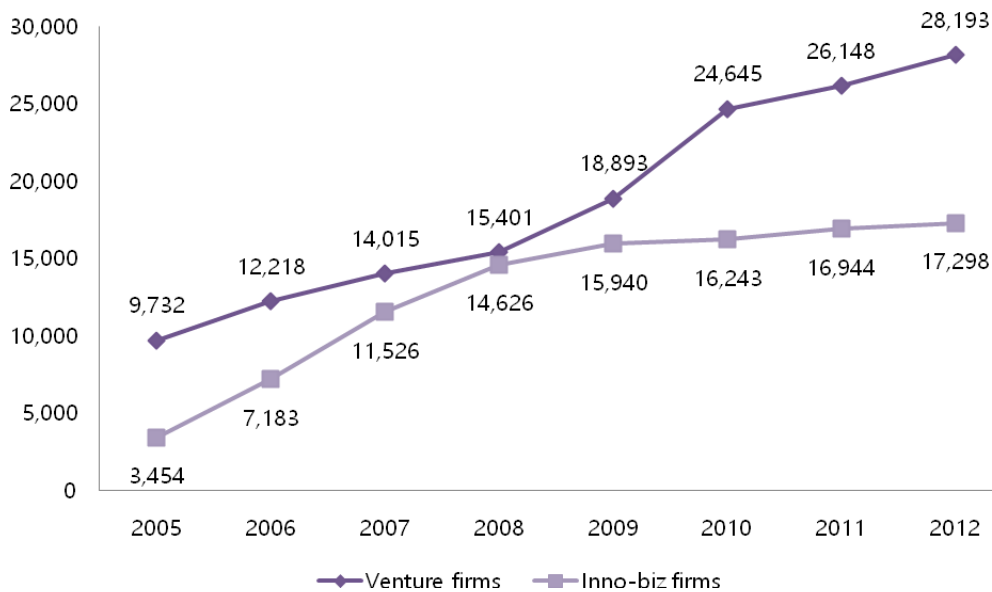


Figure 5-3 The increasing number of innovative SMEs.

Source: Adapted from SMBA (2013).

Innovative SMEs are influential actors, especially in emerging industries, providing solutions to the problem of weak competitiveness in some sectors. They have technological capabilities in specific areas and often have relationships with large corporations in the innovation process (Suh, 2004). Several authors (Choi et al., 2011; Hong, 2008; Min, Kim and Kim, 2005) consider them to be trailblazers, contributing not only to employment but also to a nation's competitiveness in technological frontiers. These SMEs have several features: 1) they are highly R&D intensive and growing fast, 2) they are doing businesses in high-risk areas, pursuing innovative and unique products, and 3) the CEOs are highly qualified.

CEOs especially seem to have specialised technical knowledge and relatively good relationships with GRIs, universities and large corporations (Y. B. Kim, 2005) because many of them have had research experience in those organisations before they established their own firms. These founders have a high level of loyalty and commitment, referenced as 'strong patriotism', which often shows as a very distinctive institutional reality. They have often chosen to receive only small-scale international venture-capital investment despite accepting several offers, due to their fear of diminishing the firm's Korean identity under the dominance of foreign investors (Dodgson, 2009). Some SMEs appear to play a very dominant role in achieving technological leadership in their fields (Hemmert, 2007) or building

business relationships with large corporations as their suppliers. This challenges them to maintain a competitive advantage in the global market.

In this regard, K-R. Lee, Choi and Park (2004) explain that large corporations in Korea are searching for globally competitive suppliers to substitute for domestic suppliers. This search puts increasing pressure on SMEs because domestic SMEs have to compete with foreign suppliers to maintain their position. To avoid competition with domestic SMEs and foreign suppliers (D. Cho, 2012), innovative SMEs try to explore global business opportunities. D. Cho (2012) expects that the competition among SMEs will decrease by 13% while competition with large corporations and global firms will increase by 14.5% in five years (Figure 5-4).

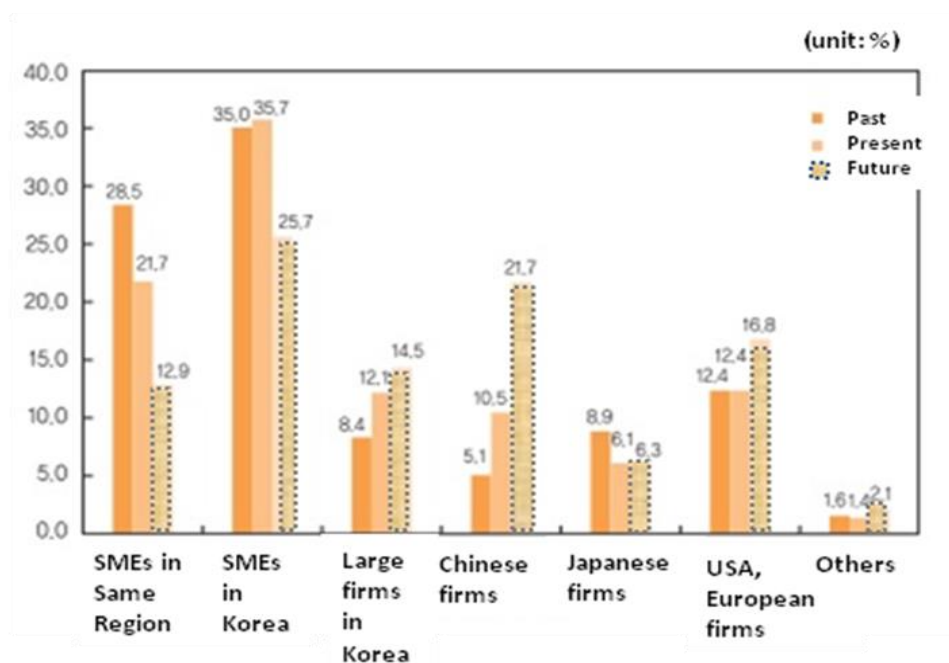


Figure 5-4 Competitors of SMEs in S. Korea.

Source: D. Cho (2012, p46).

This change contrasts with the view that relationships with chaebols have been considered to have much more satisfactory outcomes than independent growth in a Korean business context. However, the lack of capability to access knowledge sources and potential partners is a barrier to exploring global business opportunities (D. Cho, 2005). Policies that tend to focus on improvement of relationships between large corporations and SMEs is another problem that may not completely solve the

knowledge barriers of innovative SMEs. In this regards, D. Cho (2012) suggests that policies need to be diversified into not only fostering the capability of SMEs to deal with large corporations, but also enhancing the global competitiveness of SMEs as independent actors.

In summary, innovative SMEs are doing business in uncertain and risky areas, developing globally competitive products, which leads to building new-knowledge infrastructures that no longer have a homogenous group of buyers. It is important for innovative SMEs to integrate and reconfigure internal and external organisational skills, resources and functional competencies towards a rapidly changing environment in a short space of time. However, as indicated above (D. Cho, 2012), the competition among innovative SMEs is intensifying; put simply, the more innovative SMEs are in certain emerging fields, the less knowledge there is available.

Particularly at the early stage, identifying the appropriate technological and non-technological knowledge is difficult because the market has not been created yet and little information is available. Similarly, innovative SMEs do not know who their new buyers or competitors will be, and therefore do not know what their specific demands and wishes will be in a new business area. Even in a leading SME, knowledge does not flow from leader to follower as a result of increasing competition and speed of innovation, causing system failures (e.g. failures in infrastructure, interaction, networking etc.) that many SMEs face in the innovation process. Therefore, SME policy should be directed towards addressing various barriers, diverging from the myopic policy that protects SMEs against competition with large corporations in business relationships or increases only their R&D capabilities. In this context, Y. B. Kim (2005) further emphasises the importance of programmes for ‘knowledge supply and interaction facilitation’ to enhance learning and innovative capabilities in new business areas, for example providing management consulting and technology and market information, as well as promoting interactions among CEOs, GRIs and universities.

5.3.3 Misaligned Perspectives Between the Policy and Innovative SMEs

Section 5.2 indicated some gaps in the KNIS: a mismatch between input and R&D performance, a low level of cooperation among firms, and weak SMEs. In particular, the chronic problem of weak SMEs has been emphasised as a major policy issue to be resolved. Unlike the government's successful experience in fostering large corporations, SME support policies neither link to creating enough economic outcomes nor to enhancing innovative capabilities of SMEs. Lim (2008) argues that no successful cases result from cooperative R&D between GRIs and SMEs, and the 'low level of competitiveness' of SMEs limits the knowledge interaction necessary for innovation.

Notwithstanding the increasing attention to innovative SMEs as explained in Section 5.3.1, the SME policy does not seem to be effectively incorporated into the KNIS framework though the situation has been gradually improving (e.g. an increasing number of innovative SMEs and increasing opportunities for collaborative R&D). The government still tends to strengthen the role of GRIs as suppliers of services that focus on R&D and technology commercialisation stages indicated in Section 5.3.1 overlooking the interactive approach and the dynamic nature of innovative SMEs. Dodgson (2007, 2009) indicates that support programmes provided by public intermediaries do not seem to focus on linkages or joint creation of new knowledge but in dissemination of existing knowledge. Therefore, it is possible to conjecture that the programmes delivered to SMEs are not likely to match the needs of innovative SMEs. Two policy directions could describe the mismatches.

The first is the greater emphasis on R&D funding as the direct input that brings economic outcomes. It is assumed that direct investment in R&D contributes to enhancing technological capabilities to some extent, but not enough to increase capabilities of SMEs to adapt themselves to the competitive business environment. Section 5.3.2 describes the barriers of innovative SMEs (i.e. the lack of capability to access knowledge sources), which are more than lack of R&D capabilities. Compared to SMEs in general, innovative SMEs are technologically capable but still lack capabilities to address barriers such as knowledge and relationships necessary in

exploring new business areas. This lack implies a need for mechanisms to overcome the various barriers that SMEs face during the innovation process, in addition to supporting R&D and commercialisation activities. Although indirect support programmes have been designed and delivered to innovative SMEs, the programmes tend to be concentrated in the commercialisation stages that does not match the diverse needs of innovative SMEs. Furthermore, the programmes have tendency to deliver generic solutions (i.e. technology development, marketing, and equipment investment), targeting SMEs in general without considering the heterogeneous nature of innovative SMEs. Sometimes, programmes have similar content under different service schemes provided by different intermediaries.

Second is the policy focus on science and technology, which ignores the ‘economic and social aspects’ entailed in the innovation process (Lim, 2008).⁵⁹ Although innovation policy has tried to incorporate socioeconomic dimensions in the mid 2000s, adopting Technology Foresight activities and replacing the linear model of innovation (Section 5.2.1), the policy is still skewed to the STI approach (or a narrower approach) as opposed to the DUI approach. For example, the level of network is measured based on the number of joint patents, number of patents per researcher, R&D investment as a percentage of sales, and expenditure of the government and universities. Performance relating to knowledge generation is measured by number of patents, number of papers, number of patents to R&D expenditures, etc. The measurement does not reflect the complex and dynamic nature of the innovation process and as a consequence, various barriers emerging in the innovation process are difficult to identify. Lim (2008) argues that the strong focus on STI approach is why R&D input, incubation activities, competence building and other economic subsystems have not worked together to encourage innovation activities in the KNIS.

Policies and programmes driven by the supply-side view of innovation seem to have limits in capturing the complex innovation process and the heterogeneous

⁵⁹ Lim (2008) further argues that Korean S&T policy has been driven by the perspectives of the science and engineering fields. The KNIS still lack wider-DUI approaches in spite of the governmental effort in the mid 2000s, incorporating socioeconomic factors into innovation policy.

characteristics of innovative SMEs. In this vein, Chung (2002) and Lim (2008) contend that the interactive approach is vital to resolving the sophisticated problems of the KNIS, which become increasingly complex in the number of actors involved in innovation, interaction among them, and social settings. The KNIS at the macro-level does not specify specific actors, limitations and challenges in the innovation process and therefore, how public intermediaries facilitate the innovation process of SMEs and decrease the barriers still remain unrevealed. In this vein, modulating the KNIS at an appropriate level to examine the specific actors, their relationships and linkages can be a contingent condition for implementing an interactive model, and doing so may lead to explicate the detailed dynamic properties of the modulated system.

5.4 Conclusion

This chapter analysed the evolution process of the KNIS and its current perspectives, with emphasis on public intermediaries and SMEs. In particular, this chapter addresses the first research question: why public intermediaries interact with SMEs. Whereas this chapter focuses on a historical perspective on the role of government and mechanisms in fostering industries, Chapter 7 further provides in-depth analysis on why SMEs look for public intermediaries in their innovation process and how relationships evolve through the facilitation process.

The KNIS has had its beliefs about how to foster specific industries and large corporations for several decades, which might be different from the needs in current times. In spite of unsurpassed economic growth, the KNIS has faced several weaknesses in innovation policy, low levels of cooperation among firms, and weak SMEs, that have not been resolved. For example, innovative SMEs have been growing since 2000 but their linkages are relatively weak (Hemmert, 2007). For the last decade, the KNIS has grown in size and sophistication, having the scope to analyse and resolve barriers that are becoming more complex and difficult. Yet, policy is likely to focus on simple input and output factors, based on the narrowly defined NIS which seems to overlook the interactions between actors and institutions.

Lacking in interactive approaches, the loose NIS framework does not specify specific actors and the knowledge interaction between them—SMEs and public intermediaries, the linkage organisation—in the KNIS. The scope of the KNIS may need to be modified to address the research question. Innovative SMEs pursue developing innovative products or technologies in high-risk areas. Consequently the problems that hinder innovation may be different from firm to firm. However, the broad framework does not indicate how to disentangle complex innovation processes and heterogeneous demands of innovative SMEs. This can be the reason that mismatches between programmes delivered and outcomes (e.g. weak SMEs) have been solved yet, in spite of the effort, developing various programmes. In the same vein, what types of barriers emerge and how public intermediaries as bridging organisations can correct the failures by facilitating interactions have not been demonstrated in the KNIS context.

The ‘dynamic interplay’ between actors and institutions, in describing why some actors are becoming strong and some actors are not, needs to be examined based on an interactive approach, to remove the barriers and thereby facilitate innovation (K-R. Lee, Choi and Park, 2004; Lim, 2008). To do so, analysis must encompass what is happening in the innovation process of SMEs and how public intermediaries address the heterogeneous demands of SMEs and barriers to innovation. The following chapter will present five case studies explicating the dynamic nature of interaction process between public intermediaries and SMEs. Each case will demonstrate the complex knowledge-interaction process based on the conceptual framework (Chapter 4). The chapter will provide how public intermediaries perform four functions to decrease the barriers that each SME faces based on the interactive approach and identify some micro factors that the loose NIS concept is unable to explain.

6 Chapter 6. Cases: The Knowledge Interaction Process Between Public Intermediaries and SMEs

6.1 Introduction

Chapter 5 described country-specific innovation policies, characteristics of the KNIS, and the role of public intermediaries in facilitating innovation in Korea. I pointed out that weak linkages among firms and low levels of competitiveness of SMEs have been a problem for the KNIS, and highlighted the role of public intermediaries, often described as linkage organisations, that resolve problems relating to the KNIS. The previous chapter also indicated the shortcomings of the macro-level approach. The KNIS is becoming sophisticated, having the scope to analyse and resolve barriers that are becoming increasingly complex and difficult. Yet, policies (or programmes) are likely to be implemented in a linear way, based on a loose framework, underestimating the interactive approach (Section 5.3.3). This may lead to a mismatch between the demands of SMEs and programmes provided by public intermediaries.

In this chapter, I explore the knowledge interaction between public intermediaries and SMEs, based on the four functions provided by the conceptual framework: knowledge enabling, facilitating relations, learning, and managing the interface. I use these intermediary functions to discuss the main research problems of this study; a macro-level approach to the NIS overlooking the knowledge-interaction process between intermediaries and SMEs, microsociological factors embedded in the process, and different patterns of relationships. I use the conceptual framework constructed by characterising the functions of public intermediaries for interviews and analysis.

The sections in this chapter examine the results of interviews about whether public intermediaries play a crucial role in facilitation innovation of SMEs and, if so, how the knowledge interaction occurs at meso- and micro-levels between public intermediaries and SMEs, thereby decreasing the barriers to innovation. Section 6.2 presents five cases of innovative SMEs, each illustrating the history of the firm, knowledge enabling, facilitation of relationships, and changes of knowledge

infrastructure as a result of interactive learning. Managing the interface with intermediaries is a means of maintaining constant interaction, which facilitates interactive learning as an ongoing process.

In this vein, intermediary functions can be understood as a *facilitating process* rather than providing services at a specific point in time. Similarly, the four functions are carried out without clear boundaries rather than provided in order. Each case contains analysis: describing the differences among cases, why each case has different evolving patterns of relationships, and specific factors that contribute to the innovation process. Section 6.3 summarises initial findings about why these factors are important and how they affect the innovation process at the level of firms, individuals, and the interaction process. Then, I compare the different patterns of relationships and analyse two different fields of technologies—mechatronics and IT—although it was slightly problematic to classify them into only two groups, due to the multidisciplinary characteristics of their products and technologies.

The results from this chapter will be complemented by Chapter 7, which presents the remainder of the empirical findings with a focus on the rationale of engaging public intermediaries in innovation of SMEs and the underlying policies that propose public intermediaries as effective mechanisms to facilitate innovation in the KNIS.

6.2 Case Studies

6.2.1 Case 1: Firm K

Firm K is a manufacturer of semiconductor thickness analysis and measurement equipment (Table 6-1), and has been interacting with KISTI since 2008. It received knowledge services and follow-up services provided by KISTI, sponsored by the Innovation Foundation. The interaction was successful in enabling knowledge of medical-diagnosis equipment and facilitating relations with potential buyers for Firm K.

Table 6-1 Description of Business

<p>The firm has been developing and supplying the unique and advanced analytical solutions for semiconductor, flat panel displays, electronic materials, life sciences, and chemical analysis.</p> <p>Major products are as follows</p> <ul style="list-style-type: none">- Thin film thickness analysis and measurement system: analysing and measuring the thickness of flat panel displays- Bio//medical diagnosis system: Immune diagnostics, molecular diagnostics, point of care testing and surface plasmon resonance (SPR)-based biosensors
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Source: Adapted from the homepage of Firm K.

6.2.1.1 History of the Firm

Firm K was founded in 1996 by a former senior researcher at the Analysis Laboratory of ETRI in South Korea. Firm K supplied the spectroscopic equipment the CEO had designed and built using the technological expertise acquired at ETRI. The corporation's key buyers were university and government laboratories that used the equipment for their own research activities. These buyers did not prove to be a lucrative source of revenue because they tended to be small in size and operation. Limited revenue was viewed as a stumbling block to the steady and potential growth of the corporation.

The CEO began exploring other business opportunities to overcome this financial challenge. Meanwhile, a friend of the CEO, who worked as a professor, became interested in the liquid crystal display (LCD) industry in Korea. An opportunity finally arose for Firm K that would turn out to be a major stepping stone for the corporation. It was at an exhibition at which the corporation received a sales order from LG Electronics (LG) for one piece of industrial-sized thickness analysis and measurement equipment (TAME) required for the 'four-mask process', one of the stages in LCD production that analyses the layers and measures the thickness of LCDs.

In 2004, LG ordered Firm K to manufacture 14 pieces of TAME. Working for LG was indeed a blessing to the corporation. While striving for the highest possible standards of equipment to satisfy the demands of the global giant, Firm K was able to enhance its technical expertise and achieve technological advances. Firm K became the world's first developer and manufacturer of TAME for the four-mask process of

LCD production. LG became the world's first developer and manufacturer of the four-mask process. Beginning 2006, Firm K also started to supply TAME to Samsung Electronics, Co., Ltd. (Samsung). The firm's annual revenue skyrocketed to U\$14 million in 2004—the corporation had generated annual revenues of approximately U\$2 million dollars until 2003—followed by U\$10 million in 2005, and then to U\$10.5 million in 2006. Firm K had the most profitable year in 2008 with an annual revenue of U\$20 million, bouncing back from U\$8.6 million it generated in 2007.

However, Firm K's growth was accompanied by three major challenges: the firm's uncertain financial future, irregular human-capital management practices, and lack of diverse products. It was no coincidence that the CEO's desire for new business opportunities increased, weighing the challenges the firm was facing and the potential for growth the corporation might have in the long run. After trailblazing for more than a decade in this chosen line of business for the LCD industry, the CEO decided that the industry in Korea was already past its prime, as the firm had built a proven track record in the industry. The CEO decided to venture into something new, encouraged by personal assets and those the corporation had accumulated (technological expertise and advances). In the field of medical-diagnosis equipment the firm possessed the necessary technological infrastructure.

As interest in other industries grew stronger, the CEO explored new business opportunities. A new set of barriers surfaced: (a) differences in opinion and attitude between the CEO and the employees at Firm K towards new ventures, (b) differences between the technology Firm K used for the LCD industry and what it would need for other industries, (c) differences in knowledge of the LCD industry possessed by employees at the firm and what they would need to obtain for the biotechnology industry, and (d) the disconnection between Firm K and the potential players in the biotechnology industry.

The abovementioned challenges caused a gap to form between the realities of the situation at Firm K and the necessary conditions for K's success in other industries (the CEO inclined toward the biotechnology industry but was keeping options open). Essential to increase the chances of K's success was to reduce the gap significantly,

or better, completely removed it. With this ultimate goal in mind, the CEO started seeking professional intermediaries for their expertise.

6.2.1.2 Knowledge Interaction Process

6.2.1.2.1 Engagement of Public Intermediaries

The CEO contacted public intermediaries, the IF, and the KISTI.

- The Innopolis Foundation (IF): The Innovation Sponsor

IF is a not-for-profit organization administered by the Korean Ministry of Knowledge Economy. The foundation provides programmes ranging from R&D funding to commercialisation to help SMEs enhance their innovative capabilities. Since the IF was established in 2005 in Daedeok Science Town, where more than 1,400 research and educational institutions and firms reside, the organisation has played a key role in fostering the world's-best clusters by linking all resources built in the region and other regions in Korea (Innopolis Foundation, 2014). The IF has a wide network that includes GRIs, universities, SMEs, and private consultancies as a part of linkage support to build the cluster. For example, KISTI designed one consultation programme that IF sponsored and coordinated to deliver customized consulting services to SMEs seeking new ventures to maximize their success.

- The Korea Institute of Science and Technology Information: The Innovation Facilitator

KISTI is a not-for-profit research institute administered by the Korean Ministry of Science and Technology. KISTI is considered to be the national hub of science and technology information. One institute mandate is to strengthen the competitiveness of SMEs by providing support: operating a nationwide S&T data bank, operating the SME supporting centre, publishing industry reports, providing one-on-one customised consulting services, carrying out technology-feasibility studies, and managing the national supercomputing centre.

Along with a more than 10 years of history supporting SMEs, the institute has approximately 10,000+ members of the Association of Science and Technology

Information using its services. The institute has highly qualified experts in all science and engineering disciplines, and patents, databases, industry reports, methodologies, and a global network. The qualities KISTI boasts convinced the CEO to conclude that the institute had the reputation and credibility to help strengthen the argument to pursue new ventures.

6.2.1.2.2 Knowledge Enabling

KISTI and Firm K immediately organised a task-force team (TFT) for effective communication. A project manager in the IF participated as an observer to monitor the process and give support, if required. From KISTI, four qualified researchers actively participated in interactions with the CEO, CTO, top-management team, and one of the managers. Firm K considered two factors in exploring the new business area: the first was the possibility of using the technological infrastructure the firm had built in the LCD area; the second lay in determining whether the new business area was relevant to societal, political, environmental, and technological trends.

Players intensively interacted at all levels between Firm K and KISTI to articulate demand and gain a sound understanding of the firm's capabilities. This was the early stage of innovation, and little information was available on market and technology trends, competitors, or policy direction. Interaction was important for two reasons. First, it was essential for researchers from GRIs to interact with potential customers, scientists, and policymakers. These initial stages tended to be lengthy and required more resources than subsequent stages because knowledge at this stage was malleable and ambiguous, and innovation players needed time to achieve something concrete and transparent. Only organizations equipped with the right set of resources, including intellectual materials and competent players, can come through these demanding stages successfully. Second, interaction among employees is vital to facilitate knowledge absorption as well as individual learning.

Frequently, TFT members at Firm K had different points of view, resulting in KISTI researchers getting involved in facilitating knowledge interaction among employees. This interaction helped decrease the knowledge gap among employees. Interviewee H indicated the firm needed face-to-face interaction to gain insights and

interpretations of individual analysts, as Firm K had difficulty accessing and enabling the new knowledge. Interaction provided a learning opportunity for employees at the firm where the ‘original recipe of knowledge’ could be translated into a specific context through several stages of the consultation process. In particular, one researcher at KISTI and a manager at Firm K played a crucial role in delivering active feedback back and forth between the two organisations.

Four individual researchers made the best use of in-house materials and their relationships in GRIs and industries to create high-quality knowledge. Individual researchers who had varied expertise and experience in the fields of chemistry, management, and machinery interacted with each other and with other GRIs and industry experts to create new knowledge. The combination of competent knowledge and experiences specific to individuals (i.e. a productive combination of competing rationalities) inside and outside KISTI resulted in delivering credible knowledge at the early stages of innovation. When the KISTI TFT gave their first presentation, Firm K was satisfied it would facilitate the knowledge flow between KISTI and Firm K more effectively.

The quality of knowledge contributed to building trusting relationships among individuals in both organisations. Interviewee H, explained, ‘Trust was built from the moment of that presentation, and the responsible individual researchers helped us to maintain trust-based relationships.’ Interviewee C, a researcher at KISTI, said, ‘This was due to their capabilities in absorbing the knowledge. During the consultation process, the CEO and other employees gave valuable feedback which was a real challenge in enabling the knowledge.’ Because codified knowledge was unavailable, interaction with innovation players actively occurred throughout the knowledge-enabling process.

In sum, KISTI configured knowledge on technical and nontechnical aspects of the new business area, and enabled knowledge in a specific context for the firm. Firm K functioned effectively, adhering to the knowledge, ideas, and concepts that remained almost unchanged since its establishment. Employees at the firm were well versed in the nontechnical aspects of the LCD industry such as societal, political, cultural, and environmental trends. Although the firm was locked into the knowledge

infrastructure that had evolved solely in the industry, the firm was able to build new knowledge infrastructure through knowledge enabling by obtaining technology and market knowledge and identifying potential buyers in the new business area.

6.2.1.2.3 Facilitating Relations

Identifying potential buyers in the new business area and linking them to the innovative space of the firm was a different matter. As a new innovator in a new field, Firm K was incapable of accessing potential buyers. The project manager at IF participated in the entire process, realizing the missing piece remained in spite of successful outcomes. Firm K needed to enter relationships with potential buyers to co-shape the innovative space at an early stage. Interviewee C explained:

It was impossible to identify and contact potential buyers in the bio industry such as Greencross Ltd and YD Diagnostics Co., in spite of our reputation in the LCD industry. The bio industry was totally different from the LCD industry, and we could not approach to the buyers without a credible mediator.

The Foundation sponsored a follow-up programme called ‘Technology Round Table’ (TRT). KISTI, as an innovation facilitator, organised TRT, providing Firm K with an opportunity to expand its relational capital. Scientists from GRIs attended the TRT, although it was not easy for KISTI to identify the right contacts among potential-buyer firms due to the closed environment of the biotechnology industry in Korea. One professor who worked at KISTI contacted several pharmaceutical firms and managed to identify potential buyers over time.

KISTI brought together GRIs, the professor, and potential buyers through the TRT, where all participants were able to share their views and R&D plans connected with medical-diagnosis equipment. Researchers at KISTI and the professor facilitated the interaction, maintaining impartiality, narrowing the gap among all participants in a short space of time. After the TRT, a favourable environment was shaped in which Firm K could interact directly with potential buyers such as Greencross Ltd and YD Diagnostics Co., without the need for a facilitator. As the firm began developing its relationships with domestic customers, IF brought in Frost & Sullivan, a global consultancy, to provide a one-off consultation service, preparing a future roadmap to

explore the overseas market. During the interaction process, KISTI, IF, and Firm K actively shared opinions regarding the progress, bottlenecks, and outcomes, which further contributed to linking all activities to Firm K's innovative process.

6.2.1.2.4 Facilitating Learning

KISTI facilitated learning on a wide level inside the firm, and between the firm and potential buyers throughout the knowledge-interaction process. Multiple levels of interaction with public intermediaries and potential buyers led the CEO and the top-management team to learn how to create and adapt new knowledge, align potential buyers, and apply the knowledge interaction process in a new setting.

Firm K achieved three objectives by building the new learning routine that changed the mindset of employees, leading to new patterns of coordinated action towards the new business. At first, the CEO could not afford to gamble K's future by making decisions alone, even though the CEO's insight and vision had, up to that point, been a driving force behind the firm's direction and development. Knowledge interaction could help minimize the risks associated with key decision making and, subsequently, contribute to learning and achieving the ultimate goal of the firm: the future success of the new venture. Internally, the CEO would be able to articulate the vision to employees, whereas externally, the firm would venture into a new business area by integrating new knowledge and approaching potential buyers.

First, a vast disconnection existed between Firm K and the potential innovation players of the new business area. The firm was unaware of its potential buyers and suppliers, competitors, policymakers, and regulatory bodies. The firm would have to establish contact with potential players to co-shape the innovation process at the early stage. At the end of interaction with intermediaries, the firm could enter relationships with potential buyers in the field of medical-diagnosis equipment and YD Diagnostics became a major customer. This success was possible because public intermediaries facilitated learning between the firm and potential buyers, providing them with motivation, explaining how both parties could benefit from the relationship.

Second, Firm K had been using virtually the same technology for 12 years for the LCD industry, a practice that had worked successfully for employees and the industry. As a result, employees at the firm did not feel the need for technological innovation and experiment. The firm needed to confirm whether its technological expertise and capabilities were transferable and applicable to the new business area. The strong knowledge interaction among various levels of employees provided coherence of routines between an old and new area of business; performing as an effective learning mechanism that coordinated old and new skills and knowledge, and led employees to share new perspectives.

Finally, employees at the firm did not receive well the CEO's decision to explore new business opportunities. They did not share the enthusiasm and vision. They showed implacable opposition to the decision and its potential consequences. The CEO commented on the situation:

No one at the firm was as determined as I was to create a better, more secure future. Once they had got themselves into their own routines, they wanted to maintain the status quo. It is human nature to favour stability. When I told them to do something new, most of them responded negatively, asking me why they had to do it.

The knowledge interaction facilitated interactive learning at all levels inside the firm that allowed the CEO to justify the logic behind the decision to pursue new ventures and helped persuade employees through mutual adaptation towards the innovation. It was a long process, taking several years to change the perceptions of all employees and restructure the knowledge infrastructure to fit with the new business area. The presence of public intermediaries as legitimate facilitators played a crucial role in addressing the barriers during the long and uncertain innovation process.

6.2.1.2.5 Managing Interfaces

At the end of the knowledge interaction with KISTI, the firm was able to use KISTI as an innovation facilitator. KISTI and IF managed interfaces with the firm such that the firm was able to access intermediaries when necessary through which it could receive additional information services and renew the knowledge to its own context. In particular, key individuals managed interfaces in both parties. It was the CEO who

dispatched a staff to KISTI for a year to transfer methodologies and processes that KISTI used during the interaction process for the firm. The staff was able to learn the knowledge-creation process and build social capital with researchers at KISTI and other GRIs. Since then, these key individuals have acted as mediators, linking Firm K and KISTI, and integrating external knowledge into the firm.

The firm constantly obtained the specialised knowledge essential to the innovation process for the new venture it was contemplating. In addition, both parties were able to build trusting relationships where active knowledge interaction resulted in some positive outcomes. The CEO was able to rationalise insights, and employees were convinced the consultations would bridge the gap between them and the CEO at the end of the year-long process. Then, Firm K would be able to invest in medical-diagnosis equipment for further R&D activities with confidence. Since then, KISTI has been providing long-term client support, including one-on-one follow-up services, monitoring industry trends, and providing S&T information (reports and databases) that helps the firm reconfigure knowledge. This would not have been possible without the IF, the innovation sponsor. By maintaining interfaces with public intermediaries, the firm was able to interact not only with IF and KISTI—the policymakers and facilitators—but also with potential buyers for its future business.

6.2.1.3 Case Analysis

This case illustrates knowledge interactions between public intermediaries and Firm K at the early stage of innovation, which brought changes to the firm (Table 6-2): obtaining necessary knowledge, establishing new organisational structure, and entering into new business relationships.

Table 6-2 Key Events and Major Changes in Firm K

Period	Key events	Changes
1996	Established the firm	Supplied spectroscopic equipment
2004	Developed the TAME	Expanded relationships with big buyers
2008–2009	Entered into knowledge interaction with KISTI to explore the new business area Obtained the necessary knowledge	Changed the organisational structure to apply the knowledge-interaction process to the firm and address the new business area
2009–2010	Follow-up programmes provided by the KISTI and IF	Entered into relationships with potential buyers in the new business area (medical-diagnostic equipment)
2011–2012	Continued interaction with multiple public intermediaries	Went public with an IPO (2011) Dispatched a staff to learn how to translate and adapt new knowledge, and maintain relationships with KISTI

Researchers from KISTI enabled the knowledge and had a strong level of interaction with Firm K to meet its needs. In the beginning, researchers believed the firm only needed specific knowledge in certain areas, but the result produced more outcomes than they expected, as the level of interaction intensified. As in other SME cases, this case highlights the barriers to innovation, in particular, knowledge flow between the SME and big buyers. Firm K had relationships with big buyers in their old and new business areas, but the relationships had limits in bridging the knowledge gap. First, Firm K had a good business relationship with Samsung and LG in the field of TAME but knowledge in the field of LCD was different from that surrounding medical-diagnosis equipment. Second, the firm and LGLS were engaged in joint R&D for medical-diagnostic equipment, which evolved into a supplier–buyer relationship.

However, unlike the LCD industry, the major buyer did not have a knowledge infrastructure in the emerging area, showing a tendency to share the risks with Firm K. A high level of uncertainty existed as to whether the supplier–buyer relationship could guarantee sufficient revenue, as it had done in the LCD industry. Although the big buyer was successful in exploring global markets, the market share may not have been big enough in an emerging area where multiple players tended to share the market. Therefore, transformation from TAME to medical-diagnosis equipment

required not only a new knowledge infrastructure for the new business area, but also relationships with multiple new buyers.

To overcome barriers, the CEO used informal relationships with experts in academia and industry, but these relationships only helped in sharing general trends and organisational concerns. When Firm K decided to explore the new business area, it faced difficulties in obtaining the required knowledge because the market had not been created yet and little information was available. It was necessary to work with potential innovation players to obtain uncodified knowledge, but it was difficult for the firm to identify them and enter a relationship. Even if the firm had been able to access and approach them, interpretation and configuration of knowledge can be difficult. Timeframes can be a problem because speed of innovation allowed the firm to enter the market in advance and enjoy first-mover advantage.

Most importantly, the knowledge behind the firm's ostensible demands was more than just technological and nontechnological. The CEO wanted to build an internal process and methodology through interaction with KISTI that would integrate new knowledge into the firm's resources. As a reflexive individual who experienced several failures in the past, the CEO believed this process would facilitate not only individual learning by having employees follow the process, but also organisational change when adapting to a new business area. How could the firm build the knowledge infrastructure and adapt to the new business area by resolving the barriers? Was the firm capable of building the new process? Was the strong vision of the owner enough to persuade employees to work towards the new goal? It was the constant interaction with the intermediary and the formal programme that enabled the firm to bridge the barriers and enter into new relationships with potential buyers. The CEO added,

I needed the voice of a third party to persuade my employees. If the knowledge came from a credible third party, then it would become easier to absorb that new knowledge without internal resistance. In addition, I believed only global consultancies or KISTI were able to produce the level of knowledge that I could be satisfied with.

The knowledge configured by KISTI gave the firm the confidence to make the decision to invest in medical-diagnostic equipment. Additionally, bridging the

relational barriers between Firm K and potential buyers opened business opportunities with multiple buyers (see Figure 6-1) that would contribute to improving the financial status of the firm. Furthermore, as the owner expected, long-term interaction with KISTI led to individual learning as well as organisational change (i.e. establishing new divisions, new relationships, new decision-making processes and new communication processes).

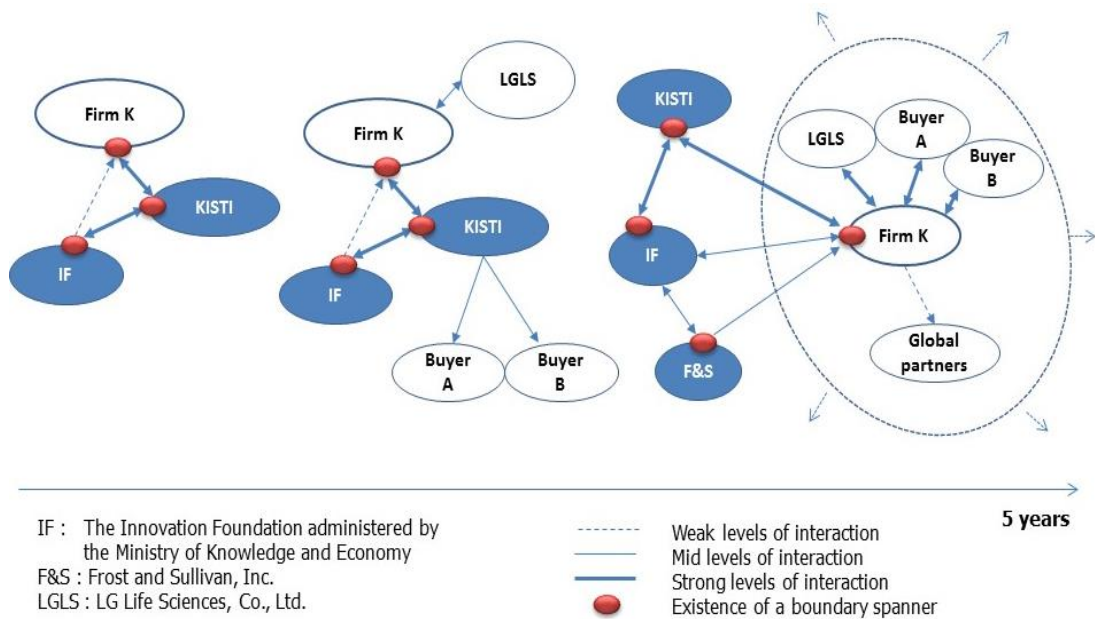


Figure 6-1 Firm K—Multiplicity of relationships and interactions.

To examine the aspects of this case that brought about such positive changes, some questions arise. What separates a successful case such as this from less successful cases? What are the crucial differences in each case? What is the key success factor?

The first major factor that differentiates this case from other cases is the firm's capabilities. First, it had built technological expertise and capabilities as a supplier of LG and Samsung, gaining better knowledge of the technical specifications required by fastidious big buyers. Second, the learning capabilities of individual employees had improved as the firm interacted with big buyers. In addition, the firm experienced organisational changes in early 2000 when it changed its target market from university laboratories to big buyers.

Being a supplier to big buyers in the LCD industry was different from working in the small test-equipment market, and the firm faced several challenges such as market fluctuation, technical failure, lack of skills, and managing human personnel. The experience enabled the firm to build specific routines and learning capabilities, resulting in greater possibilities to bring about change by rebuilding the knowledge infrastructure through knowledge interaction. Crucially, the CEO had a very strong vision from the outset that had a positive influence on the integration of new knowledge and learning, and adapting it to the new field of technology.

The CEO remarked on this new-found objective,

As I was emboldened by the competitiveness Firm K had demonstrated over the years, I became more confident about exploring other possibilities that would require the use of analysis and measurement equipment. I was also convinced of my ability to lead the corporation on yet another path to success because virtually all industries would need the equipment we specialized in. It was not too obvious then, but doing business with big buyers such as LG and Samsung helped us lay the foundation for investing in other industries at a later time.

I had always paid attention to the changes taking place in the world outside of business that influenced industry and commerce. Being mindful of those changes, I had been thinking constantly of the direction in which Firm K should be headed. To draw an analogy, if the Firm would be a boat, the changes were the sea, and I would be a shipbuilder. I was responsible and ready for constructing a vessel well equipped for travelling in a sea of change.

The routines the firm had adopted in the past could be successfully replicated for a new business area if the knowledge intermediary and ‘professional shipbuilder’ joined in the turbulent process of constructing a vessel. The CEO proactively used the intermediary as a partner to access necessary resources as well as facilitate learning inside the firm during the process of innovation. In this case, the consistent and strong levels of knowledge interaction over relatively long periods of time were an important factor in building a new routine. This affected patterns of relationships with the intermediary. Compared to other SMEs in the field of IT that needed technology transfer, joint R&D, or test sites, Firm K had very focused knowledge demands that resulted in strong levels of interaction with few intermediaries (Figure

6-1). The interaction evolved over time at meso- and micro-levels addressing the knowledge and relational barriers.

The second major difference is the technology-specific factor, which affected different levels of relationship and interaction. When Firm K made its decision to enter the biotechnology industry, technological capability was not the main difficulty. The same technology infrastructure was applied to manufacturing the medical-diagnosis test equipment, requiring a slight modification of equipment and measurement methods. However, the business environment of the biotechnology industry, where potential competitors and customers had not emerged yet, was different from that of the LCD industry. Interviewee H, the business strategy division manager at Firm K, expanded on the objectives:

We needed to examine the biotechnology industry in its entirety and investigate the societal, political, environmental, and cultural trends surrounding the new industry. We knew nothing about the existing or emerging markets for the industry, and were ignorant about prospective customers. However, we knew full well our business strategy had to be altered from one-on-one customization tailored to the LCD industry to the mass production required for the biotechnology industry.

The new business required a different set of players, expertise, and skills. What became crucial, especially in the early stages of the innovation process, was configuring the vague knowledge. It was also important to bring potential key players into the innovation process to co-shape early markets and gain a competitive advantage. However, this may have hindered participation by private intermediaries or potential buyers, as this stage is far removed from commercialisation. Therefore, it was essential to have long-term interaction with a public intermediary capable of configuring a high quality of knowledge and bringing in potential players.

Monitoring the changes in a sociotechnical setting was also important, because the level of market uncertainty was quite high. Along with the firm's capabilities, the technological characteristics affected the firm's pattern of relationships, which was shaped to centre around a few intermediaries with targeted buyers. Individuals in Firm K, KISTI, and IF played a crucial role in maintaining strong levels of interaction, sharing views and monitoring activities.

The crucial question is whether this knowledge interaction facilitated the innovation process, even though the CEO clearly asserted gaining a great deal from it, including a logical justification and validation for the vision. Answering this question requires a determination as to whether the knowledge interaction contributed to interactive learning and thus reduced the various knowledge barriers, thereby overcoming the obstacles to innovation. Several influential factors were behind this.

First was the level of individual and organisational capability in the intermediary, producing reliable knowledge throughout the process. The capability to enable a high quality of knowledge provided the basis for trust-building relationships in which both parties had a sense of fellowship that, as the consultation progressed, facilitated frequent interaction at all levels of employees. To do so, it was essential for both parties to have mutual interests and responsible correspondence. However, the level of trust depended on individual capabilities rather than the name of KISTI or IF, as relationships developed throughout the process.

Interestingly, researchers from KISTI and a project manager at IF were involved in the interaction process with the owners, top-management teams, CTO, managers, and researchers, facilitating knowledge interaction and learning among employees inside Firm K and increasing consensus in views about the new business. Interactions helped the firm approach other types of service functions in KISTI such as technology mentoring services, education programs, and one-on-one follow-up services that minimized barriers at different stages of innovation.

Coupled with KISTI, IF played an important role in monitoring the process and sponsoring the follow-up programme for the firm. The private global consultancy had advantages over public intermediaries in accessing foreign markets and related information. By linking KISTI's service with the follow-up programme to provide a global-marketing plan, the weakness of a single public intermediary service could be overcome. The interaction contributed to resolving the barriers (e.g. lock-in barriers) between owners and employees, and between internal and external resources. Interviewee H explained: 'Relationships bring more than the knowledge. These relationships resulted in successful outcomes of the consultation project and organizational changes.' In summary, this was due to a multiplicity of relationships

and interactions. To be more exact, it was the result of interactive learning that brought changes to the firm as well as to individuals.

This case illustrates the knowledge interaction that decreased the barriers Firm K faced. Focusing on the firm's knowledge demands, the interaction succeeded in enabling the knowledge required at all levels of employees. Trusting relationships influenced both organisations. Since then, Firm K has interacted with KISTI in reconfiguring knowledge, where necessary. The process contributed to rebuilding the knowledge infrastructure and the organisational structure. It was possible for KISTI to have knowledge interactions with Firm K due to the existence of a sponsoring organisation, IF, and their project manager actively involved in the whole process, ensuring satisfaction of the SME. The not-for-profit structure of KISTI and the participation of IF improved not only the quality of knowledge but also quality of the relationships. As can be seen in the case, some firm specific factors affected success, summarised as follows.

First the CEO's level of urgency was quite high, evoking internal risks and delivering this vision to employees. This sense of urgency decreased any unnecessary discrepancy in the interaction processes between Firm K and the intermediary, and facilitated learning. The second was the quality of the top-management team and employees. Members of the top-management team had a variety of working experiences in GRIs, government agencies, and larger firms before they joined Firm K, bringing different skills and knowledge. They had communication and adaptive skills that increased the level of absorption of new knowledge and learning. Third was the existence of reflexive individuals who could integrate external knowledge into the firm and constantly facilitate learning. For example, Firm K dispatched some staff to KISTI for a year to learn the knowledge-configuring process and to secure the relationship at individual levels. Finally was the reconfiguration of knowledge throughout the process inside the firm. The top-management team actively reconfigured the knowledge at every stage of innovation and used it when the firm went public with an IPO.

The abovementioned barriers, innovative outcomes and micro-level factors yielding a successful innovation process are summarised in Table 6-3.

Table 6-3 The Result of Knowledge Interaction: Firm K (Successful)

		Summary of the interaction process
Barriers resolved	Internal	<ul style="list-style-type: none"> - Different views on innovation between the CEO and employees - Lack of nontechnical knowledge required in the new business domain
	External	<ul style="list-style-type: none"> - Lack of relationships with potential buyers
Outcomes	Internal	<ul style="list-style-type: none"> - Building new learning routines (new decision-making process) - Acquiring new technical and nontechnical knowledge - Entering into relationships with big buyers
	External	<ul style="list-style-type: none"> - Expanding relationships with intermediaries and policymakers
Micro-level factors	Firm	<ul style="list-style-type: none"> - Capability of CEO (long research experience and a wide network throughout the industry) - Technological capabilities and experiences with big buyers in the existing business domain - High level of urgency of the CEO - Failure experiences in the existing business domain - Existence of reflexive individuals
	Process	<ul style="list-style-type: none"> - Long-term interaction with focused intermediaries - Multiplicity of interactions and relationships, and a productive combination of competing rationalities - Strong levels of interaction between the firm and intermediaries
	Intermediary	<ul style="list-style-type: none"> - Capability of intermediaries to generate new knowledge - Existence of monitoring organisation - Existence of reflexive individuals
Current status		<ul style="list-style-type: none"> - Entered into the new business area

6.2.2 Case 2: Firm P

Firm P is a manufacturer of semiconductor-packaging inspection systems, established in 1995 (Table 6-4), that has been interacting with KISTI since 2009. The firm is involved in knowledge services and follow-up services provided by KISTI and sponsored by the IF. The knowledge interaction was successful in enabling the knowledge of the LED packaging-inspection system and bringing changes to the knowledge infrastructure.

Table 6-4 Description of Business

The firm has been developing and supplying a precision-measuring tool that can be used in detecting defects in nanometre-sized semiconductor surfaces.

Major products are as follows:

- The world's fastest component-inspection equipment for semiconductors that provides packaging inspection, detecting surface defects such as scratches and cracks, based on moiré interferometry technology
- LED vision-inspection equipment to monitor the LED assembly line
- Vision-inspection equipment to detect manufacturing processes of solar wafers and solar cells

Source: Adapted from the homepage of Firm P

6.2.2.1 The History of the Firm

Firm P was founded in 1995. The founder of the firm was a former contract researcher in the Precision Measurement Laboratory at KAIST in South Korea. The laboratory was operated by a well-known professor who boasted world-class research outcomes in measuring degrees of precision.⁶⁰ The founder was actively engaged in conducting research on analysis and measurement equipment during the contract period at the institute. When the contract period terminated, the founder had a chance to join Firm P as a CEO where the professor of KAIST owned a major share.

The professor started playing a conduit role, with the CEO absorbing state-of-the-art technology and building strong technology competitiveness in the firm. The laboratory provided a source of talented human resources, as the major management team of the firm consisted of Ph.D. graduates from the Precision Measurement Laboratory at KAIST. They had the professional technical knowledge about measuring the 'degree of precision' that affected the direction of innovation.

During the early years of business, Firm P was an R&D service provider for Samsung Electronics Co. Ltd. and LG Electronics Co. Ltd. In early 2000, the firm tried to develop its own product and lured enough funding from angel investors. However, the firm failed to develop its own product in 2 years, and began running out of funds. The CEO took the view that the failure was due to the lack of nontechnical knowledge such as market trends, needs of customers, and regulations.

⁶⁰ This technology has been crucial in developing flat panel displays that require to 'the ruler' for the inspection of display surfaces.

The CEO said, 'I had painful experiences in the past. I only expended effort on technology development, but had no idea how the business would progress.' The experience of failure showed the importance of societal aspects of the technology that caused the CEO to prepare for knowledge before starting a new business at a later date. From the failure experience, the CEO learnt how and why nontechnological knowledge needed to be considered in technology development.

At the end of the 2002, Samsung offered the firm a contract to supply the inspection system, because the firm had experts from KAIST who had been researching the moir é technique for 10 years. Until then, companies used a laser technique to inspect semiconductor packages, which limited the test speed. When Firm P entered the industry, the global firm RVS, which was a supplier for Samsung, took 80% of world market share with a testing capacity of 200,000 semiconductors per 24 hours. Applying the moir é technique to the component inspection system, the firm could increase the test speed threefold. In 2004, Firm P finally could supply 'Semiconductor Packaging Inspection Equipment' (SPIE) to Samsung with which the firm could increase technological expertise continuously. The firm came to produce the world's fastest semiconductor-component inspection system, boasting high levels of accuracy and performance by the mid 2000s.

A new business opportunity came to the firm in late 2008 when Samsung Electro-Machine Co. Ltd. offered some information on its future roadmap. The big corporation held a briefing session on its future plans and requirements for cooperative SMEs, where the CEO got an idea about new products in the LED industry. Although the firm had a good relationship with Samsung Electronics Co. Ltd., it did not initiate a new business relationship with Samsung Electro-Machine Co. Ltd. Severe competition ensued among SMEs and having technological competencies was the first condition to become a supplier to the big buyer in the chosen field.

Although the CEO was interested in an LED-inspection system that could make the best of the core technical competencies the firm had built in the field of SPIE, the CEO did not know about the inspection process, market prospects, or the strategy of big buyers. If it was to fail, Firm P would be responsible for financial damages. This,

coupled with failure experiences in the past, led the CEO to examine the LED industry ahead of big buyers, but limited capability was a barrier to accessing and analysing the industry and business opportunity.

However, P's growth was accompanied by major challenges: most prominent was the firm's uncertain financial future caused by the subprime financial crisis and a lack of diverse products. Samsung and LG were the only customers whose sales decreased between 2008 and 2009, due to the crisis that affected Firm P's sales. The CEO's desire for new business opportunities grew stronger in view of market fluctuation; Firm P put a plan into practice earlier than scheduled. Furthermore, as the leading firm in the field of semiconductor-packaging inspection for many years, the CEO knew that the semiconductor industry in Korea had already reached saturation. The CEO decided to venture into new areas, encouraged by the assets the firm had been accumulating: technological expertise and advances. The firm could use the technological infrastructure in LED packaging-inspection equipment.

A new set of challenges surfaced as the CEO determined to explore new business opportunities and interest in the business area grew stronger: (a) the difference between the knowledge of the CEO and the firm, and the knowledge that the new venture required, (b) the difference between the technology the firm had and used for the semiconductor area and the technology the corporation would need for other business areas, and (c) the disconnection between the firm and potential players in the new industry.

The abovementioned challenges were the gap between the reality at P and the necessary conditions for the firm's success in the new business area. The CEO and employees inclined toward the same industry area—using technology infrastructure—but they were keeping their options open in case they may have missed some opportunities. What was essential to increasing the chances of P's success was to have the gap reduced significantly. Because the CEO had a good relationship with the IF, having regular contacts, the CEO could get the information about KISTI that led the firm to use external expertise to fill the gap.

6.2.2.2 Knowledge Interaction Process

6.2.2.2.1 Engagement of Public Intermediaries

The CEO came to contact public intermediaries such as KISTI and the IF.

6.2.2.2.2 Knowledge Enabling

KISTI formed a team consisting of researchers who had the same educational background as staff in Firm P. One researcher, a KAIST graduate, had active communication with the executive director from the beginning. A project manager in IF participated as an observer to monitor the process and to give support if required. Because the CEO already knew the firm could use the technological infrastructure in developing the new inspection system, the company wanted to gain confidence by obtaining two types of knowledge: first was the nontechnical knowledge regarding the LED inspection system, whether the market would be promising, and whether there were other business opportunities in addition to the LED inspection system; second was the technical knowledge regarding the new process and technical specifications required in the new inspection systems.

Although the firm had a good relationship with Samsung Electronics, the firm had limited ability to gain decisive information from Samsung Electro-Machine. Other SMEs were capable of competing with the firm and the relational capital might not help unless the firm was considered to be the best partner for Samsung Electronics. The CEO explained:

I believe the reason we could not get information from the big buyer was due to a lack of capability in accessing them. At that time, we were not recognised as the capable firm that Samsung had to deal with. Thus, we had to figure out its investment plan one step ahead so we could prepare for new products proactively.

Intensive interaction occurred to articulate demands and to get a sound understanding of the firm's capabilities. Similar to Firm K's case, little information on market and technology trends, competitors, and potential buyers existed regarding the inspection system. Reports from global consultancies have a tendency to focus on upstream markets where big buyers are major players. Knowledge of policies and regulations

were considered less important for Firm P because the firm had relatively useful knowledge about them. However, Firm P did not have strategic information on whether big buyers would invest in the new area because the investment plan was normally classified as secret information.

Interaction was important for two reasons. First, it was essential to have interaction with researchers from GRIs and potential big buyers. This stage required greater relational capital of individual researchers to access in-house information of the big buyer, because no codified knowledge was available regarding investment plans in the new industry. Only the organisations that could maintain an impartial position were able to access both parties—buyers and suppliers—addressing the demanding stages successfully. Researcher R at KISTI explained:

They did not ask me to find the in-house information of the big buyers. They might think it was not impossible for us to access the crucial information. However, I quickly noticed that the investment plan of big buyers would have an impact on the firm's future business. What I could do was put myself in an impartial position between them and contact the big buyers.

Interaction with researchers in GRIs was also considered an important process to figure out the inspection process required in the new business area as well as industry trends. A combination of multiple levels of competing knowledge, skills, and experience embodied in individuals from different GRIs resulted in discovering more business opportunities than Firm P expected.

Second, the interaction with the CEO and the top-management team required feedback to ensure they absorbed the knowledge. In this connection, the CEO indicated that the firm needed an interpretation of the knowledge in the new business area while the CEO accumulated technological knowledge over time. Interactions provided a learning opportunity for the firm in how the LED industry would bring new business opportunities that helped the firm overcome its bounded rationality. The firm only focused on the LED inspection system but was also able to access solar cell and bump wafer systems through several stages of the interaction process. Also, the interaction process played an important role in providing learning space

where the CEO and the top-management team shared and developed insights and ideas for new businesses.

One researcher in particular made very good use of relationships in GRIs and Samsung Electro-Machine, to access in-house information. The researcher and a manager in Samsung Electro-Machine were KAIST graduates and used to work in one of the GRIs before they joined their current organisations. Along with the trust-based relationship, the researcher's impartial position helped in communicating with a manager and gaining the information.

I told the manager about the SME. The manager already knew since the firm was one of the suppliers. I told her that the information would be used only for the firm and never be released to any other parties, emphasising that I would not represent the interests of any parties. The manager also agreed that having the competitive SME was also good for the corporation.

The investment plan was very important but was only partial information that did not reveal the whole picture of industry prospects. The right set of resources, including intellectual materials and competent researchers, played a crucial role in supplying the qualified set of knowledge the firm required.

KISTI configured the knowledge on technical and nontechnical aspects of the new business area, and was able to enable the knowledge more than they initially expected. The firm was satisfied with the process as well as the quality of knowledge, which facilitated knowledge flows between KISTI and the firm more effectively. The accuracy of knowledge as well as the attitudes of researchers contributed to building trusting relationships in both parties, which brought some visible outcomes. The CEO considered the firm to be capable of filling the R&D gap with its own efforts but incapable of bridging the knowledge barriers such as trends, strategies of big buyers, and regulations that hindered interaction with potential buyers.

Firm P found it difficult to access and interpret the knowledge even when they were able to access it. By bridging the gap, the firm could make a decision to explore not only LED but also related areas for further R&D activities with confidence. This confidence exerted positive influences in initiating relationships with big buyers at

reasonably equal levels. Currently, KISTI provides long-term client support in the form of one-on-one follow-up services, and provides S&T information (reports and databases) helping the firm reconfigure the knowledge.

Interviewee I, the executive director of Firm P, conceded,

We were experts in semiconductor inspection systems and interested in the LED inspection system. KISTI configured the knowledge not only about LEDs, but also solar cells and bump wafer systems where we explored more business opportunities. Even though they were our buyers, we had limited access to their in-house information. Sometimes, people who maintained a long-term relationship with us had to quit, which resulted in a disconnection of information. However, KISTI found the facility-investment plan of the big buyer, which gave us confidence in entering into the new business area.

KISTI enabled the knowledge that let the SME proactively prepare for the new inspection system over its competitors. The quality of knowledge and strong levels of interaction contributed to articulating demands even more than the firm demanded. Although the firm was mainly interested in the LED-inspection system, the researchers discovered more business opportunities in the field of solar cells and bump wafers.

6.2.2.2.3 *Facilitating Relations*

Unlike in the case of Firm K, Firm P knew the potential buyers, so the role of KISTI was limited to enabling the knowledge. The CEO remarked: 'It may be difficult for any intermediaries to make a business deal between buyers and suppliers.

Intermediaries can link us to potential buyers but then the cultural and psychological background of individuals must vary, that we only can deal with.' Instead, the firm aligned different types of services provided by IF. IF played a crucial role in aligning different types of intermediary services to the innovation process of Firm P. Because KISTI service did not cover R&D activities, the support programme was complemented by the follow-up programme. The firm entered into a cooperative relationship with R&D partners in Germany and Switzerland and, in the latter case, was sponsored by the IF. IF played a crucial role in enhancing technological competitiveness proactively, which helped the firm build a credible image for big buyers.

Firm P was also able to decrease the knowledge gap between the firm and big buyers. The firm was not aware of nontechnical aspects of the industry that could have hindered entering into business relationships with big buyers. The CEO said,

We decided to enter into the LED industry with my insights. What could we do if we did not get the knowledge? What we needed was anticipative research ahead of big buyers so they would choose my firm as an equal partner. The knowledge provided the firm with a sound understanding of the inspection process, market trends and other business opportunities.

By filling the knowledge gap, the firm was able to extend relationships towards not only big buyers but also international R&D partners. The firm entered into joint R&D with two foreign firms: One was the German firm that owned the world's best vision technology, which contributed to increasing the accuracy of the inspection system; the other was a Swiss firm that owned high-velocity sensors that would improve the velocity of the inspection process. In the latter case, IF supported the firm to open an international joint R&D centre. The various levels of knowledge interaction contributed to the firm's ability to overcome barriers such as financial deficits, knowledge asymmetry, and relational gaps.

6.2.2.2.4 Facilitating Learning

The knowledge interaction facilitated learning associated with the new business area among employees and subsequently contributed to building the new infrastructure in a short period of time. The firm effectively adhered to the knowledge, new business ideas, and inspection process in the new area. At first, the CEO was unsure about the insight that the new business area could be another lucrative source for the firm. 'The most important thing in running a business is confidence that drives active promotion of the new business. If KISTI had a negative opinion about the new area, I would have not expanded the business area.' The knowledge interaction gave the CEO justification for the logic behind the insight to explore new businesses. The CEO gained confidence in exploring the new venture, which intertwined with the myriad barriers the firm needed to overcome. The strong knowledge interaction between KISTI and the top-management team brought broader learning to the firm, providing coherence of routines between old business areas and new ones. Firm P achieved two

objectives by building a new learning routine that changed the relationships and patterns of knowledge interaction inside the firm.

First, the CEO adopted a new scheme called *research fellowship*, gathering new knowledge and linking the CEO and employees to facilitate learning at all levels. As the CEO indicated, the knowledge interaction was not a one-off process because changes of sociotechnical contexts consistently required the firm to reconfigure the knowledge to its own context. Thus, the CEO let employees apply the same process to the firm, analysing customer needs and trends to absorb the methodologies and processes KISTI delivered. Because most employees had an engineering background, lacking knowledge of nontechnical aspects of the industry and customers, the CEO had meetings with the top-management team twice a week to talk about social, political, and environmental changes. The replication of the knowledge-interaction process inside the firm contributed to establishing its own learning routines to integrate external knowledge into the firm's innovation process. Second, the firm could align not only with IF and KISTI—the foreign firms, the R&D partners—but also potential buyers for its future business.

6.2.2.2.5 *Managing Interfaces*

During the interaction process, the firm was able to gain access to KISTI and its services. The interaction took place when the firm needed to reinterpret new knowledge to its own context or required additional services (e.g. providing technology or market information). The CEO continued,

We should adapt ourselves to the new environment. We came to know the weaknesses of the firm while we were interacting with the intermediary, which provided us with industry prospects and the needs of the big buyers. It is a necessary and important ongoing process to remove waste elements constantly in managing the firm during the innovation.

KISTI provided follow-up services, helping the firm reconfigure the knowledge when necessary. The CEO had regular meetings with the management team in charge of monitoring and sharing new knowledge trends. This process required constant interaction with intermediaries to scan and renew societal trends, and interpret them in the firm's own contexts. In linking the firm to KISTI's experts, the two major staff

members from the management team and the researcher at KISTI acted as conduits of constant knowledge interaction and maintained interfaces for a long period of time. Because they were alumni of KAIST, it seemed easy to build trusting relationships. Interviewee I at Firm P remarked,

When we heard that she got a degree from KAIST, it gave us a kind of relief in the sense that she must be capable of understanding our needs. I felt comfortable in communication because she was one of our graduates.

Since then, these key individuals have been acting as mediators, managing interfaces between Firm P and KISTI, and integrating external knowledge into the firm. The firm constantly obtained the specialized knowledge and industry reports essential to the innovation process for the new venture. The interfaces have been facilitating learning through interactions that have contributed to achieving more innovative outcomes than the CEO expected.

6.2.2.3 Case Analysis

This case illustrates knowledge interaction between public intermediaries and Firm P at the early stage of innovation (Table 6-5). Researchers from KISTI enabled the knowledge and had a strong level of interaction with the SME to meet its needs. Researchers focused on enabling the specific knowledge in the field of inspection systems where the firm could make the best use of technologies accumulated in the past.

Table 6-5 Major Changes in Firm P

Period	Key events	Changes
1995	Established the firm	Supplied the inspection system to Samsung
2004	Applied the new technology and developed the SPIE	Supplied the SPIE to Samsung
2009–2010	Found the new business opportunity Entered into knowledge interaction with KISTI to obtain the knowledge about the new business area Obtained the necessary knowledge	Carried out R&D in the new business area (Inspection systems for LED, solar wafers, and cells)
2010–2011	Follow-up programmes provided by the IF	Entered into relationships with foreign firms for technological collaboration Developed inspection systems in the new areas and expanded relationships with new buyers
2011–2012	Continued interactions with multiple public intermediaries	Went public with an IPO (2011)

The case illustrates various barriers (i.e. infrastructural, lock-in, and network failures) the SME faced in exploring the new venture. Although the firm had a long-term relationship with big buyers, it had limits to overcome the barriers in the new business area. Often SMEs that could enter into a supplier–buyer relationship with a new big buyer have difficulty maintaining the relationship, due to the lack of resources. Firm P had to improve their capabilities by themselves but they hardly built their capabilities, spending all their energy on addressing the exact requirements of big buyers. This limitation brought two problems: On one hand, the firm had to learn the new knowledge and relationships required in the new business area; on the other hand, it had to increase technological and managerial capabilities consistently. This caused huge barriers between the current business area and the new business area that the firm had to resolve. Lacking in resources, like most SMEs, Firm P have limits in addressing barriers.

How do SMEs survive by themselves? How could the firm build the new knowledge infrastructure and transform into the new business area by overcoming barriers? Was the firm capable of building the new process? It was the interaction with the intermediary and the formal program through which the firm could bridge the knowledge gap and enter new relationships. The knowledge configured by KISTI gave the firm confidence in a new business area by enabling the technical as well as

nontechnical aspects of knowledge. Along with long-term interactions, it also brought organisational changes such as adopting research fellowships, informal knowledge, and configuring processes. To examine the differences in this case that brought such changes, some questions could be answered. Why did this case become the successful one? What different things happened in this case? What was the key success factor?

First is the capability of the firm. On one hand, it was the technological expertise and capabilities the firm could build as a supplier of Samsung. Interviewee I explained:

SMEs are forced to build technological and managerial capabilities as suppliers to Samsung since the big buyer diagnoses technology, marketing, and management capability of cooperative SMEs regularly. It is like a consulting service. Then the big buyer evaluates SMEs again: whether they make changes based on the consulting services. The problem is that SMEs have to make the changes by themselves.

Considering the technology-development speed of Samsung and its high criterion for choosing cooperative SMEs, only a few SMEs could meet its requirements. As a firm that had met the demands of big buyers for a long time, the firm could build technological and managerial capability, addressing the fastidious requirements.

On the other hand, it was the capability of highly qualified employees from KAIST that had a world-class level of precision-measurement technologies. The CEO and the top-management team had the same research background in KAIST that helped the firm achieve high levels of technical expertise without internal discrepancies in exploring the new business area. The confluence resulted in knowledge absorption and active knowledge interaction, with a researcher in KISTI sharing similar experiences. Equipped with technical knowledge, active feedback also contributed to having frequent interactions that may have led to the articulation of hidden demands for Firm P.

Furthermore, their long-term relationship with Samsung let the firm accumulate the knowledge on the inspection process of semiconductor packaging that was one of the key factors in maintaining competitive advantage that other firms could not imitate. Like the case of Firm K, these experiences allowed the firm to build specific routines

and to enhance learning capabilities that had a positive impact on knowledge interaction with intermediaries. The CEO and the top management team did not lock their knowledge in experiences accumulated in the past. The CEO and individuals did not passively receive the knowledge, but gave active feedback to intermediaries. This resulted in bringing organisational changes through knowledge interaction. However, the case of Firm P differed from the case of Firm K in the way the firm searched for new products in the same business area, the inspection industry. The demands of filling the relational barrier with potential buyers were considered less important because Firm P knew who the potential buyers would be.

The CEO explained,

My role is to read industry trends and customer needs. I am always thinking of discovering new products that ensure sustainable growth. In terms of technologies, there's nothing I have to do urgently because we already know what to do in the field of inspection systems.

Thus the CEO had strong needs for the knowledge that could show the direction the targeted industry would be headed so the firm could proactively comply with the trends. When the CEO and the top-management team started to use government support in the process of innovation, they had very focused knowledge demands. These demands led to having strong levels of interaction with few intermediaries, compared to other SMEs, who needed different type of services.

The second difference is the technology-specific factor, which affected different levels of relationships and interactions. In inspection areas, the effectiveness and speed of the inspection system had been the major issue for big buyers who always pursued more accurate, faster, and more precise systems. Thus proactive R&D to achieve competitiveness was crucial to maintain a fair and competitive position with big buyers. Also, the level of uncertainty in the LED or solar-cell industry is relatively high. These characteristics brought different patterns of relationships.

The accuracy and accessibility of the knowledge of big buyers were crucial. Once Firm P made a decision, the new business required considerable investment of time and effort. Accurate information on the investment plan of big buyers was highly important, followed by industry and technology prospects. In this case not only the

capability of a public intermediary enabling the knowledge, but also the relationships of individual researchers were crucial to accessing the in-house information of big buyers, shaping strong levels of interaction between Firm P and KISTI, and between KISTI and the big buyer.

Unlike the cases of SMEs engaging in IT technology, it was essential for the firm to have long-term knowledge interactions with a few intermediaries on focused demands. Enabling knowledge at the early stage of innovation took time. In relationships with other innovation players, the firm needed to expand towards R&D partners rather than potential buyers to improve the level of effectiveness and speed of inspection systems. IF gave follow-up support, which let the firm carry out additional joint R&D with the international partner. Consequently, the relationship was shaped around the firm, KISTI, and IF at meso- and micro-levels, maintaining strong levels of interaction throughout the whole process (see Figure 6-2).

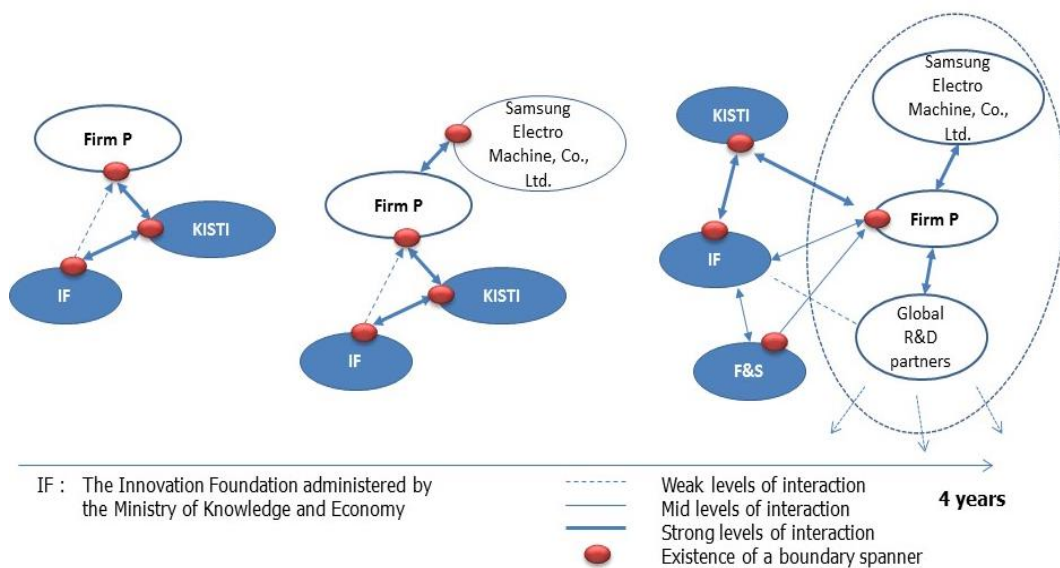


Figure 6-2 Firm P—Multiplicity of relationships and interactions.

The crucial question is whether these knowledge interactions facilitated the innovation process. How does the knowledge interaction contribute to lowering the various knowledge gaps and thereby the barriers to innovation? Several crucial factors underlay successful outcomes.

First was the multiplicity of relationships centred around public intermediaries. Collective action of public intermediaries played a crucial role in bridging the gap from the specific knowledge to finding R&D partners. The knowledge service was followed by additional follow-up services such as monitoring services (KISTI), transfer of foreign technology (IF), and market research (Frost & Sullivan). These collaborations minimised the risks in investment and strengthened the relationships between the firm and big buyers. Interviewee I, the executive director, explained:

There may be some firms that don't have unique technologies. Instead they may offer a discount to big buyers, but that won't work at all. They are the high-end users who require the best quality product in the world. By obtaining the vision technology from abroad, we could occupy the unique position in the inspection-system area and only then were able to be an equal partner with big buyers.

The CEO added:

We proactively presented improved systems before the buyer requested it. I believe it raised awareness of our products inside Samsung. This was possible due to support programmes that played a key role in upgrading the technical performance of the systems.

Second was the learning ability of the firm. The firm had a long period of business relationships with big buyers, which positively impacted building managerial skills and specific learning patterns. Individual employees had high levels of urgency towards changes and knew how to interact with external knowledge and integrate it into their own context. This led the firm to be involved in active knowledge interaction with the intermediary. Firm P reconfigured knowledge when it applied to go public. After the firm was listed on KOSDAQ, it had a healthy cash flow that provided the firm with opportunities to build technology-entry barriers by acquiring state-of-the-art technologies from Germany. Currently, the firm expects to reduce the several steps of the inspection process, which will result in achieving a simpler highest speed system.

Third was the failure experiences in the past. The CEO learned a lesson that innovation in the firm could be achieved only through exogenous shock.

State of the art technology does not guarantee anything if there are no societal needs. I came to look into megatrends only after I failed. This is why I searched for knowledge intermediaries: because I and my employees have limited knowledge.

Accompanying learning capability, the failure experience enlightened the CEO about the importance of building the new knowledge infrastructure in addition to R&D factors in pursuing innovations. The CEO became a reflexive actor applying the failure experience in exploring the new business area. Since then, the CEO and the top-management team did not lock in their knowledge, conceding the limits of their knowledge. The active knowledge interaction consisted of absorbing and reconfiguring knowledge during the interaction process.

Fourth was the quality of knowledge, which related to the quality of individuals and relationships that may have influenced the ability to produce reliable knowledge throughout the process. The capability of enabling the quality of knowledge provided a basis of trust-building relationships that facilitated knowledge flow. As previously explained, the quality of knowledge was the result of a productive combination of competing knowledge embodied in individuals at KISTI and GRIs. The CEO remarked,

I believed in the name of KISTI, but it is all about people. We felt that researchers were already equipped with similar levels of knowledge in the first meeting. It was quite surprising that we have been engaging in this area more than 10 years and KISTI has just started to analyse the industry.

Fifth was the existence of boundary spanners. Researchers in KISTI and a project manager at IF interacted with the owner and the top-management team in the firm during the interaction process. This resulted in facilitating knowledge flow among participants in the knowledge-interaction process. The interaction helped the firm approach other types of service functions in KISTI and IF, such as one-on-one follow-up services and technology cooperation, supporting programmes that minimised gaps at the different stages of innovation. IF, especially, played an important role in monitoring the process and sponsoring the follow-up program for the firm. Interactions contributed to filling the knowledge gap between existing knowledge and the new knowledge required in a new business area. The firm could

forecast industry needs, getting ahead of big buyers, and ultimately got a chance to succeed as a result of proactive planning and preparation.

The case illustrates the knowledge interaction, which decreased the gap that faced the firm. The knowledge interaction also facilitated ongoing learning during the process that resulted in some organisational changes. Although the internal structure did not change markedly, external relationships with R&D partners expanded.

The barriers, innovative outcomes, and micro-level factors that affected successful knowledge interaction are summarised in Table 6-6.

Table 6-6 The Result of Knowledge Interaction: Firm P (successful)

		Summary of the interaction process
Barriers resolved	Internal	- lack of knowledge required in the new business domain
	External	- Relationships with new buyers
Outcomes	Internal	- Building new routines (e.g. regular meeting with the top-management team) - Acquiring new technical and nontechnical knowledge - Entering into relationships with two foreign firms for joint R&D
	External	- Expanding relationships with R&D partners and a big buyers
Micro-level factors	Firm	- Technological capability and relationships with big buyers in the existing business domain - Failure experiences - Highly qualified employees
	Process	- Long-term interaction with focused intermediaries - Multiplicity of interactions and relationships, and productive combination of competing rationalities - Strong levels of interaction between the firm and intermediaries
	Intermediary	- Capability of intermediaries to generate the new knowledge - Existence of reflexive individuals and monitoring organisation
Current status		- Entered into the new business area

6.2.3 Case 3: Firm T

Firm T is a manufacturer of electrolysis ballast water-management systems (EBWSs),⁶¹ and has been interacting with KTVF since 2000. Firm T received various types of services for several years at the business incubation centre (BIC). The interaction was successful in enabling knowledge of the EBWS and facilitating relations with potential buyers for Firm T.

Table 6-7 Description of Business

<p>The firm has been developing and delivering the first explosion-proof-type ballast-water management system, which first obtained approval in principal from IMO.</p> <p>Major products are:</p> <ul style="list-style-type: none">- EBWS for disinfecting ballast water that treats all incoming water and sediment passing through the electrolysis chamber unit.

Source: Adapted from the homepage of Firm T.

6.2.3.1 History of the Firm

Firm T was founded in 2000 as a first venture firm that moved into the BIC at KIST,⁶² the centre at Hongneung Venture Valley (HVV). Firm T supplied the water-quality diagnostic reagent based on electrolysis-disinfection methods, sterilizing microorganisms in wastewater from industries. The firm's key buyers were private firms from various industries that used the system to sterilise wastewater. The CEO faced a problem in that a variety of wastewater required a different data set and methods for sterilisation. Firm T had to measure, experiment, and produce a new system each time and was unable to accumulate experience. It seemed the existing business did not prove to be a lucrative source of revenue. The CEO began exploring other business opportunities to overcome this financial challenge, preferably in an area where Firm T could use their electrolysis-disinfection methods.

⁶¹ According to the International Maritime Organization (IMO), ballast water is pumped to maintain safe operating conditions throughout a voyage. Although ballast water is essential for modern shipping operations, it may cause ecological and economic problems due to the multitude of marine species—bacteria, microbes, eggs, cysts, etc.—carried in ships' ballast water. To protect the marine environment for future generations, the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BMW Convention) was adopted by consensus at a Diplomatic Conference held at IMO Headquarters in 2004 (International Maritime Organisation, 2014a).

⁶² The BIC had been administered by the HVV team at KTVF until the HVV team at KIST became an independent foundation in 2000.

Meanwhile firm leaders attended an exhibition where the CEO met a researcher from the Korea Institute of Ocean Science and Technology (KIOST) who inquired whether electrolysis-disinfection methods could be applied to sterilise ballast water. After a while, the CEO received the same inquiry from a researcher at KIST, when the new venture gained momentum. The CEO decided to venture into something new, encouraged by personal assets, those from GRIs that had technological expertise, and experiences. Firm T considered two factors in exploring the new business area: the first was building technological and nontechnological infrastructure as a start-up; the second lay in determining whether the newly developed technology was able to create a new market.

Exploring the new venture might require a long period of time, money, and resources whereas the future market was quite uncertain and complex, involving several actors, regulations, technologies, and governments. A new set of challenges surfaced: (a) differences between the new technology Firm T developed to manage ships' ballast water and existing technologies industries used—ozone or ultraviolet radiation, (b) differences in knowledge of the wastewater treatment possessed by the firm and what they would need to obtain to manage ships' ballast water and sediments, and (c) the disconnection between Firm T and the potential innovation players (e.g. buyers and technologists) in the emerging field.

The abovementioned challenges formed barriers between the realities of the situation at Firm T and the necessary conditions for T's success in the field. Essential to increase the chances of T's success was to have the barriers removed. With this ultimate goal in mind, the CEO started to seek professional intermediaries for their expertise.

6.2.3.2 Knowledge Interaction and Development of Relationships

6.2.3.2.1 Engagement of public intermediaries

The CEO interacted with public intermediaries, the KTVF, KIST, and KIOST.

- The Korea Techno-Venture Foundation (KTVF): The Innovation Facilitator

The KTVF is a not-for profit foundation that specialises in commercialising global technologies and fostering start-ups and small firms. Along with more than 15 years of history supporting small firms, the KTVF has highly qualified experts in all science and engineering disciplines, and patents, databases, industry reports, methodologies, and networks such as an HVV network, and domestic and overseas networks.⁶³ In particular, the global technology-marketing programme designed by KTVF to deliver customized consulting services provides innovative SMEs and young start-ups with expertise to expand their business opportunities throughout the world. The qualities KTVF boasts convinced the CEO to conclude that the foundation had the credibility to help strengthen the argument to pursue new ventures.

- The Korea Institute of Science and Technology (KIST): The Innovation Facilitator

KIST is a not-for-profit research institute administered by the MSIP, founded in 1966. KIST was the first multidisciplinary scientific research institute in Korea and has contributed significantly to the economic and industrial development of Korea in the 1970s and 1980s.⁶⁴ KIST has a research staff of more than 1,800 research scientists, fellows, and trainees, and foreign scientists involved in basic research in various fields of science and technology. It has also been active in technology commercialisation and supporting SMEs throughout Korea.

- The Korea Institute of Ocean Science and Technology (KIOST): The Innovation Facilitator

KIOST is a not-for-profit research institute administered by the MSIP (founded in 1973 as the Korea Ocean Research and Development Institute). The institute has been playing a crucial role in researching and developing ocean science and

⁶³ HVV includes seven universities, three banks, the Seoul Metropolitan Government, and another 12 not-for profit organisations such as KISTI, KIST, and the Korea Technology Finance Corporation (Korea Techno-Venture Foundation, 2014).

⁶⁴ Recently, the institute announced it would put in effort to meet challenges such as the aging society and energy-food-resource shortages directly, while focusing on convergence research and open cooperation (Korea Institute of Science and Technology, 2014).

technology as the need arises from government policy, to keep current with developing ocean-industry trends.

6.2.3.2.2 *Knowledge Enabling*

HVV is a nickname for northern portion of Seoul that is said to be home to many GRIs, universities, and hundreds of start-up firms. KTVF was established as the HVV team at KIST and became an independent foundation in 2000. Since then, KTVF had close relationships with KIST in sharing facilities, resources, knowledge, and experts. Unlike Firms K and P, Firm T, as a new start-up, did not have a history of relationships with buyers and lacked human, financial, and technological resources at the beginning of the business. The CEO was actively involved in acquiring new knowledge and experiences through multiple intermediaries to address the different technological and nontechnological barriers the firm faced.

The CEO learnt electrolysis-disinfection methods in sterilizing wastewater from a neighbouring firm in the BIC and was able to develop the methods to sterilise ballast water in collaboration with KIOST and KIST. The researcher from the KIOST already had sound knowledge of trends in ballast-water treatment and of the IMO⁶⁵ plan to regulate the sterilisation of ships' ballast water and sediments. KIOST built the pilot plant for experimentation of the new methods and the results from an experiment were used when Firm T presented a report to the IMO. Technology development and the standardisation process involved unexpected problems and negative feedback from buyers. It was crucial for Firm T to interact with GRIs and policymakers constantly, aligning them with the innovation process in sharing risks and making the vague technology market more concrete. As the CEO indicated, the market was strongly affected by regulations and government policy that required not only technology development, but also shaping the new regulations. Firm T had strong interactions with KIOST and KTVF to address complex problems in the innovation process.

⁶⁵ As a specialized agency of the United Nations, the IMO is the global standard-setting authority for the safety, security, and environmental performance of international shipping. Its main role is to create a regulatory framework for the shipping industry that is fair and effective, universally adopted, and universally implemented (International Maritime Organisation, 2014b).

In addition to the achievement, the CEO proactively established a market strategy and led the relationships, as a result of knowledge enabling. The following quotation seems to suggest the value of knowledge enabling that resulted in individual learning. While adapting the knowledge to the firm, the CEO came to know how to create the market by bringing in competent players.

After exploring for several years in the field, I decided to [share] my [technological knowledge] to encourage the participation of potential competitors in the field. Although disclosure of technological knowledge in international conferences or seminars could be a risk for [Firm T], I believed that participation of potential competitors could contribute to the market growth of EBWS; that turned out to be true.

6.2.3.2.3 Facilitating Relations

It was crucial for Firm T to enter relationships with big buyers to gain a competitive position in a young market. However, identifying and approaching potential buyers was not easy. Big buyers tended to be reluctant to have business relationships with an unknown small firm, although the technology developed by the firm first received approval from the IMO. A barrier existed between a young firm and big buyers that needed to be removed in a short time. Only organisations equipped with the right set of resources—expertise and relational capital—could weather the demands successfully.

Meanwhile, the CEO and Dr. H. J. Kim at KTVF had been sharing opinions on the progress and bottlenecks entailed in the innovation process since the firm moved to the HVV. The constant interaction helped the KTVF capture the urgent need of Firm T and the KTVF put efforts into searching for potential Japanese buyers, linking them to the firm through a global technology-marketing programme. These efforts were possible because the KTVF had an international office in Japan with hundreds of coordinators working for the foundation, building reputation and relational capital throughout industries. On the basis of their credible image, resources, and experience, the KTVF was able to act as an innovation facilitator between Firm T and potential Japanese buyers. The CEO, Dr. G. P. Lee, explained:

The name value of KIST [and KTVF] provided good footing for the new venture. The Japanese government came to know that Firm T got

approval from the IMO and contacted Dr. H. J. Kim at KTVF to meet us. The contract with Japanese [sales agencies] helped the young firm build credibility at the stage that resulted in expanding big buyers towards a global market.

In particular, the name value of KTVF played a crucial role in expanding the relational capital of Firm K rather easily. Business environments in Japan are quite conservative; small foreign firms hardly start businesses without involvement of credible third parties. Dr. H. J. Kim remarked,

The not-for-profit structure of KTVF has significance in Japan. Japanese firms normally require mediators and seldom contact buyers or sellers directly. In this case, Japanese firms prefer public organisations to private agencies. Actually, many Korean small firms have tried to contact them directly but failed.

The KTVF brought together Firm T and potential buyers (sales agencies) through the programme where all participants were able to share their views. As the CEO indicated, these relationships helped the firm shape the favourable innovation environment at the early stage and align more potential buyers with the innovation process.

6.2.3.2.4 *Facilitating Learning*

The firm faced diverse barriers in exploring the new venture as a start-up and thereby interacted with experts outside the firm, which was crucial to absorbing diverse knowledge and overcoming the barriers. Firm T had knowledge interactions at multiple levels of public intermediaries to facilitate learning on a broader level, which minimised the risks associated with exploring the new business, and subsequently contributed to developing the global-standard technology. Unlike other cases in the field of mechatronics, the CEO was unable to use government-support programmes easily at the early stages of business. To do so, the CEO built networks to bridge internal infrastructural and relational barriers, and the network was extended, centred around public intermediaries including GRIs and ministries.

In the case of Firm T, several intermediaries contributed to learning, although the KTVF seemed to play the major role in providing learning space at the early stages of the business. Knowledge interaction with diverse experts from public

intermediaries took place actively for a long period of time, helping the firm learn about knowledge of technical and nontechnical aspects of the new business area, and co-shaped the new technology market.

The firm established an informal decision-making process that played as a new routine for learning: (a) first, interacting with experts (b) second, deeply interacting with experts at a wider level, and (c) interacting with employees to configure knowledge to the firm's own context. Because the firm lacked organisational infrastructure and experiences, the CEO proactively used intermediaries as partners to access necessary resources and facilitate learning inside the firm during the innovation process. At first, the firm was unaware of its potential buyers and regulatory bodies, and it was difficult for an unknown small firm to enter a relationship with big buyers. A vast disconnection existed between Firm T and the potential innovation players of the new business area, even though the firm successfully developed the EBWS. However, the long-term relationship with the KTVF and other GRIs opened a global-business opportunity at the right time.

To summarise, the strong knowledge interaction among various levels of experts facilitated the interactive learning that provided a new organisational routine and created the new technology market structure. In the field of ballast water-treatment systems, the EBWS was the first technology approved by the IMO in 2006, despite domination of chemical, ultraviolet, and ozone methods in managing ships' ballast water and sediments at that time. The EBWS soon became the major standard technology and Firm T was able to enjoy first-mover advantage in the field. Firm T achieved three objectives through the knowledge interaction. First, the firm was able to use GRIs as innovation facilitators. Second, the firm obtained the specialized knowledge essential to the innovation process for the new venture and received approval from the IMO as a result. Finally, the firm was able to interact with potential buyers for its future business as the first firm to develop electrolysis-disinfection methods in the manufacturing of EBWS.

6.2.3.2.5 *Managing Interfaces*

KTVF managed interfaces with the firm after the firm moved into the BIC operated by KTVF. The firm lacked experience, expertise, networks, and physical infrastructure; therefore, residing in the incubating centre played a crucial role in achieving innovation in two ways: accessing all the resources, experts, and facilities in KIST; and constant knowledge interactions with KTVF. By managing interfaces with KTVF, Firm T received various services such as management consultation, marketing, and use of equipment to conduct experiments that might have been essential for the new start-up. The KTVF observed and monitored the firm and provided support throughout the process that helped decrease various barriers at the early stage of innovation.

For example, it was KTVF that advertised EBWS to Japanese industries when the firm received the first basic approval from the IMO. Interviewee Dr. H. J. Kim, explained, ‘We supported firms even if their project was completed. Follow-up services normally take 3 years, although the contract period is just 1 year.’

Interviewee K, a staff member at KTVF, went on, ‘This may be the reason that firms trust us. We emphasise consistency and responsibility in delivering services, meaning we continue to provide necessary services to firms.’

From the CEO’s perspective, managing interfaces with multiple levels of public intermediaries was important in the field of ballast-water-treatment systems because the firm needed diverse activities: developing and improving the new technology, creating the new market, and leading technology standardisation. The barriers were often unpredictable and addressing the barriers required long-term collaboration with multiple intermediaries. In this vein, managing interfaces with KIST, KIOST, and KTVF played a crucial role in resolving the barriers over time, ranging from developing new ideas to establishing new rules and regulations for electrolysis-disinfection methods.

In particular, the CEO played a crucial role in establishing and managing interfaces with KIST, KIOST and KTVF, which helped the firm build its routines, especially when the firm did not have organisational infrastructure (e.g. human and financial

resources) at the beginning of the business. The constant knowledge interaction at various levels took place through the interface that brought some outcomes the CEO desired: Firm T built technological capabilities based on relationships with GRIs and experts from diverse industries, and shaped the new technology market.

6.2.3.3 Case Analysis

This case illustrates knowledge interactions between public intermediaries and Firm T at the early stage of innovation. Multiple intermediaries enabled those with technological and nontechnological knowledge to strongly interact with Firm T to meet its diverse needs. Table 6-8 describes the major events and changes that occurred as a result of relationships with public intermediaries. The changes include not only a sales increase but also technology development, expanding relationships, and the creation of a new technology market.

Table 6-8 Major Changes in Firm T

Period	Key events	Changes
2000	Established the venture firm and moved into the BIC	Entered into a relationship with KTVF Expanded a relationship with KIST
2005	Participated in the Exhibition	Entered into a relationship with KIOST
2006	Entered into a cooperative R&D relationship with KIOST	Obtained the world's first in-principal basic approval from the IMO
2007	Initiated the knowledge interaction with KTVF	Expanded relationships with potential buyers in Japan
2008	Continued to interact with KIST, KIOST, KTVF, and new buyers Upgraded technological capabilities	Obtained final approval from the IMO Created the new technology-market using the electrolysis methods
~ 2012	Obtained orders from global buyers	Sales increased

In the beginning, the firm only needed technological knowledge, but the innovation journey required additional knowledge about relationships and the standardisation process, as the level of interaction intensified. Unlike other cases, this case highlights the barriers of innovation, in particular, knowledge barriers between the firm and the new field where the technology market and regulations were not yet identified.

Firm T had limits in exploring the new venture. First, the firm had no idea how regulations on EBWS would be designed and applied in the new field. A high level

of uncertainty existed as to whether the IMO might approve the new technology, allowing the firm to create the new market. Second, the technological knowledge and supplier–buyer relationships in wastewater-treatment systems were no longer useful in the field of ballast water-treatment systems, which required a different set of knowledge. Like other cases in the mechatronics field, Firm T faced difficulties in obtaining the required knowledge because little information was available when Firm T decided to explore the new business. It was necessary to work with innovation players to obtain uncodified knowledge and co-shape the innovation path at the early stage of innovation.

Having little internal organisational infrastructure, the CEO put effort into building relationships with public intermediaries (i.e. multiple GRIs and ministries) to overcome the barriers. The CEO believed this process would consistently bridge knowledge infrastructure problems and relationships necessary in the uncertain innovation process when adapting to a new business area. How could the firm explore and adapt to the new business area by resolving the barriers? Was the young firm capable of building new relationships from the beginning?

The constant interaction between the CEO and other innovation players (i.e. intermediaries and experts), and the formal programme through which the firm could bridge the barriers, allowed Firm T to enter into new relationships with potential buyers. The CEO added, ‘As a CEO, I observe the trends in how this business would progress through the relationships with many experts in various areas. The [informal and formal] relationships helped me establish the business direction by constantly reconfiguring the idea.’ Residing in the BIC was advantageous to the newly established young firm, which lacked human resources and physical infrastructure. The CEO was able to gain technological knowledge from a neighbouring firm and KIST, and access experimental equipment. Additionally, the KVTF played a crucial role in bridging the relational barriers between Firm T and potential buyers at the beginning, which opened business opportunities with multiple buyers (see Figure 6-3).

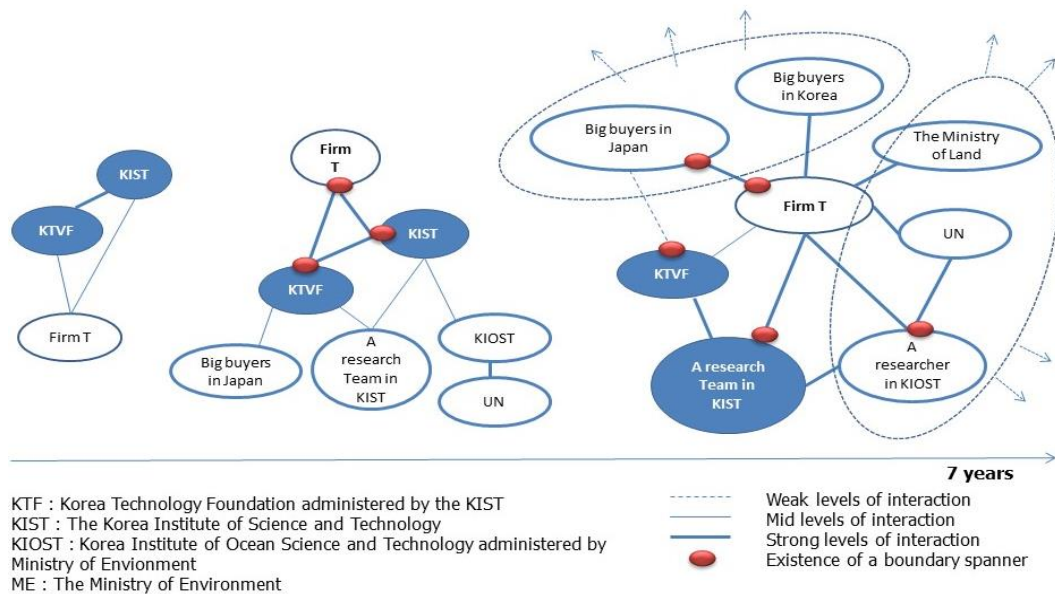


Figure 6-3 Firm T—Multiplicity of relationships and interactions.

The first major factor that differentiates this case from other cases is the firm’s capabilities in building technological expertise and relationships. More precisely, the learning capabilities of the CEO improved the level of knowledge infrastructure and built necessary relationships. Because the firm faced several challenges such as market creation, technical failure, and lack of skill and human resources, the firm had little chance of obtaining government support at the beginning, due to a high level of uncertainties and risks. However, the CEO had a very strong vision from the outset that positively influenced the integration of new knowledge, relationships, and learning. The CEO remarked on his vision and strategy,

From the beginning, Firm T targeted becoming a global leader. I met government officials and persuaded them to support us. I formed relationships with experts from various industries [to shape the favourable innovation environment]. I also worked with a law firm to establish regulations in Korea and these activities contributed to increasing the level of awareness of Firm T.

In this case, the consistent and strong levels of knowledge interaction with multiple intermediaries over long periods of time were an important factor in building a new routine for the young firm. Like two other firms in the field of mechatronics, Firm T

had very focused knowledge demands that resulted in strong levels of interaction with a few public intermediaries.

The second major difference was the technology-specific factor, which may have affected different levels of relationships and interactions. When Firm T made its decision to explore the new business, it required a different set of technological knowledge, rules, players, expertise, and skills. As the CEO described, the interaction process was the rule-making process surrounding the development of the EBWS. These initial stages tended to be extended and required more resources than subsequent stages because the knowledge at this stage was ambiguous and entailed contingencies. It took time for the firm to achieve technological development and shape the business environment that might be far from commercialisation or gaining profits. Therefore, it was important to bring public intermediaries into the innovation process to enable knowledge in the early technology market. Along with the CEO's capabilities, the technological characteristics affected the pattern of relationships, which were shaped to centre around several intermediaries with targeted buyers.

The crucial question is whether this knowledge interaction facilitated the innovation process and thereby reduced various knowledge barriers. Several crucial factors undergirded this process. First was the capability of the CEO. The CEO played a role as a boundary spanner who learnt quickly, constantly integrating and reconfiguring new knowledge. In particular, the CEO actively engaged in expanding relationships towards GRIs, ministries, and buyers, linking them into the innovation process. "Success depends on powerful committees [with multiple levels of relationships] relating to areas of policy, media, regulations, and technology that hedge unexpected risks. This offered me insights on the business." The powerful committees provided the CEO with the learning space where competing rationalities could be combined and tested.

Second was the level of individual and organisational capability in intermediaries, producing reliable knowledge on technology, buyers, and societal trends throughout the innovation process. GRIs provided the firm with necessary knowledge and constantly bridged diverse barriers. Coupled with KIST and KIOST, KTVF played an important role in monitoring the firm and discovering potential buyers for the firm

through the formal support programme. The credible image of KTVF played a crucial role in linking the firm to potential buyers when the firm entered relationships with big Japanese buyers. However, like other cases, the level of trust depends on individual capabilities rather than the name of GRIs, as relationships develop throughout the process.

This case illustrates the knowledge interaction that decreased the barriers Firm T faced. The long-term interaction and multiplicity of relationships contributed to resolving the diverse barriers between internal and external resources and relationships at the early stage of innovation. The CEO, researchers from GRIs, and KTVF played a crucial role in maintaining strong levels of interaction, shaping rules, and monitoring activities over a long period of time. The multiple levels of interaction process can be viewed as the learning process that brought organisational changes (knowledge infrastructure and social capital) and created the new market structure. Firm T had starting capital of US\$500,000 in 2000 and its annual revenue sharply increased to US\$80 million in 2012. The EBWS became the leading technology that shared 60% of the market, despite its short history of market entry. The barriers, innovative outcomes, and micro-level factors that affected successful knowledge interaction are summarised in Table 6-9.

Table 6-9 The Result of Knowledge Interaction: Firm T

		Summary of the interaction process
Barriers resolved	Internal	- Lack of technological and managerial capabilities - Lack of knowledge, human and financial resources
	External	- Relationships with GRIs and buyers
Outcomes	Internal	- Building wide networks throughout industries and academia - Acquiring new technological and nontechnical knowledge
	External	- Entering into relationships with big buyers - Expanding relationships with policymakers - Creating the new market
Micro-level factors	Firm	- Capability of the CEO (wide networks) - Residing in BIC at KIST and gaining name value
	Process	- Long-term interaction with multiple intermediaries - Strong levels of interaction between the CEO and multiple intermediaries - A productive combination of competing rationalities
	Intermediary	- Existence of reflexive individuals in each intermediary - Existence of monitoring organisation (KTVF) - R&D capabilities and providing test sites
Current statue		- Entered into the new business area

6.2.4 Case 4: Firm H

Firm H is an IT-solution provider established in 2001 that has been interacting with KISTI since 2006. The firm was involved in knowledge services provided by KISTI, followed by other services provided by GRIs. The knowledge interaction on wind-field modelling technology⁶⁶ failed at first and interaction was initiated exploring smart power-distribution units (PDUs). The smart PDU has integrated equipment with a computer rack and isothermal-isohumidity functions that were managed separately before Firm H started to develop. Table 6-10 describes the business area of Firm H.

Table 6-10 Description of Business

<p>The firm has been developing and manufacturing a range of high-quality cooling and monitoring systems: smart racks and smart PDUs</p> <p>Major products are:</p> <ul style="list-style-type: none">- Smart racks: Cabinets for holding computers, networking equipment, and air-conditioning systems in the data centre, maintaining temperature and humidity- Smart PDUs: PDUs refer to equipment fitted with multiple appliances designed to distribute electric power to smart racks in the data centre. Smart PDUs refer to rack-based intelligent PDUs that maintain constant temperature and humidity, manage data, and measure CO² emission.
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Source: Adapted from the homepage of Firm H.

6.2.4.1 The History of the Firm

Firm H was established in 2001 specialising in network management. The chair had a 20-year history of working in GRIs and had sound knowledge of network management. The chair's experiences and relationships with GRI customers shaped a stable business environment for several years until the firm faced stagnant sales growth. When the firm recorded a turnover of US\$2.3 million in 2006, the chair realised the market share could not expand in the current business area at that time, and decided to look for another business opportunity. The chair sensed the limits of expanding market share in the network-management area and began exploring other business opportunities to weather the stagnant period. One member of the chair's

⁶⁶ The simulation and modelling technology of wind speed (or wind-flow velocity) analyses the movement or diffusion of air pollutants in the atmosphere. It can be used in placement (arrangement) of buildings at construction sites by analysing congested areas of air pollution (or bad-smelling areas).

informal network, working as a researcher in KISTI, initiated interest in wind-field-modelling technology.

The firm had an opportunity to merge with another small firm that had been specialising in system integration for 10 years, and where the CEO had a good reputation. The CEO had several strengths: first, the CEO had a good relationships with GRI customers in the field of system integration; second, the firm had proficient marketing capability; third, the CEO had managerial capabilities. The CEO was well aware of the characteristics of the IT industry where severe competition ensued among SMEs and innovative products appeared frequently. Thus, it was necessary for the firm to build a new knowledge base in a short period of time to gain competitive advantage.

Although the firm had a relatively long history in system integration and the network-management business with human resources, the infrastructure did not seem to work in the new business area. Furthermore, long experience and accumulated knowledge in the existing business area made the firm hesitant to explore the new business. The firm was faced with new challenges: (a) the difference between the technology the firm had used and the new field of technology, (b) the difference between the knowledge the firm accumulated in SI and network management and the knowledge they might need to obtain for wind-field modelling technology, and (c) the disconnection between Firm H and potential players in the new business area. As a result of these significant barriers between existing knowledge and new knowledge of wind-field modelling technology, along with the increasing urgency of the CEO to make changes, the firm started to seek professional intermediaries.

6.2.4.2 Knowledge Interaction Process

6.2.4.2.1 Engagement of Public Intermediaries

The CEO contacted the KISTI, the Small and Medium-Sized Business Administration (hereafter SMBA), and other GRIs.

- SMBA: The Innovation Sponsor

The administration delivers SMEs a large number of services from R&D funding to knowledge consultations through public and private intermediaries. KISTI is one organisation that links its policies and knowledge services to SMEs.

- KISTI: The Innovation Facilitator
- Other GRIs: The Innovation Users

The Korea Electronics Technology Institute (KETI), Korea Aerospace Research Institute (KARI), National Fusion Research Institute (NFRI), and the Korea Basic Science Institute (KBSI) were government research institutes that played a role as intermediate users.

6.2.4.2.2 *Knowledge Enabling*

Two researchers from KISTI participated in the process of knowledge enabling. In addition to the two researchers, Senior Researcher K from KISTI facilitated communication between KISTI and Firm H, because Researcher K had interacted with the chair and CEO for a long time. Researcher K was quite interested in the technology as well as the firm, having a positive view of its future market share, which influenced two other researchers to have a biased view of the technology and the firm. Instead of having comprehensive interviews with the owner and the CEO, the researchers presumed the firm could be successful in developing the wind-field-modelling technology. Without analysing the capability of Firm H, two researchers analysed the technology itself, overlooking the nontechnological factors such as regulations, policies, and potential customers.

Furthermore, knowledge enabling regarding wind-field-modelling technology connoted some assumptions that were conditions to be successful in the wind-field-modelling technology market. The first assumption was that the firm could overcome the R&D gap through joint R&D; second, the firm could have been the system provider for the environmental assessments required by regulatory legislation. The government tried to legislate that any construction company would have to have an environmental-impact assessment for any new building, which included an assessment of the new wind field caused by the building. If this legislation had come

into effect, Firm H could have been a provider of these assessments, which would have constituted a significant market. However, they faced several difficulties in carrying out the additional R&D and marketing.

The first difficulty related to technological capabilities. Firm H accumulated technological competencies in the field of network management and system integration. It had neither the technological capability nor the human resources for the new business area. Thus, the firm became involved in a technology-cooperation programme with the university to cope with the rapidly changing IT environment. However, the R&D period was longer than the CEO expected, and this led the firm into financial stress. Moreover, according to the CEO, the university partner had a closed attitude and did not open the technology source, which started to hamper mutual trust. As a result, technological capability building through technology cooperation for launching a new business failed. Because knowledge flows from the intermediary to the firm unidirectionally, the intermediary was not aware of the problems involved in the technology-cooperation programme.

The second difficulty related to policy legislation. The researchers forecast that the environment-effect assessment market would be created but the market had not yet been formed. The third difficulty related to the marketing capability that the CEO had in the system-integration area. When the CEO started marketing, the technology targeted bigger customer groups than expected and had to be expanded for the new business. The CEO explained, 'In fact, wind-field modelling technology was not appropriate for a small firm. The assumed price of a final product is about US\$500,000, whilst we have been building a sales network targeting products worth US\$20–30,000.' The researchers analysed the future technology market but the analysis turned out to be wrong in enabling knowledge in the firm's context because the knowledge-enabling process did not involve experts or policymakers; rather, it centred on researchers in the intermediary who seemed to lock in their own knowledge and experiences.

The researchers erred in forecasting the future market by configuring knowledge based simply on the interaction with a few experts, rather than interactions with policymakers and other innovation players. Another problem was that researchers

analysed the wind-field-modelling technology without enough interaction with the CEO, which resulted in an overestimation of the firm's capability. They did not consider the possibility of a failure of technology cooperation between the firm and the university, but only presented an optimistic future market. Although the firm was incapable of bridging the R&D and managerial barriers in the new field, which required new experts and skills, KISTI did not participate in the process of interaction between Firm H and the university and other players in knowledge configuration. This led to the mismatch between the knowledge supply and the knowledge demands.

The problem was not only from the intermediary side, but also from the firm side. The firm had never been involved in knowledge services before, which seemed to affect the pattern of interaction with KISTI. The chair and the CEO passively received the knowledge and seldom gave feedback to KISTI, which shaped knowledge flow from the intermediary to the firm unidirectionally. Instead, the CEO tried to build the new relationship and new knowledge by taking a formal academic programme, using the topic of wind-field modelling as the CEO's master's thesis, not fully depending on KISTI's knowledge service. Despite the lack of active knowledge interaction with KISTI, the CEO was able to use the knowledge network, which helped in making a quick decision to withdraw from exploring wind-field-modelling technology before the firm lost more money. This action reduced the costs of failure at an early stage. The CEO considered the failure of knowledge interaction to be due to the unilateral interaction with KISTI, receiving the knowledge that was offered.

Because the firm had a strong relationship with customers in the field of system integration, the CEO started to consider new business related to existing customers. The government support policy offered an idea: to foster a 'Green' IT industry (an environmentally friendly IT technology contributing to saving energy and decreasing carbon dioxide), from which the manufacturer of PDUs could benefit. The CEO supposed the existence of customer needs and markets if the technology was strategically supported by the government. In exploring the new business opportunity of PDUs, the CEO considered government support to be essential to resolve the

barriers in carrying out R&D, testing the new equipment, and launching the new business in a short period of time.

The second knowledge enabling took place when researcher K introduced the firm to the centre in KISTI to identify problems with the first model of PDU through the supercomputing-simulation programme. KISTI consistently enabled knowledge regarding the technology market, together with the aerodynamic structure of the PDU and related policies, focusing on the firm's capabilities and demands. This time, the knowledge interaction occurred actively to customise the technological knowledge to the firm and the firm sometimes pushed the researchers in KISTI to keep to the service schedule, which may have affected entry to the market at an earlier stage. As a result of the second knowledge enabling with KISTI, the firm could minimise the trial-and-error process in R&D activities. The reliable technical data and market prospects from KISTI also helped the firm get R&D funding as a firm capable of creating new markets. The CEO remarked,

Since we found the problem with the first model of PDU, we needed more time for additional R&D and more resources, such as budget and personnel etc. However, there were limits for a small firm in sustaining a long period of time just doing R&D without yielding profits. Reducing the R&D period using the KISTI facility, gaining credible data and its linkage to the funding programme of SMBA, let us overcome the lack of those resources in developing and improving the equipment.

Along with the knowledge interaction with KISTI, the firm needed to test and improve its new products simultaneously to meet with reduced R&D cycle and innovation speed in the field. Thus, the firm planned to expand its relationships from GRI buyers to big buyers, which required participation from innovation facilitators to overcome the relational barrier between the firm and potential buyers.

6.2.4.2.3 Facilitating Relations

Initially, the firm targeted data centres in GRIs, as they were the customers of the firm. The firm used the relationships with GRI customers to test its first, second, and third model before it started to develop big customers. The firm sold the first model, which had many technical defects, to KARI, which played the role of a proxy user.

The institute investigated and reported all problems in the first model to the firm. Although the supercomputing centre in KISTI helped improve the second and third models, KISTI also acted as a proxy user together with other GRIs such as KARI, NFRI, and KBSI, which participating in monitoring and delivering feedback on the equipment to Firm H. The CEO explained,

We do not have customers in the private sector. They are quite fastidious about new products and we cannot expect any feedback from them. We would feel lucky if our ideas are not stolen. However, GRIs allow failures and mistakes while it is difficult to sell the first product. Of course, we promised to upgrade the equipment on a free basis if they gave us feedback. Firm H would not exist if we did not have relationships with them.

When the firm developed the final product, as expected, it started to expand its customer base from GRIs to global firms in cooperation with KISTI. Because the firm had interacted with KISTI for several years, the CEO came to know other services that would fit their needs. The Technology Commercialisation Information Department in KISTI helped facilitate relations between the firm and potential innovation players such as big buyers, GRIs, and policymakers. Strong interaction occurred between KISTI and the firm at all levels of employees, enabling them to identify appropriate markets and innovation players. It was crucial for the firm to enter the market in the shortest period of time to attain a competitive advantage. The impartial position of the public intermediary played an important role in aligning potential buyers to the unknown firm's innovation process in a few months. As a small firm without name value, it would have taken a long time to build relationships with potential buyers without the innovation facilitator, even though the firm was successful in developing the new innovative equipment.

KISTI guaranteed the firm's technology and credibility, which helped the firm build its social capital with innovation players. The CEO said,

Since we entered into a relationship with KISTI, researchers have been showing consistency in supporting us that led us to trust KISTI. Researcher [K] was the bridge to link to the other types of services in KISTI and SMBA. KISTI not only introduced potential buyers, but also shortened the gap between us. If we would have done that it would take several years and it might be too late to gain a competitive advantage.

It takes time to build technological and managerial capabilities to lead big buyers into business relationships; most SMEs are easily exhausted and stop putting effort into capability building due to a lack of resources to sustain them during this period. Instead, the firm used KISTI as its knowledge repository to overcome the knowledge and relational barriers prior to entering a fair relationship with big buyers.

6.2.4.2.4 Facilitating Learning

At the beginning of knowledge interaction with KISTI, the firm passively received knowledge from KISTI; therefore, knowledge interaction did not take place. Knowledge interaction itself seemed to fail because it did not bring any changes, but the CEO learned how to use the knowledge services and decided to actively use 'external knowledge' to search for other business opportunities: 'I came to know many programmes provided by the government that seemed to be very useful for SMEs. I made a government-support map for SMEs to use establishing our business strategy.' The KISTI researcher also learnt the importance of knowledge interaction and tried to focus on the needs of the firm. The reflexivity of the CEO and researcher brought new patterns of interaction to the intermediary and firm that led to active learning inside the firm. Passive interaction changed to active interaction with wide levels of researchers inside KISTI, other GRIs, and potential buyers after the firm experienced the knowledge service. Multiple levels of relationships with various partners in GRIs led the CEO and the top-management team to learn how to interact with GRIs, filling the knowledge barrier as scheduled.

Well, researchers in GRIs tended to react quite slowly regarding our requests because they did not know or care about the business environment we were facing. Thus, we showed them our progress and product-delivery plan, pushing them to follow our schedule. (Vice President)

The proactive attitude of the firm brought positive effects on trust-building relationships with partners, showing capability and responsibility. The firm could build its networks for further knowledge interaction in the new business area. In addition to constant interaction with GRIs, the CEO and the top-management team enthusiastically attended various education programmes, such as patent-management programmes, to cope with the changing market environment and potential

competitors, which helped in replicating knowledge interactions with KISTI and other GRIs on the new knowledge processing inside the firm.

As previously explained, interaction with the supercomputing centre in KISTI facilitated technological learning by identifying the problem with the first model of PDUs. It was KETI that improved the technological defects of the first and second models of PDUs, based on collaboration with Firm H, whereas KARI, NFRI, and KBSI acted as proxy users who delivered feedback on PDUs. The knowledge interaction with these public intermediaries facilitated not only individual and organisational learning but also brought about transformation of the SME from a small firm to an innovative learning SME. Learning contributed to build the new business and organisational structure.

The CEO established three departments responsible for system integration, new business development (Smart PDUs) and future strategy, and all departments were in charge of acquiring and reconfiguring the related knowledge. Employees came to share the problems and risks of the new business through multiple levels of relationships and interactions that contributed to decreasing discrepancies between the CEO and employees. The CEO explained,

Now, employees start to indicate problems related to our business by themselves. It seems there was no gap between employees and me since I had been trying to deliver all the knowledge to them and let them communicate with experts outside the firm.

The interactions with KISTI and other GRIs led the firm to learn how to interact with experts, how to apply external knowledge to the firm, and how to build an internal and external knowledge structure. This long social process requires interfaces in which the firm and intermediaries identify and resolve problems along the innovation process.

6.2.4.2.5 *Managing Interfaces*

As explained in the knowledge-enabling process, the first knowledge enabling regarding the wind-field-modelling technology was unsuccessful. In spite of the disappointing result, both parties were able to initiate the second knowledge

interaction when the firm needed support to explore the second business opportunity—smart PDUs. Researcher K in KISTI had maintained good relationships with the CEO and the chair, delivering necessary information on government-support programmes and regulations in the IT sector after the first knowledge interaction. During the interaction, Researcher K came to know that Firm H faced technical barriers to developing PDUs. The researcher introduced the firm to the supercomputing centre in KISTI to identify problems with the first model of PDU through the supercomputing-simulation programme. KISTI provided the market knowledge, together with the aerodynamic structure of the PDU, to the firm. In addition, the CEO maintained relationships with several GRIs (i.e. KETI, KARI, NFRI, and KBSI), which helped the firm constantly identify and resolve barriers during the innovation process.

The firm was able to access different types of services which brought benefits to the firm such as receiving additional funding for product development, shortening the R&D period, and bridging the gap between the firm and potential buyers. Considering GRIs as innovation partners, maintaining interfaces with multiple intermediaries was crucial for the firm as a mechanism to overcome the lack of capability of the firm. The interfaces acted as the conduit for constant knowledge interaction such that the CEO was able to absorb specific knowledge from each intermediary, deliver the experiences and knowledge to employees, and make the best use of them to develop the new equipment, contributing to enhancing the innovative capability of Firm H. The firm finally succeeded in developing the integrated equipment of rack and smart PDUs, which had the unique functions of controlling, monitoring, and storing temperature, humidity, and energy consumption. By adopting the new equipment, the data centres could manage the level of carbon emissions as well as energy consumption. Being certified as the Innobiz firm in 2012, the sales record of the firm reached US\$9.2 million, four times higher than in 2006.

6.2.4.3 Case Analysis

This case showed knowledge interaction between the public intermediary and the SME at the early stage of innovation, which started with the emerging need of Firm H, based on the barriers in knowledge and resources the firm faced when exploring

the new business area. Although the firm had business experience in the field of system integration for a long period of time, the relationships built in that field and technical knowledge were not helpful when the firm started to look for a new business area.

Like Firm H, many SMEs have an informal relationship with experts in academia and industry to overcome barriers, but the relationship does not decrease the barriers in the 4 or 5 years that are the maximum expected period for yielding profits. Informal relationships bring indirect benefits in the short run but may take a long period of time to yield positive economic outcomes. Few SMEs can survive while investing huge resources to cope with changes during the period. The problem for Firm H came when the R&D period of developing PDUs got longer without yielding profits. The firm needed various types of services such as R&D funding, technical support, and help discovering potential buyers. Marketing of the new product was not a problem because the CEO had good relationships with former customers in GRIs, whereas entering into business relationships with big buyers was a barrier the firm had to overcome.

How could an SME keep abreast of new knowledge in the innovation process? Engaging in formal programmes provided by the government to resolve the barriers and to shorten the distance with innovation players could be the answer. Table 6-11 shows the major events and changes that occurred as a result of knowledge interaction with public intermediaries.

Table 6-11 Major Changes in Firm H

Period	Key events	Changes
2001	Established the firm	Maintained the business in the field of system integration
2007–2008	Entered into knowledge interaction with KISTI to explore the new business area Entered into technological collaboration with the university	No changes occurred as a result of the knowledge interaction and technological collaboration Withdrawal from developing the wind-field modelling technology
2009–2010	New business areas found by the CEO Entered into technology collaboration with several GRIs	Active interaction occurred with GRIs and universities Achieved a technological goal in developing smart PUDs and smart racks
2010–2011	Produced the first and second models of smart PDUs Continuing collaboration with KETI to improve defects in the first and second models	Expanded buyers by targeting GRIs that delivered defects of the two models Established a research laboratory affiliated with the firm (2011)
2012	Continued interaction with multiple GRIs	Restructured the organisation to address the diverse needs
~ 2013	Developed 3rd models Received the supporting programme from KISTI (Technology Round Table)	Expanded relationships with potential players who operated big data centres

Firm H interacted with several GRIs throughout the innovation process. Impartiality and capability of innovation facilitators were crucial because the not-for-profit structure, assets, and social capital of the public intermediary allowed the firm to configure and align the necessary resources of an SME, regardless of the support period and interests representing specific parties. The KISTI, as one of the GRIs, had a large number of reports, databases, experts, and relational capital as a result of long-term government support. By engaging in the SME support programme together, KISTI could fill the knowledge barrier in the early stages and link the firm to other types of services and players, facilitating relations throughout the process. However, the status of the intermediary does not always guarantee successful knowledge interaction. If the intermediary loses its impartial position or lacks interaction with experts outside the intermediary in knowledge configuration, the knowledge interaction may not bring positive outcomes.

As shown in this case, knowledge enabling failed at first for two reasons: the supply view of the public intermediary, and a lack of knowledge interaction with the SME in articulating its demands. This caused a mismatch between the supplier's view of knowledge and the SME's demands. The researchers at KISTI overlooked the capabilities of the firm, and instead provided a simple analysis of the technology itself. The researchers seemed to lock their experiences and processes in configuring knowledge rather than considering the firm's capabilities, embedded in its experiences, which varies from firm to firm. The knowledge lacked a 'combination of competing rationality' of various innovation players, mainly relying on the knowledge from published reports and databases. Lack of multiplicity of interaction resulted in exaggerated prospects of the wind-field-modelling technology. In contrast, a problem arose in the firm, which maintained a passive attitude in knowledge interaction that deepened the one-way interaction from KISTI to the firm and hence resulted in failure to deliver the firm's needs. The researchers could not analyse the firm's technology and managerial capability.

However, trust-based relationships and reflexivity elicited a second opportunity for knowledge interaction from the initial failure in knowledge enabling and interaction. In this case, reflexive individuals or organisations played an important role in reopening and shaping the multiple levels of relationship. To look at the differences between this case and other cases in which the public intermediary failed in the knowledge interaction in the first place but then redeemed the mistakes in enabling the knowledge, some questions arise. Why did this case become successful after the initial failure? What are the differences that happened in the case? What are the crucial factors?

The first major factor that differentiates this from other cases can be explained as a technology-specific factor that affected different levels of relationship and interaction. The smart PDU is strongly affected by the IT-industry cycle, which is relatively short. The boundary between the early R&D stage and later commercialisation stage in the innovation process is unclear. Unlike in other cases, the firm could not fully depend on one intermediary, but needed to use several intermediaries, aligning them to its innovation process at nearly the same time. Timing was crucial and various kinds of

support, from R&D funding to testing the product in a short period of time, were necessary. The CEO believed large corporations could imitate the products in a few years, as they had done with other IT-related products. Also, competition among SMEs had become severe because many start-up firms emerged with innovative products in the sector. Developing innovative equipment may not have been enough for the firm and entering the market at the right time was key to gaining a competitive advantage.

To do so, the capability of the intermediary to configure the market-prospect knowledge, followed by developing potential buyers, was highly important. In particular, enabling a high level of accurate knowledge in a timely manner was more important than the depth or amount of knowledge because the level of market uncertainty was not very high. In this case, the network and reputation of the public intermediary played a crucial role in identifying potential big buyers and aligning them to the innovation process in a short period of time. This process bridged not only the knowledge barrier but also the credibility and relational barrier of the firm in a short period of time.

The second difference also concerned a technology-specific factor: the multiplicity of relationships on different levels of the support system. Unlike cases in the mechatronics industry, the interaction with many GRIs occurred simultaneously, not in serial order, due to the characteristics of the technology. As mentioned above, although the firm was willing to develop a new business, it still needed support in the short term and someone to help and share the risk. In addition to the knowledge interaction with KISTI, the firm was involved in joint R&D with KETI to fill the technological gap. Then, the firm used GRIs as proxy customers who were the customers in the system-integration business and had a good relationship with the CEO.

The GRIs delivered all the defects of the first and second models to the firm, influencing production of the final product: smart PDUs targeting big buyers. At the same time, the firm interacted with KETI to improve the performance of the models. When the firm came to have confidence in their product, KISTI organised a technology round table of potential buyers, policymakers, and GRIs, to share their

views on the business opportunities. Because KISTI had monitored and shared knowledge with the CEO in the innovation process, it was not a difficult issue to link an appropriate programme to the firm. The relationships evolved centred on multiple public intermediaries at meso- and micro-levels that resolved technological barriers constantly and provided interfaces with potential buyers (see Figure 6-4).

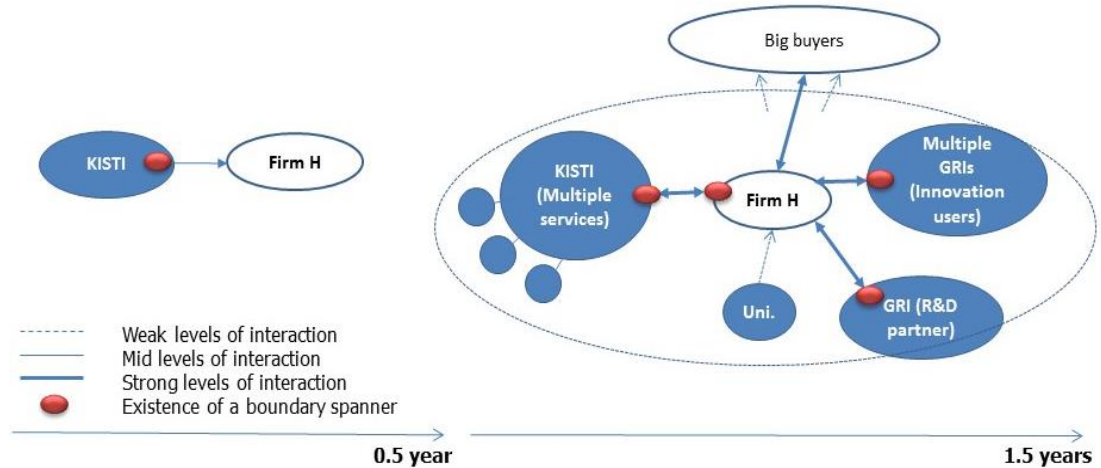


Figure 6-4 Firm H—Multiplicity of relationships and interactions.

Whenever the firm faced problems in the joint project, not only KISTI, but also other partners in the GRIs were more responsible than partners in private sectors in delivering feedback (i.e. defects or problems of the new equipment). Each public intermediary had its own strengths: KISTI provided knowledge; KETI was a R&D partner; and KARI, NFRI, and KBSI were proxy users. These complementary relationships with multiple levels of GRIs helped the firm overcome different types of barriers and achieve development of the new equipment in a short period of time.

This is one success factor of the knowledge interaction. Being together in the innovation process of the firm, they could link their activities closely and understand the activities more clearly. Furthermore, entering into multiple relationships could help the firm learn from the GRIs in the way the firm approached other services and researchers. Those services consistently bridged the barriers at every stage of innovation. More importantly, multiple levels of relationships and interactions with various players played an important role in launching the new product from

technology development to finding buyers. Although the first interaction brought disappointment, the learning initiated relationships again to overcome the weaknesses in the new business area: the computer rack and smart PDUs. In addition, the firm could take advantage of a good relationship with the KISTI and GRIs, using them as test beds before targeting big buyers in private sectors.

The case illustrates the barriers the firm has in the new business area. As can be seen from the beginning, the firm was willing to move to a new business area but lacked technical and nontechnical knowledge and the S&T expertise to explore the new business. The intermediary failed to enable knowledge based on a supply-side view of supports, transporting the knowledge to the firm unidirectionally, but then initiated the knowledge interaction, focusing on the firm's demand was likely to have good result in the near future. This knowledge interaction was possible because the CEO learnt about several government-support programmes during previous failure experiences and managed interfaces with public intermediaries. As a reflexive actor, the CEO saw an opportunity to use government support, even though the relationship with KISTI had failed in the first place. Instead, the CEO learned how to make the best use of government-support programmes and policies in the firm's business strategy, linking all the services in GRIs with the innovation process of the firm.

However, not only the CEO's attitude, but the CEO's experience and effort in learning paved the path to success. The CEO took a postgraduate course with the theme, wind-field-modelling technology, and on completing the course, started a Ph.D. programme. The coursework initiated an idea about the innovation process and how to align resources and relationships to the firm's business. Researcher K in the intermediary also learned from the first knowledge enabling, which turned out to be irrelevant for the firm. The researcher maintained the relationship with the CEO and delivered the information to the firm focusing on the demands of the firm. They were reflexive individuals who learnt from failures and were able to apply experiences in the second knowledge-enabling process.

The firm could build technological competencies in cooperation with GRIs. The learning capability of the firm could rebuild the knowledge infrastructure through interaction. The interaction led multiple public intermediaries to join in to resolve the

barriers the firm faced. The public intermediaries were able to consistently provide various types of services such as knowledge enabling, funding, using facilities (supercomputing), technology transfer, and technology roundtable. The not-for-profit status of the public intermediary played an important role in supporting the firm for several years at the early stages of innovation, especially when the firm hardly made profits and was unable to pay for the services.

Table 6-12 summarises barriers, outcomes and micro-level factors that resulted in one-way knowledge interaction at first but led to successful knowledge interaction when both parties entered into second knowledge interaction.

Table 6-12 The Result of Knowledge Interaction: Firm H (less successful)

		Summary of the interaction process
Barriers resolved	Internal	- Lack of technological capabilities - Lack of technological and nontechnological knowledge
	External	- Lack of relationships with big buyers
Outcomes	Internal	- Establishing three departments - Acquiring new technical and nontechnical knowledge
	External	- Expanding relationships with GRIs and big buyers
Micro-level factors	Firm	- Learning and marketing capability of the CEO - Long-term trust-based relationships with multiple GRIs - Existence of reflexive individuals
	Process	- Multiplicity of relationships with GRIs - From one-way knowledge flow to multidirectional knowledge interaction - Productive combination of competing rationality
	Intermediary	- Various types of support programmes provided by multiple GRIs at nearly the same time - Existence of reflexive individuals
Current status		- Used failed experiences to develop another business opportunity, occurring at the time of interviews

6.2.5 Case 5: Firm M

In this case, the firm used knowledge services provided by KISTI in 2008; this relationship continued until the firm closed down in 2011. The knowledge interaction centred on ‘multiview and photography based 3D scanning technology’, which was the major business area of the firm from its inception (Table 6-13).

Table 6-13 Overview of Business

The firm developed multiview and photography-based 3D-scanning systems to measure body fat, body frame, body shape etc.

Major products are

- Body Scanning Systems: The system scans the entire body in few seconds and uses the image to make fit and sizing predictions, create avatars for 3D virtual fit, and produce custom garments. Scan data can be used across industries such as fitness training, weight-loss tracking, and pre and postsurgery medical applications.

Source: Adaptation from the interview script with the CEO.

6.2.5.1 History of the Firm

Firm M, established in 2006, specialised in a photography-based 3D-scanning system. The CEO had worked as a consultant for a global consultancy in the United States for more than 10 years before becoming special economic advisor to the South Korean President in 2003. During this period, the CEO succeeded in building broad formal and informal networks throughout Korea. Although the firm did not initially have any technological infrastructure, the CEO believed the firm could make the best use of IT infrastructure as well as the CEO's networks in Korea. Using these relationships, the CEO was able to attract angel investors to help develop the 3D-scanning system to measure body fat and size (e.g. obesity rate, skeletal muscles, and basal metabolic rate).

Between 2006 and 2008, the CEO employed qualified graduates with backgrounds in engineering to carry out in-house R&D. At the same time, the CEO developed potential customers by targeting hospitals after entering the market at the right time, one of the main factors in the firm's success. To bridge the technology gap, the firm entered into joint R&D with a university developing 3D-measurement technology. However, no proper process or methodology existed that could transform and integrate external knowledge into the firm's innovation process. Lacking in business experience and internal resources for this new field, the CEO experienced difficulties in carrying out additional R&D, as well as in marketing and operating the firm.

Although there were few major global corporations in the industry, some innovative SMEs were likely to enter the 3D-scanning-system market a few years after the firm initiated R&D. Because the firm aimed to compete with laser-based foreign products using its photography-based products, the timing of market entry was an important

factor in enjoying first-mover advantage. Knowledge regarding market feasibility, competitors, and regulations was a major barrier to be solved at the same time, along with securing funding for additional R&D. In particular, the CEO put greater emphasis on bridging the technology gap than on other factors because the firm had relationships with potential customers. The CEO, therefore, started seeking professional intermediaries for their expertise.

6.2.5.2 Knowledge Interaction Process

6.2.5.2.1 Engagement of Public Intermediaries

The CEO contacted KISTI, followed by SMBA and other intermediaries.

- SMBA: The Innovation Sponsor

The role of SMBA was the same as in the case of Firm H.

- KISTI: Innovation Facilitator

The role of KISTI was the same as in the case of Firms K and P.

- Other Intermediaries

The IF and one design company took part in the innovation process. The ETRI, a GRI, participated in the technology-transfer process.

6.2.5.2.2 Knowledge Enabling

Researchers from KISTI participated in the process of knowledge enabling and articulated the demands the firm would face in developing this technology. When the firm started a knowledge interaction with KISTI, it had a research contract with S university regarding 3D-measurement technology. Developing a 3D-scanning system required not only 3D-measurement technologies but also system building and application technologies that could process the data and produce an image. The CEO employed qualified experts to develop the application technology while seeking GRIs to receive the 3D-imaging-process technology. This situation resulted in a lack of funds, and the CEO became interested in acquiring funding rather than the knowledge itself, even though technical and nontechnical knowledge gaps continued.

Based on their interaction with the CEO, researchers assumed the firm could be successful if more funding was provided for additional R&D. Moreover, the researchers seemed to place too much confidence on the networking capabilities and reputation of the CEO. This view resulted in the researchers overlooking knowledge interactions with potential innovation players such as policymakers, GRIs, and potential buyers. As a result, knowledge was combined under two assumptions: the technological capability of the firm was such that they could manufacture the final product without failure; and the managerial capabilities of the CEO meant the firm could align all the necessary technologies into the innovation process successfully. Lacking an in-depth knowledge of the firm's capabilities, the researchers provided it with a rosy picture of the future of 3D-scanning systems.

In addition, the researchers did not appear to have any interaction with experts or potential buyers, and only used reports and databases from KISTI. They simply combined this knowledge into exactly what the CEO wanted, overlooking any obstacles the firm may have had to face in the innovation process. The researchers and the CEO believed the firm would be successful in developing the scanning system that might generate economic outcomes. This resulted in enabling a poor quality of knowledge. The CEO remarked,

Whomever I talked to, I knew more about 3D data processing than they did. My employees or the researchers in GRIs did not have enough knowledge, which was frustrating. In terms of KISTI's report, I assume the analysts produced the report based on my knowledge and their communication with me. There was nothing new in the report.

The CEO's disappointment at the level of knowledge caused hesitation in interactions with the researchers, which hampered ongoing learning and trust building. However, the CEO had a very passive attitude and had not sent feedback to the researchers, resulting in a one-way knowledge flow from the intermediary to the firm. Although the CEO was dissatisfied with the report, the CEO requested no additional information or knowledge. He added, 'I did not know myself [what the problem was] at that time. Although my intention was to get the funding rather than acquire the knowledge, the researchers should have let me know that those goals might not be achieved.' The CEO considered this failure of knowledge interaction to

be due to the ambiguity of knowledge, but could not see the problems caused by a unilateral knowledge interaction.

Based on their two assumptions, the researchers overestimated the firm's technological and managerial capabilities, which contributed to securing the R&D funding from the SMBA. This helped the firm invest in additional research on the 3D-body-scanning system. However, problems arose when, contrary to expectations, the research contract with one university failed to develop image processing. This outcome, in turn, negatively affected the profit structure of the firm, as it meant the product launch was delayed. Under increasing pressure from the angel investors, the CEO made use of other intermediaries to fill the technology gap and yield profits. At the same time, the CEO brought forward R&D inside the firm and decided to receive technology from a GRI that had a good reputation in the field.

6.2.5.2.3 Facilitating Relations

KISTI introduced a programme sponsored by the IF through which firms could receive design support along with help in building a business model. First, the firm applied to the 'Total Design Support' programme sponsored by the IF, grafting technologies onto design to create a new business model. One famous design company took part in the programme as a partner of the firm, and focused on materialising the design rather than the firm's status at the time. Although the firm was able to produce a 3D-upper-body-scanning system that could yield initial profits, the design firm insisted on designing and manufacturing a 3D-full-body-scanning system because it would have more design value. KISTI advised the CEO to produce the 3D-upper-body-scanning system in advance and observe the response from the market. Because the CEO had a negative attitude towards KISTI (based on initial disappointment with their work), the CEO was reluctant to follow their advice and decided to adopt the new business model suggested by the design company. This required additional R&D, more funding, and more time, and the firm had to address the situation without generating any sales. Such a risky decision led the CEO to enter into a relationship with ETRI.

The CEO signed a contract with ETRI for the transfer of multiview-photography-based 3D-image-processing technology that could visualise the scanned object on the screen. Lacking in technological knowledge, the CEO was unable to have an informed discussion with the researchers at ETRI. Instead, employees took part in the interactive process, but this was a unilateral transfer of knowledge rather than genuine interaction. The engineers were less active than the CEO in developing the system. When the CEO received the technology, it was imperfect and required additional R&D to visualise the scanned object. From that moment, some arguments arose between the firm and ETRI regarding technology readiness. Because the signed contract had not indicated any detailed technological requirements, the firm could do nothing, leading to a second failure in filling the technology gap.

The CEO explained,

I had potential customers for the scanner and funds for manufacturing. If the technology had met my expectations, I could have sold the products to the National Health Insurance Corporation and health centres throughout the country. As I could not provide the products, I lost all the trust I had built, and this is linked to the failure of the business.

There were limits as to how much KISTI could mediate this problem for two reasons: first, the researchers at both public intermediaries seemed to be reluctant to have communication with each other because KISTI was not the organiser for the technology-transfer programme. The lack of a programme coordinator hindered the facilitation of interaction, especially when both parties had problems; second, the CEO seemed not to have interest in support from KISTI at the beginning because of experiences of knowledge service that fell short of the CEO's expectations.

Although the CEO tried to align all the resources in the innovation process, the support programmes of KISTI, IF, the design company, and ETRI did not link effectively. The design company seemed to have interest in the value of the design itself rather than the commercial side of the product, whereas ETRI was more likely to focus on technology-transfer activities, which was the main reason for collaboration. Individuals involved in the interaction were not responsible for bridging the barriers that had resulted in poor quality services. However, problems

also arose when the CEO received knowledge service from the intermediaries but did not use it actively to improve the services for which he was responsible. The CEO said,

Many government agencies have good programmes but it is my responsibility to organise all the support. Now I can tell I should have been more proactive in telling them what I wanted. Even so, if there had been someone or an organization that could have controlled the process or monitored the services, then that would have been much better.

The knowledge interaction among all intermediaries was not active, and the firm's knowledge gap remained the same. Continuous failure led to angel investors leaving, bringing about financial difficulties for the firm. To make matters worse, the firm had to return funding to the SMBA because of its R&D failure. As a result, employees started to leave, one by one, followed by potential buyers. As the firm had lost its internal organisational structure along with its external relationships, it was forced to close down in 2011, just before product commercialisation could begin.

6.2.5.2.4 Facilitating Learning

Unlike the other four firms, Firm M lacked accumulated experiences in R&D and businesses and this lack of capabilities seemed to affect the pattern of knowledge interaction with public intermediaries. Knowledge interaction mostly took place unidirectionally from each intermediary to the firm and there was lack of communication between the CEO and employees. Facilitators did not exist and as a result, learning did not take place throughout the knowledge-interaction process.

6.2.5.2.5 Managing Interfaces

The interfaces between intermediaries and the firm for delivering feedback, accessing additional services and human resources to each intermediary, and adapting the new knowledge to Firm M's context were not managed well.

6.2.5.3 Case Analysis

This case shows knowledge interaction between a public intermediary and an SME at the early stages of innovation. The firm sought knowledge services to overcome the barriers in its capabilities. When it decided to develop a new product aimed at

competing with global products, it did not have an adequate infrastructure. There was little knowledge about a ‘photography based 3D scanning system’ and it was not possible to approach global corporations to obtain knowledge regarding the level of technology, expected competitors, research trends, related organisations, and potential customers. Like CEOs of other SMEs, the CEO chose public intermediaries to bridge the knowledge barrier at the early stages of innovation. The major events and changes in the innovation process are summarised in Table 6-14.

Table 6-14 Major Changes in Firm M

Period	Key events	Changes
2006	Entered into technological cooperation with the university	Failed in achieving a technological goal within the timeframe
2008	Entered into knowledge interaction with KISTI	No changes occurred Received R&D funds from the SMBA
2009	Entered into a relationship with the IF and the design company	Designed the entire body scanner but did not link to product development
2010	Entered into a cooperative R&D relationship with a GRI	Failed to achieve a technological goal within the timeframe Failed in commercialisation
2011	Withdrew funds due to the failed R&D	Closure of the business

The knowledge was provided, followed by funding, but the firm failed because it did not succeed in overcoming technology barriers. Because the ‘multiview and photography-based 3D image processing technology’ for the body-scanning system was the core technology for the final product, the ostensible reason for closing down the business was the failure of technology transfer, indicated by the CEO. However, analysis of the interaction process revealed some interesting factors other than mere technology gaps.

The firm was successful in developing optical, electronic, and electric technologies, and was capable of manufacturing a 3D-upper-body-scanning system, so why did failure of technology transfer cause the firm to close down? It is questionable whether technological and managerial barriers could be overcome. If the firm had manufactured the 3D-upper-body-scanning system in the first place and generated profits, the situation might have been different. If the CEO was capable of securing

potential customers while starting R&D, it begs the question as to why the firm closed down.

One reason for failure relates to the firm's abilities to interact with new knowledge and absorb it. In other words, no routines were in place for learning in the firm because the firm was a new start-up and did not have any business experience, which hindered the interaction of the CEO with employees, as well as that of the firm and other organisations. Unlike CEOs from the four cases that had long period of technological or marketing experiences before they explored the new business areas, the CEO of Firm M did not have any expertise in the new area.

In most cases, the CEO received the knowledge passively and did not translate it into the firm's innovation context. The CEO did not think that accuracy of knowledge was a problem as long as the firm could obtain funding for additional R&D. Taking a linear view of innovation, an inability to communicate and absorb external knowledge not only resulted in passive one-way interaction with intermediaries, but also in an inability to maintain relationships with potential players.

A lack of routine also affected communication with employees inside the firm. Unlike CEOs from successful cases, who facilitated knowledge interaction inside their firms, the CEO put little effort into communicating with employees. The CEO did not transmit a sense of urgency to employees; thus, employees were unable to act as bridge builders when the CEO experienced problems with intermediaries. Formal and informal communication channels did not appear to work well, hindering interactive learning and maintaining the barriers inside and outside the firm.

Characteristics of the technology and multiplicity of relationships provided another reason for failure. The 3D-scanning technology was to replace laser-based scanning technology soon after the firm started R&D. The CEO was well aware of the market, where potential competitors would emerge in a few years. If the CEO had been successful in developing the 3D-photography-based-scanning system as planned, and had entered into the market earlier than potential competitors, the firm could have dominated the domestic market. Therefore, the CEO entered into relationships with

multiple intermediaries to address rapid changes in the market and a lack of resources.

It was crucial to obtain support from multiple intermediaries to fill the various barriers—from technology development to design and marketing—in a short time. To do so, two factors needed to be fulfilled during the innovation process: the capability of the intermediary to configure the credible knowledge and the alignment of multiple relationships in the innovation process. In particular, enabling a high level of credible knowledge in a timely manner was more important than the depth or amount of knowledge, as the level of market uncertainty was not very high. In aligning all the services, KISTI linked the firm to the programme sponsored by the IF through which it could enter into a relationship with a design company. In addition, the CEO signed a contract with ETRI to receive technology to shorten the R&D period. Relationships were formed at meso- and micro-levels but the levels of interaction among organisations was not active, showing one-way knowledge flow (see Figure 6-5).

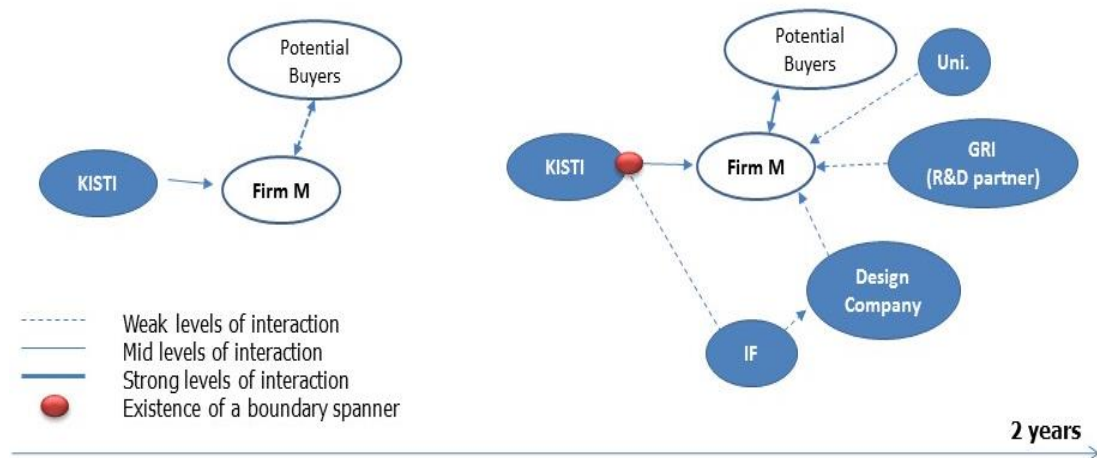


Figure 6-5 Firm M—Multiplicity of relationships and interactions.

Relationships seemed quite successful at first, but problems emerged during the interactive process. The first of these was the CEO, who linked all the services but focused mainly on technology development, ignoring knowledge interaction with intermediaries. It seemed the CEO believed the degree of completeness of technology might guarantee commercial success and this thought hindered constant

knowledge interaction in the complex innovation process. Because the firm was capable of producing the 3D-upper-body-scanning system, one researcher at KISTI advised the CEO to produce this system to yield initial sales, which would also cost less than developing a whole-body scanner. The researcher from KISTI added,

I advised him several times to produce the upper-body scanning system, but he decided to invest in developing the whole-body scanner. It was too risky to invest more money in R&D without sales for several years. I think he was unable to assess the quality or credibility of the knowledge he received.

The CEO may have been disappointed with the knowledge service provided by KISTI, but it was the CEO who had insufficient interest in that knowledge, preferring to focus on funding. Learning did not occur as knowledge tended to flow in one direction and the CEO's views remained unchanged as a result.

Similar problems arose when the firm signed the contract with ETRI for technology transfer. There was no clear consensus over the level of technology readiness for commercialisation and the CEO simply believed in the name of the GRI, a unique organisation that owned the photography-based 3D-image-processing technology. This resulted in a second failure of knowledge interaction and a failure to fill the knowledge gap. The CEO noted,

I carried out a marketing survey but I wanted to get an objective opinion from industry experts. Should I not have trusted the design company? Should I not have trusted GRIs? I do not think so. If they had acted responsibly, or if there had been someone who could have monitored them, I would not have had to close down the firm.

However, the CEO made a choice based on his own instincts (rationality) rather than on interactions with employees or intermediaries at multiple levels who had different competing knowledge. This resulted in fragmentation of relationships and services rather than their alignment.

The second major problem was the wholehearted trust the CEO placed in public intermediaries. As other cases have shown, trust can only be built when there is responsibility, credibility, and a quality of knowledge. The status of the intermediary does not always guarantee successful knowledge interaction. If the intermediaries

lose impartiality, they can easily lead SMEs in the wrong direction, delaying innovation. In this case, misplaced trust resulted in the provision of a poor level of knowledge, damaging the trust-built relationship. By losing their credibility, KISTI became limited in their ability to facilitate relations between the firm and the design company.

The third factor was the one-way knowledge flow and the mismatch between knowledge demand and supply. The one-way knowledge flow caused several problems. Crucially, researchers failed to assess the firm's capabilities. Due to a lack of experience, the CEO could not envisage what the firm might face during the innovation process. Considering the firm's 2-year history, funding would only have bridged the technology gap but would not have solved other issues such as the relational and managerial barriers. In particular, intermediaries should have outlined the technological barriers the firm would face during the innovation process. For example, the firm aimed to compete with foreign products in Korea. That being the case, KISTI should have provided knowledge about who owned state-of-the-art technologies and an accurate assessment of them. It was also the intermediaries' responsibility to provide access to the experts and facilitate interaction so the firm could successfully shape its innovative environment.

Instead, the researchers followed the CEO's interests in securing the funding rather than enabling the knowledge. From a linear view of innovation, the researchers appeared to overestimate the abilities of the CEO, ignoring whether the firm could absorb and reconfigure the required knowledge. They followed their routines of analysis work based on the supply-side perspective. One researcher at KISTI involved in the interaction process admitted, 'We thought our role was to provide technology market expectations and help them obtain funding. The design company was interested in designing the new product itself, and ETRI was interested in technology transfer activity.'

The fourth major problem was the lack of productive combination of competing rationalities; a healthy mix of different views. The researchers appeared to make a mistake in forecasting the future market by interacting solely with the CEO rather than with multiple levels of innovation players. This lack of differing viewpoints

resulted in limited knowledge that misled the young firm and hampered any chances of positive prospects for its 3D-scanning technology. The researchers at KISTI analysed the technology theoretically and talked about the promising aspects without interacting sufficiently with the technology developers. The CEO explained,

The analysis should have considered two different views, one of which was the profitability of the technology, which was important to me. The report was good in that aspect. But they neglected the other view which was the technology's credibility. They should have analysed the level of technology development, and whether it was enough to commercialise if it was transferred.

It seemed both the intermediary and the firm overlooked multiple levels of interaction, emphasising the technology itself. As was shown in this case, knowledge interaction did not bring changes for the following reasons:

Along with the weak, one-way interaction, the enabled knowledge was not credible enough to fill the firm's knowledge gap. It is likely that the firm's lack of knowledge and poor levels of interaction with other innovation players in knowledge configuration led to a mismatch between the knowledge supply and demand. However, the firm maintained a passive attitude during the knowledge-interaction process, deepening the one-way interaction from intermediary to the firm, thereby failing to meet its needs. Researchers could have analysed the firm's technology and managerial capability. Furthermore, intermediaries and the firm had a very narrow, linear view of innovation, believing that funding for R&D would guarantee commercial success for the firm.

As a result, the interaction did not lead to any changes in the approach of the firm or the CEO, who seemed to have a similar attitude towards all intermediaries. In addition to the firm's limited resources, a lack of experience meant the CEO had to rely on knowledge from personal limited experience. Unlike other CEOs, this CEO believed that technological capability was the essential factor and overlooked other knowledge necessary in the innovation process. Although the first interaction was unsuccessful, the firm failed to learn from its mistakes, and the barriers remained the same (Table 6-15).

More importantly, multilevel relationships with a one-way interaction did not bring about changes. No capable boundary spanners existed in the multiplicity of relationships, as KISTI was limited in providing links to all services for two reasons: the CEO's dissatisfaction with the knowledge provided meant the CEO was reluctant to interact, and a lack of formal programmes for interaction existed. Although the CEO tried to play the role of boundary spanner, the CEO was unable to align to the innovation process.

The barriers, innovative outcomes, and micro-level factors that affected the unsatisfactory knowledge interaction are summarised below (Table 6-15).

Table 6-15 The Result of Knowledge Interaction: Firm M (Failure)

		Summary of the interaction process
Barriers remained	Internal	<ul style="list-style-type: none"> - Lack of routines to absorb, integrate and transform external knowledge into the firm's innovation process - Lack of technological capabilities - Lack of nontechnological knowledge
	External	<ul style="list-style-type: none"> - Lack of relationships with GRIs
Outcomes	Internal	<ul style="list-style-type: none"> - None
	External	<ul style="list-style-type: none"> - None
Micro-level factors	Firm	<ul style="list-style-type: none"> - Lack of interaction between the CEO and employees - Lack of experience in the existing business area - A breakdown in trust between individuals in GRIs and the CEO, and between GRIs and the firm
	Process	<ul style="list-style-type: none"> - Lack of interaction between intermediaries and the firm - One-way knowledge flow from intermediaries to the firm (lack of feedback) - Lack of linkages among multiple intermediaries and their services
	Intermediary	<ul style="list-style-type: none"> - Lack of multiplicity of interaction in knowledge enabling - Absence of individuals who could have linked all the services in GRIs with the innovation process of the firm - Linear view of innovation from the intermediary and the firm
Current status		<ul style="list-style-type: none"> - Closed the firm

6.3 Case Summary and Initial Conclusions

6.3.1 Evolution of Knowledge Interaction at Meso-and Micro-levels

In this chapter, I observed the knowledge-interaction process of five SMEs to answer the first, second and third research questions. To open the black box of the interaction process at specific levels of the KNIS, I combined other disciplines—intermediary studies and sociological dimensions—into the NIS concept to aid in investigating how knowledge flow takes place at meso- and micro-levels, decreasing the barriers in the innovation process. Knowledge interaction in five cases involves more than two parties as simply identified in the NIS concept (Section 2.4.1). The relationships evolve around multiple intermediaries and potential buyers over time to address the heterogeneous barriers of SMEs.

Multiplicity of relationships at meso- and micro-levels is crucial to overcome the various barriers at the early stage of innovation or niche markets that innovative SMEs plan to explore because less information exists on the area. In this case, the multiplicity of relationships and interaction provide an opportunity to combine competing rationalities of individual minds and knowledge relating to very specific areas (or local problems). Actors involved in the knowledge interaction often co-shape a favourable innovation environment where multiplicity facilitates interactive learning among actors, resolving disagreements among actors, and removing the barrier to a particular problem of innovation. This process may initiate other problems that typically require different types of relationships and knowledge in the uncertain and complex innovation process.

From this point of view, innovation can be seen as a cyclical process of trial, failure, and resolving the barriers to innovation; therefore, specific knowledge requirements and relationships need to shape and evolve along with the process. The loose NIS framework has not yet fully explained this dynamic nature of the system but examining the interaction process at meso- and micro-levels seems to unpack the different patterns of relationships. Although evolution patterns of relationships differ from five firms, two different fields of technologies have similar patterns of knowledge interaction (Table 6-16).

Table 6-16 Different Patterns of Relationships: Mechatronics vs. IT

	Mechatronics	IT
Demands of firms	- Technological and nontechnological knowledge - Identifying potential partners	- Technological and nontechnological knowledge, testing products, discovering potential partners, additional R&D, and marketing
Characteristics of sectors	- High level of uncertainty - Lack of available information	- Medium to low level of uncertainty - Existence of technological information and infrastructure
Evolving patterns of relationships	- Centred on few intermediaries - Strong levels of interaction	- Multiple levels of intermediaries addressing various demands
Period of interaction	- 4 to 5 years	- Less than 2 years

In particular, the cases belonging to mechatronics are differentiated from the cases belonging to IT. In the case of mechatronics, as stated in Chapter 4, the technology is characterised by a combination of mechanics, electronics, and other technical fields. Because the firms in this field try to create new markets or products that are able to replace existing ones, the process entails a relatively high level of uncertainty in emerging areas. Firms K, P, and T spent a long period of time in planning, R&D, and market research as potential partners of large global corporations, but they did not know whether this pathway would lead them to successful innovation. The emerging areas require different sets of players, regulations, expertise, and skills, and these become huge barriers for the firms to overcome. Most of all, less information and knowledge is available at the early stages in this field, and private consultants may avoid becoming involved at this stage due to the vagueness of expected outcomes. Thus, a frequent and strong level of interaction with public intermediaries is crucial to articulate demands and address the diverse requirements of innovation during the interaction process. As a result, the pattern of relationships focuses on a few intermediaries, but with relatively long-term interactions.

The firms in this field tend to require high-quality knowledge and align the potential innovation players to hedge the risk, which takes 3–5 years in the knowledge-interaction process. In the cases of Firms K and T, actors involved in the knowledge-interaction process shaped the innovation and created new business opportunities together. Long-term interaction is also crucial for SMEs because they may bring

more learning opportunities to firms, so individuals might replicate the problem-solving process to address the unexpected problems they may face. Due to the high level of uncertainty in emerging markets and for innovation players in the field of mechatronics, managing the interface with intermediaries is important to address changes in the innovation setting in the uncertain innovation process. In this sense, managing the interface acts as a conduit for the process of identifying and resolving barriers through ongoing interactive learning.

In the field of IT technology, SMEs have easy access to the accumulated technological infrastructure, compared to firms in the field of mechatronics, whereas the competition among SMEs is quite intense. As illustrated in Chapter 5, a large number of IT ventures were established in the early 2000s as a part of a government-support policy to foster the IT sector and small venture businesses in this field. As a result, abundant accumulated infrastructure exists at the industry level in technologies, funding, information, support policies, and programmes. The level of uncertainty in the future-technology market is less high than in the case of mechatronics, due to a relatively short product life cycle and, consequently, entry timing to the target market is crucial for SMEs to gain competitive advantages over potential competitors. In this case, the services required at the early R&D stages and the later commercialisation stages in the innovation process need to be provided at nearly the same time to overcome barriers in a timely manner; the service provision can be R&D funding, testing opportunities for new ideas, technology transfer, or aligning potential buyers.

Multiple levels of relationships evolved, centred around GRIs, to meet the various demands of SMEs. For example, GRIs could take the risk on behalf of SMEs and act as proxy users in the case of Firm H. Interaction with GRIs gave Firm H a certain period to test and enhance the quality of the new equipment for global markets. In this case, a single intermediary was unable to provide all the services needed to complement and enhance its own services, which were limited, to address diverse barriers in a short time. Therefore, managing the interface with multiple intermediaries seems to be more important than long-term interaction with a few focused intermediaries to make sure all services (e.g. testing products, discovering

potential partners, additional R&D, and marketing) are simultaneously well connected. In the field of IT, aligning the resources and actors takes 1–2 years whereas it takes 3–5 years in the field of mechatronics.

In the case of Firm H, the CEO was capable of aligning different types of intermediaries (mostly GRIs) to overcome the weaknesses the firm faced in the targeted market. The CEO monitored the process and actively requested what was needed from intermediaries. However, in the case of Firm M, neither the CEO nor intermediaries monitored the whole process of alignment of resources and actors. Although the firm was successful in identifying all the necessary resources and actors at the beginning of the innovation process, the weak linkage resulted in poor knowledge interaction. Consequently, the innovation process of trial, failure, and solution was not observed and the barriers to innovation remained the same. From this point, monitoring the innovation process is crucial to connect all actors and facilitate efficient knowledge interaction among them.

6.3.2 Influential Factors Determining the Innovation Process

Section 6.2 tacitly explained that intermediaries supported SMEs externally around the four dimensions that have been pulled out for analysis: facilitating relations and managing interfaces (i.e. linking SMEs to other GRIs or potential buyers), thereby enhancing the external capability of firms. Long-term interactions with SMEs during the process of knowledge enabling and facilitating learning helped firms build internal capabilities. These are described as outcomes in five tables: the result of knowledge interaction. The section further identified several factors that differentiate patterns of interaction and relationships, thereby bringing a certain level of change to the firm. Although factors differed by firm, some influential factors determining the innovation process could be summarised at the level of firms, intermediaries, and interaction processes.

First, specific resources that SMEs accumulated in their history have positive (or negative) impacts at the organisational level: learning routines and capabilities, technological strengths, relationships, levels of urgency, and vision. Firms K and P had been suppliers of big buyers (or GRIs) for more than 10 years and these two

firms had accumulated technological, managerial, and learning capabilities through these relationships. These SMEs are able to manage interactive relationships, giving frequent and active feedback to intermediaries. Learning routines embedded in these firms seem to have positively impacted the knowledge-interaction process and thereby brought changes inside firms. In contrast, lack of learning routines of Firm M hindered knowledge interaction and interactive learning with intermediaries and, as a result, little change occurred. The technological, managerial, and learning capabilities of the five firms differed and these differences affected knowledge interactions with intermediaries.

Second, capability of public intermediaries and their constant supports to resolve the barriers seemed to have significantly impacted positive changes in firms. Public intermediaries are equipped with intellectual materials, experts, and supporting experiences with firms. They are capable of shaping a network with other actors to address the heterogeneous barriers throughout the innovation process. As explained in Chapter 5, public intermediaries, as linkage organisations in the KNIS, generate new knowledge, connecting all the actors and addressing barriers of firms. Therefore, public intermediaries can be the innovation partners of SMEs because their members' capabilities specialise in identifying barriers and responding to the challenges faced by SMEs in the KNIS.

For example, Firms K and P had technological capabilities in existing business areas but existing relationships with big buyers may not be helpful in acquiring necessary knowledge in the new business area. According to the cases, knowledge hardly flows through relationships or interactions from big buyers to SMEs unless SMEs are able to offer valuable information to big buyers. In addition, the more SMEs are innovative in certain fields, the less knowledge is available at the early stages of innovation. In this case, participation in support programmes provided by public intermediaries can be opportunities for SMEs to overcome the lack of capabilities and resolve heterogeneous barriers at the early stages of innovation.

Third, two influential factors were essential at the process level: the existence of reflexive individuals and a productive combination of competing rationalities. The existence of capable individuals who are more reflexive and learn faster than others

is important. In SMEs, most of these capable individuals were CEOs who had experienced several failures in the past and took the experiences for granted in the innovation process. In common, they had a wide network throughout the industry and research institutes, providing learning opportunities for them. They acted as boundary spanners, providing an interface for interactive learning through which firms could constantly access various services in intermediaries, and thereby absorb and reconfigure the knowledge in their own context. Trust building among actors is a crucial factor in constructing the quality of relationships that facilitate active knowledge interaction and learning. Reflexive individuals in intermediaries and firms played a crucial role in bridging the different boundaries of organisations in the knowledge-interaction process.

Productive combinations of competing rationalities were crucial in knowledge-interaction processes because the combinations involved experience, skills, and knowledge embodied in individuals. Knowledge was not simply technological but also social, concerning the technology-development process that linked with routines, expertise, regulations, and management systems taking the specific form of knowledge to individuals. Four successful and less successful cases illustrated that researchers at intermediaries had a multiplicity of relationships in the knowledge-interaction process, whereas researchers depended on their own knowledge without interaction with external experts in the failure case. This difference implies the successful process requires interaction among multiple levels of knowledgeable individuals who have not only technological knowledge, but also insights and experience to address uncertainties in the early technology market. This section demonstrates influential factors that affect the innovation process at the level of firm, intermediary, and process.

As summarised in five tables on the results of knowledge interaction (see Section 6.2.), five firms were heterogeneous in innovative capabilities, which resulted in different demands of knowledge and barriers. In other words, micro-level interaction processes differed by firm. Some firms might need more diverse services than others. The range of services provided by public intermediaries might increase over time, in addition to providing the four functions. The following chapter will explore the role

of public intermediaries in specific contexts: how they address the dynamic and uncertain nature of the innovation process, which has not been well defined in the NIS literature.

7 Chapter 7. Public Intermediaries: Creating Dynamics in the KNIS

7.1 Introduction

Chapter 5, in describing the history of KNIS, emphasised the role of public intermediaries that act as non-market mechanisms to correct systems failures, stimulating knowledge interaction by enhancing the innovative capabilities of SMEs. Chapter 6 examined the knowledge-interaction process and the constraints between intermediaries and five SMEs. The knowledge-interaction process between public intermediaries and SMEs addresses a number of challenges and constraints, such as the limited capability of SMEs to access other actors and resources reflecting the heterogeneous knowledge requirements at the early stages of innovation processes. In this context, the previous chapter analysed five cases, each with different demands on knowledge and relationships in the innovation process, due to different types of internal and external barriers arising from a lack of capabilities.

This assemblage of heterogeneous barriers and constraints leads SMEs to depend on credibility and reputation of public intermediaries in the KNIS. This chapter observes how four functions of public intermediaries can be expanded or multiple levels of (public) intermediaries collaborate to address various types of barriers and how public intermediaries act as innovation facilitators, augmenting capabilities of SMEs. Then the chapter includes criticism of the linear view of innovation underlying supporting policy, which tends to consider innovation too simply, overlooking the wider dimension of innovation that can be achieved by a DUI mode of learning. Hence, this chapter argues that perspectives between policymakers and SMEs misalign.

Section 7.2 considers how SMEs define innovation as a process that involves a number of failures and constraints, and covers a wide range of activities such as technological progress, exploring markets and customers, and organisational changes. This section describes the characteristics of functions that are open and flexible, due to the uncertainties and complexities embedded in the innovation process. Next, I investigate the strengths of public intermediaries that facilitate innovation at the

systems level in Section 7.3, which examines how these intermediaries augment the innovative capabilities of SMEs at the early stages, maintaining constant knowledge interaction with multiple actors and facilitating a mutual-learning process. Section 7.4 puts forward the option of public intermediaries focusing on their role as linkage organisations in the KNIS, and explicates unresolved issues. The perspectives of the innovation concept between policymakers and SMEs misaligns. Section 7.5 highlights the nature of knowledge interaction as *a process*, with some policy considerations.

7.2 What is Meant by (Successful) Innovation?

7.2.1 Innovation: From Narrower to Wider approaches

The previous chapter examined the knowledge-interaction process and its effect on innovation for SMEs. Some SMEs are successful in innovation whereas others are not. Therefore one may ask how SMEs define successful innovation and what SMEs define as its characteristics. As defined in Chapter 4, this study adopted a wide approach to innovation following Schumpeter, which corresponds to the view of CEOs. Many interviewees had a similar view of innovation as ‘something new’ that ensures sustainable growth in the long run, rather than a ‘quantum leap’. From an SME point of view, innovation means not only technological progress but also expanding relationships, exploring new markets, and organisational changes, all of which bring changes to organisational infrastructure and individual behaviour in the long run: a wider DUI mode of innovation.

The CEO of Firm K said,

All employees need to know the management system [what is happening in the firm] as active participants in the innovation process. To create the best company, I believe all employees need to think differently and that their way of working also needs to change. All individuals in the firm are able to create value. Innovation is fostering the company as a space for creating value.

The CEO at Firm A affirmed,

Policymakers consider innovation as radical change accompanying intense pain. We regard exploring new markets and new customers also

as innovation because it ensures the sustainable growth of firms. You have no idea how many years of effort I have made to form relationships with new customers.

The explorative paths of the new venture varied among the five firms described in the case studies.

As explained in Chapter 5, innovative SMEs do business in risky, uncertain, and unique areas where ideas on technology are vague and innovation players have not yet been identified. SMEs are heterogeneous in history, technological expertise, routines, and relationships; factors that may shape different innovations. Thus, innovation can be seen as a unique, localised process, embedded in components and individuals in firms interacting with sociotechnical actors and conditions in the system. In this regard, the CEO at Firm E stated,

Policymakers always emphasise the importance of being the best SME in the world as the result of government support. But ironically, they always ask if I know of any firms to benchmark whenever my firm requests certain types of service. Basically, the government encourages us to copy competitors' technologies or products. If firms are really innovative, they have no idea what circumstances they are going to be dealing with in the innovation process. The programmes that government organisations provided did not consider the uniqueness of our technology and products.

Due to the heterogeneous and localised nature of the innovation process, each SME faces different types of intertwined barriers. SMEs often fail when facing unpredictable barriers at the early stage of innovation. CEOs emphasise that innovation involves a number of failures, but that this does not necessarily mean the failure (closure) of the innovation or the business. CEOs also contend that no company can achieve success 10 times in 10 tries, and they cannot predict how many trials will lead to successful innovation, due to contingencies and uncertainties. For some SMEs, interim failures become opportunities when firms meet serendipity.

From this point, I have chosen the term 'barriers to innovation' rather than 'system failures',⁶⁷ because the term 'failures' seems to imply the end state of a certain

⁶⁷ This concept has also been described as 'barriers', 'problems', 'inefficiencies', and 'weaknesses' by different authors (Chapter 2).

system or situation. Various types of barriers can be resolved through bridging mechanisms, as emerged in the five case studies. The barriers are often beyond the internal capability of SMEs, and therefore SMEs must increasingly complement their technological (or nontechnological) efforts by accessing external expertise and knowledge, learning how to organise a wide range of collaborative relationships and knowledge to shape the innovation process to suit their own circumstances. In other words, innovation is a complex process rather than ‘a quantum leap’ that takes place in a systemic context related to identifying and mobilising resources and elements and interacting with multiple actors and institutions.

In this regard, interviewees emphasised the importance of various types of support rather than one-off services (e.g. R&D funding) to address the barriers that emerged in the process. Thus, facilitating innovation for SMEs does not mean simply transferring one single piece of technological knowledge at a specific point in time, but is an interactive process that enables complex knowledge and facilitates multiple relations at the systems level. By participating in an interactive process, SMEs can achieve successful innovation that guarantees the sustainable growth of firms, addressing uncertainties that lie ahead in their innovation process. The manager from Firm K said,

If the funding agency asks me how much we earn as a result of the support programme, we would answer that we are not successful [even if we’ve made profits]. I consider innovation success to mean establishing infrastructure, such as a processual change, which promises sustainable growth.

Sustainable growth can be encouraged by constant knowledge interaction through four functions, leading to interactive learning between intermediaries and SMEs and innovation. The previous chapter delineated that public intermediaries have decreased the internal and external barriers of each firm and brought various structural changes (i.e. innovation outcomes) to firms in new technology development, organisational change, individual learning, or expanding relationships. The following section will provide understanding of how public intermediaries perform four functions to augment the innovative capability of SMEs and facilitate innovation in the KNIS.

7.2.2 Four Functions: Openness and Flexibility

Public intermediaries are obliged, as linkage organisations, to achieve targets imposed by the government, supporting firms to enhance their innovative capabilities. Public intermediaries have close and continuous knowledge interactions with each SME which seems to involve crucial, but largely hidden, functions in supporting innovative outcomes in SMEs. Four functions of public intermediaries—knowledge enabling, facilitating relationships and learning, and managing interfaces—are crucial in addressing diverse barriers relating to a wider dimension of innovation, thereby achieving the sustainable growth of SMEs. Four functions of public intermediaries supported firms to overcome barriers and achieve innovative outcomes, not only improving linkages in the KNIS, but also creating new opportunities and dynamics in the KNIS at meso- and micro-levels.

As indicated in Chapter 5, the KNIS has grown in size and sophistication for several decades where demands for innovative SMEs were more diverse than ever. SMEs faced heterogeneous barriers, some of which were unexpected at the beginning of the knowledge interaction due to contingencies and uncertainties embedded in the innovation process. For example, Firm H found technological defects of first and second models of PDUs and entered into traditional joint R&D with KETI while the firm received four functions of public-intermediary services. Associated with this, a wider range of intermediary functions needs to be considered when public intermediaries provide services to a single firm. Some evidence in the previous chapter supported the concept of four functions that can grow over time.

As analysed in Chapter 6, Firms H and M passively received knowledge service at the beginning of first knowledge-interaction process when the public intermediary (i.e. KISTI) acted as a traditional intermediary that did not involve interactions with other actors and organisations but transferred knowledge to the firm unidirectionally. However, KISTI performed four functions as the innovation intermediary in the second knowledge-interaction process while working directly with the firm on a one-to-one basis. Likely, Firm K and I constantly received information services through managing interfaces after these firms achieved innovative outcomes through long-term knowledge interaction. In the case of Firm M, the CEO required a single type of

services—technology transfer or funding—partly because the CEO did not know the importance of knowledge-interaction processes.

Public intermediaries did not solely restrict themselves to those functions, but rather covered more traditional roles such as providing supercomputing facilities in KISTI, access to experimental facilities in BIC at KIST, and supplying additional information (e.g. technology-market reports, policy reports, and government publications) without involving third parties. The question is, when do public intermediaries play the roles of traditional intermediaries in addition to performing innovation-intermediary roles?

First, public intermediaries seemed to act as traditional intermediaries by managing interfaces. In the case of Firms K, I, and T., public intermediaries provided four functions as innovation intermediaries that led firms to overcome barriers and achieve various innovative outcomes (Chapter 6). Although public intermediaries supported firms to achieve initial goals of knowledge interaction, that interaction often resulted in demands for additional services. For example, four firms came to learn how to apply their experiences of knowledge interaction with intermediaries to their own innovation processes. However, the replication of knowledge-interaction processes required firms to constantly access external knowledge sources because firms needed to adapt the knowledge to their firms repeatedly. In this case, public intermediaries tended to act as traditional intermediaries. Often, individuals in public intermediaries were aware of changes in societal contexts and delivered new information to the firms with which they interacted.

Second, public intermediaries provided traditional intermediary roles when firms required services such as delivering market information, providing test sites, or acting as proxy users close to commercialisation stages. Firms H and M required various types of services—information service, one-off funding, designing the product, and joint research—in addition to the four functions. Firm H had strong knowledge interactions with KISTI while formed relationships with other GRIs that provided traditional types of services. KISTI, as the S&T information institute, provided knowledge and aligned potential buyers but was not able to provide funding or carry out joint R&D. Other GRIs—KETI, KIST, and KIOST—carried out joint

research to overcome the technological barriers that Firms H and T had while these GRIs did not involve themselves in any innovation-facilitation activities as third parties. GRIs can be seen as ‘sources of innovation’ rather than ‘innovation facilitators’.

Third, public intermediaries acted as traditional intermediaries when they failed to articulate demands of firms or firms did not have learning routines and did not know how to interact with external organisations. In the case of Firm M, the CEO was interested in acquiring R&D funding, overlooking the importance of interaction with multiple actors in the innovation process. In this case, public intermediaries might weigh in more with traditional intermediary roles rather than facilitating the innovation process as innovation intermediaries. As a result, no public intermediaries or individuals were involved in the innovation process of Firm M as third parties to facilitate interaction among multiple intermediaries.

In sum, at the early stages of innovation, public intermediaries are increasingly involved in more complex relationships such as a single intermediary to an SME or multiple public intermediaries to an SME collaboration, facilitating interactions. Certainly, although public intermediaries tend to remain specialised around four functions, the range of services during the complex knowledge-interaction process provided appear to be expanding over time in five cases. On one hand, public intermediaries are often not only involved in providing four functions as innovation intermediaries, but also supplying traditional services directly to firms. On the other hand, performing four functions can be (partly) iterated if new barriers emerged that were unexpected at the beginning of the knowledge-interaction process. In this vein, performing four functions can be understood as an open and flexible activity that can be iterated and expanded to address specific innovation barriers and consistently augment the capability of SMEs. The following section will explore the functional characteristics of public intermediaries.

7.3 Augmenting Capabilities of SMEs in the KNIS

7.3.1 Constant Knowledge Interaction in the Early Stages

As examined in the previous chapter, innovation in its early stages entails several barriers. Service provision and the period of knowledge interaction may expand more than intermediaries planned at the beginning of the knowledge interaction. This is partly due to the nature of future technology markets and unexpected problems that are difficult to foresee during the early stages of innovation. Accordingly, the knowledge-interaction patterns of the five SMEs in the case studies evolved in different ways to address specific problems that each SME faced during their innovation process (Chapter 6). These issues have enormous impact on the interface between SMEs and intermediaries, leading to SMEs consistently interacting with public intermediaries and joining in formal programmes to build internal capabilities that address uncertainties and remove barriers.

Few SMEs can survive coping with a diverse range of barriers during the innovation process. The situation can worsen when this period continues without yielding profits. Asymmetry of knowledge intensifies the distance between the SMEs and potential innovation players (e.g. competitors or buyers), and this situation isolates small firms from the innovation environment. The CEO from Firm I said,

They need to build their own capacity for becoming a medium-sized firm but business environments are [not favourable for SMEs]. The trust that makes big buyers adopt our new products does not exist even if we develop innovative products. We do not know when the relationship is over. I do not complain about the tough business environment which should be the same everywhere in the world. Instead, improving innovative capabilities for dealing with this tough business environment is the best strategy for maintaining the relationship.

Many SMEs attempt to maintain an informal relationship with experts in academia and industry to create new knowledge at the early stage of innovation. However, these relationships do not help remove knowledge barriers because informal relationships are only helpful in sharing general trends in technology markets. Often, a lack of internal capabilities hinders the establishment of informal relationships with potential buyers. The CEO at Firm I said,

There is a give and take rule between SMEs and big buyers. We could get the information from them only if we are able to provide them with something that solves their problems. My firm was not capable enough of doing this so that global big buyer S would not have liked to meet with us. I needed to anticipate their needs one step ahead, but it was really difficult.

In this context, constant knowledge interaction with public intermediaries plays a crucial role in enhancing the internal capabilities of SMEs over time. Director S. J. Lee of the IF, former industry analyst for Hyundai Securities Inc., had a very strong sense of the importance of constant knowledge interaction. He explained:

Most SMEs do not know what they do not know. They have to identify the nontechnical aspects of an industry such as markets, policies, and regulations before making key investment decisions. However, the limited resources of SMEs impede their access to in-house knowledge, although that knowledge may help increase their chances of success.

As a way of facilitating successful innovation, the IF manages a business-information centre that houses a large collection of highly valued reports and data on emerging technology markets acquired from various domestic and international sources. This, along with SME support programmes, may help SMEs overcome their lack of internal resources by gaining easier access to the resources of public intermediaries.

In addition, SMEs can benefit from their relationships with public intermediaries by accessing other types of resources (or services) and thereby constantly renewing their knowledge to suit their own contexts. Individuals at SMEs can expand their relational capital through the staff in public intermediaries, which often results in obtaining critical information such as government policy, regulations, or other support programmes from various government agencies. Dr. H. J. Kim at KTVF said, 'The SMEs in our incubating centre [belonging to KIST] can use its facilities under the same conditions as KIST researchers. We also provide management support services and sometimes link external experts to the needs of SMEs.' The staff at KTVF provide follow-up services after project completion, emphasising responsibility and consistency that contributes to resolving the various problems SMEs face during the innovation process. This can be possible because public

intermediaries work towards the success of SMEs in the KNIS, as their objective is not their own success.

In this regard, one researcher at Firm V conceded,

There are differences between public and private organisations. Service provisions provided by private organisations are quite limited and thus there was little chance to see them again after the project completion. However, public organisations have many services, and we could therefore obtain additional services on a free basis after project completion. It is good to know other researchers who sometimes provide us with useful information. Relationships with public organisations give us long-term benefits.

The innovation journey is unpredictable. Decision making on future technology markets is conjecture on an uncertain future with inevitable time lags between creating new knowledge and market application. The process requires constant efforts to identify problems, mobilise resources, and facilitate interaction with different types of knowledge, as well as to engage with heterogeneous actors at the systems level to shape a favourable innovation environment.

Consequently, the innovation process can be mediated by public intermediaries involving multiple levels of actors, arrangements between firms, and individuals, and building confidence among actors to minimise the risk of an uncertain innovation process. Public intermediaries can be appropriate innovation partners of innovative SMEs, sharing the risks and uncertainties embedded in the innovation process. They interact with institutions and multiple actors at the systems level on behalf of SMEs, as their resources and capabilities specialise in identifying barriers and responding to the challenges faced by SMEs. This aspect will be discussed further in Section 7.4.

7.3.2 Multiplicity of Knowledge Interaction

Multiplicity of knowledge interaction has been emphasised in removing barriers, especially at the early stage of innovation. The interaction process has two characteristics: the process entails several barriers rarely solved with one single type of service or knowledge, and little information is available relating to niche markets.

First, innovation does not depend purely on technological capability but on other activities such as management, marketing, networking, societal trends, and policies, as several CEOs indicated. The CEO at Firm L said,

A single technology does not guarantee the success of a business. In my experience, technology does not solve hunger, but most people do not know this. There is no way to make profit only with technology. It may contribute to 10% of a successful innovation. There are factors other than technology [such as regulations, relations, or luck].

This viewpoint suggests that removing barriers requires the interaction of constellations of actors, from scientists to policymakers, who have different expertise and experience on specific matters.

In addition, young venture firms often do not know how to use the R&D funding they receive. Dr. H. J. Kim at KTVF offered,

Most start-up firms look for funding. They have technological ideas and believe sufficient funding will make them succeed. Once SMEs have experienced failure, they begin to realise that nontechnical factors are just as important as technology. [The problem is that] they do not know where or how to spend the R&D funding. This is why SMEs who receive R&D funding from the government often fail [when they meet unexpected barriers].

SMEs are unsure what kinds of demands they have and are thus unable to have effective knowledge interaction, forcing intermediaries to guess. Because it is not possible to predict future technology markets, interaction with multiple actors plays a crucial role, not only in compensating for insufficient infrastructure in a short time but also in facilitating interactive learning as a way to strengthen the internal capability of the SME in the long run. By doing so, SMEs are also becoming capable of addressing various and unexpected barriers.

Second, codified information is rarely found in the niche areas where innovative SMEs do business. This information is too expensive to purchase or requires an additional in-depth-analysis process. However, SMEs are limited in identifying and accessing all resources, and acquiring information is a different matter from interpreting it to fit their own contexts. The interviewee, H, at Firm K added,

We are limited in accessing all information. It is time consuming, and costs are high in contacting people and buying overseas reports. We also do not have specialists dealing with information. I think it is the role of specialized organizations to purchase reports and databases to reproduce reliable knowledge. At KISTI, one researcher analyses the information and then may have a discussion with other researchers about the initial analysis results. [In my firm,] I have to depend on one member of staff, and it can therefore be unreliable because I know basically how it is produced.

The interviewee understands the complexity of the knowledge-interaction process through which knowledge becomes useful and reliable to a specific context. The question arises, what makes knowledge more accurate and reliable? Multiplicity of knowledge interaction may increase the level of accuracy of what was vague knowledge.

Knowledge interaction occurs among constellations of actors, and the process may provide a space with a productive combination of competing rationality. If the knowledge interaction is completely dominated by two parties—intermediaries and SMEs—or between staff in intermediaries, very little knowledge would be gained and very little learning would occur (i.e. Firm M). Dr. YJ Choi at KISTI said,

KISTI is the national S&T information centre, but this does not mean all researchers produce the same quality of knowledge. I do not simply use purchased information by myself to meet the demands of SMEs. I look for specialists from industries and academia to get their insight and compare their opinion with mine. It is especially important to increase accuracy and reliability of expectations when there is a different interpretation of information on the same issue. There are always active interactions between me and other experts.

Knowledge interaction is the combination process of individual minds, knowledge, and experiences (defined as competing rationalities in Section 2.2.2). The CEO at Firm K said, ‘What you provided us was not simple knowledge. It was the combination of insights, relationships, experiences and characteristics.’

Therefore, the system is the connections of knowledgeable individuals, and the knowledge interaction is a dynamically complex web of these individuals (Figure 7-1).

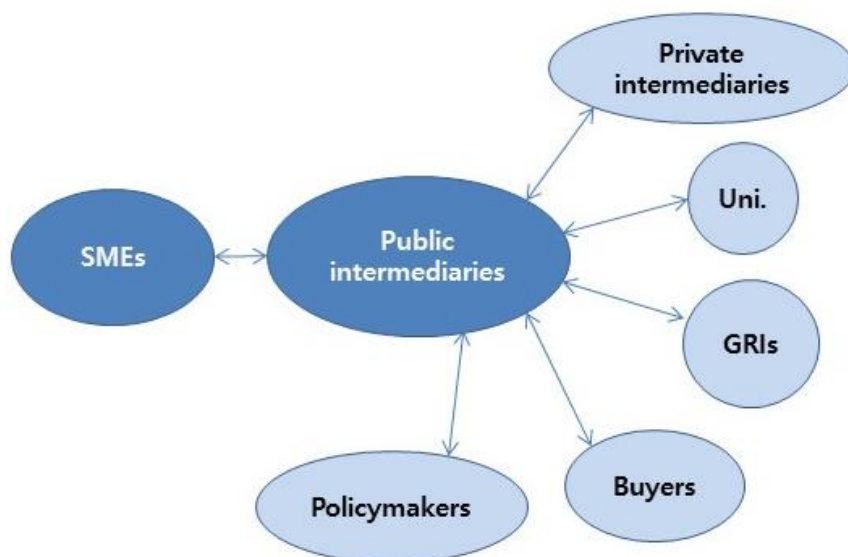


Figure 7-1 Multiple levels of interactions in producing knowledge.

In sum, creating knowledge requires the imagination to analyse future technology markets and find solutions for new businesses that have not yet been identified or articulated at the early stage of innovation. Multiple levels of interaction are important to coordinate all the resources in the system and the different views of actors. This increases the accuracy of future technology-market expectations by overcoming the bounded rationality of individuals in intermediaries or SMEs. Knowledge interaction may generate a wide range of outcomes not only for SMEs but also intermediaries. Intermediaries can constantly accumulate and renew their knowledge repository, and SMEs can combine necessary resources throughout the interaction process with competing knowledge enabled by intermediaries at the systems level. Considering it brings mutual benefits, knowledge interaction can be seen as a mutual-learning process.

7.3.3 Knowledge Interaction as a Mutual-Learning Process

7.3.3.1 Public Intermediaries and SMEs

As explained in Chapter 2 (Section 2.4.1.), involving public intermediaries helps to overcome different types of internal and external barriers such as infrastructural barriers, relational barriers with big buyers, lock-in barriers of firms, or organisational barriers among employees. A single type of service is insufficient to

address the different types of barriers that are not defined easily at the beginning of an R&D planning stage. In this context, the previous two sections emphasised that overcoming these various barriers requires constant knowledge interaction among multiple actors at the systems level, bringing organisational as well as individual learning opportunities. From an SME perspective, knowledge interaction provides a learning space where organisational and individual changes occur, such as the expansion of relationships with potential innovation players, entering into new markets, and establishing an interaction process in the firm.

Some innovative SMEs are becoming capable of using knowledge in various ways as a result of ‘learning by interacting’. Figure 7-2 shows the result of knowledge interaction between Firm K and intermediaries. The decision-making process was quite linear before the firm became involved in the programme, but they established a new department where interaction among employees actively occurred. This change can be defined as an innovative outcome. The firm replicated the knowledge-interaction process with intermediaries and began, by themselves, to monitor and integrate various types of knowledge—technological, buyers, or market based—in specialised local contexts.

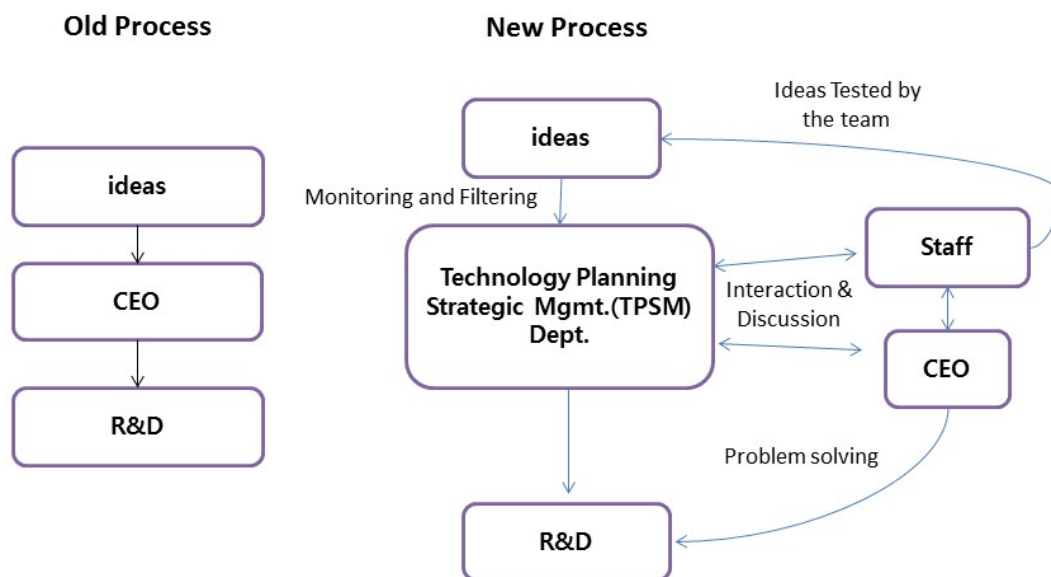


Figure 7-2 Example of organisational change (Firm K).

One interviewee at Firm K said,

It made our firm, which had previously had had a passive attitude towards big buyers, proactive. Now we can present a new process in advance before a big buyer comes to us. We interact, communicate, and make decisions based on the established system.

The SME contributed to the innovation of the big buyer by providing the improved process proactively. By adopting a new process provided by the SME, the big buyer was able to decrease its production costs for manufacturing semiconductors.

Individuals in firms often change dramatically through knowledge interaction and become active boundary spanners, as examined in the previous chapter on firms and innovation players. They learn about themselves, discerning why they need specific resources and how they are going to develop these resources to provide sustainable or competitive advantages over potential competitors. Sometimes, individuals consider themselves lobbyists, finding solutions through trust-based relationships and constant interaction with intermediaries. The CEO at P emphasised, ‘After all, it [successful innovation] is all about people.’ Innovations are rooted in the everyday activities of firms and in the capabilities of individual employees.

Thus, the consequences of knowledge interaction cannot be examined without considering individuals and combinations of multiple minds, where innovation emerges through the course of interactive learning. These systems depend on the way knowledgeable individual’s link by knowledge flow; thus, innovation takes place when this connection creates new knowledge by solving a problem. This can be seen as a learning process, identifying opportunities and solving problems. The interviewee at Firm HC continued,

This firm uses a consultation service every year, which has changed me and the firm gradually [through interaction]. As our firm has been growing rapidly, I feel it is necessary to improve the culture of the organisation. In my case, I can catch up with the speed of growth, thanks to the consultation programmes I am involved in. I study a lot to keep abreast of requirements from the intermediaries. The way of thinking has changed. People need the motivation to grow, which needs to come from outside.

These individuals contribute to producing invisible outcomes by approaching additional services and researchers in intermediaries. Although not directly linked to

sales growth, the firm was able to save time in R&D or marketing costs. Outcomes do not only come from SMEs but also from the intermediary side. This interaction provides learning opportunities for intermediaries as well.

7.3.3.2 Individuals as process facilitators of social learning

As noted in Section 7.3.2, individuals in intermediaries became knowledge repositories, expanding their own relationships with innovation players in specific areas. Along with these individuals' progress, the knowledge of intermediaries increased as a result of the knowledge interaction, and this interaction positively impacted their reputation as a competitive knowledge source. In particular, interaction failures give individuals in intermediaries the opportunity to re-examine the knowledge-interaction process and address any weaknesses in the support programme. When these individuals become involved in the support programme again, they seem to focus on the demands of SMEs and the process itself rather than on achieving visible outcomes (i.e. sales growth).

Individuals begin to realise that they can be wrong, even though they have strengths in accumulated experience and knowledge. In other words, these are reflexive individuals who store particular experiences and knowledge, and can apply these to the knowledge interaction with other SMEs. They learn that the expected outcomes that an intermediary predicts at the early stage may turn out to be wrong at the later stages. They start to retain what they learn over time through effective forms of interaction, and tend to give feedback to the knowledge-interaction process through continuing self-evaluation. Individual learning in intermediaries takes place in the same way as it occurs in the SMEs.

As described in Section 3.2.2, some individuals act as intermediaries performing more than these four functions. They identify specific barriers to each firm and steer the customised interaction process based on their understanding about firms. Although these individuals link government programmes to SMEs, they did not deliver the knowledge to SMEs based on the top-down approach. Rather they creatively shape the interaction process reflecting specific problems of each SME. Knowledge enabling and managing interfaces with SMEs can be crucial through

which individuals can identify problems and solutions because several problems intertwine that may change over time. Therefore, individuals often go beyond these four intermediary functions to address the new problems, such as acting as test sites, or linking SMEs to funding agencies (i.e. SMBA) or other intermediaries, as illustrated in five cases. These individuals are not bound by formality of intermediary roles and often link the formal programme to programmes provided by other GRIs (i.e. Firms H and T); expanding intermediary functions when necessary.

Existence of reflexive individuals in SMEs is a crucial factor that affects successful social learning and thereby innovation of firms. CEOs in innovative firms tend to learn faster than others, span boundaries across intermediaries, policymakers, and other firms, and have constant interactions with multiple parties after project completion. CEOs have strong responsibilities and have a broad scope of authority and action. They seem to feel they own knowledge-interaction processes rather than depending on public intermediaries to effect interactive learning.

Thus, the knowledge-interaction process can be seen as a mutual-learning process taking place between intermediaries and SMEs, as well as between organisations and individuals. Intermediaries are the legitimated actors to facilitate social learning, aligning potential innovation players into the specific innovation process based on impartial position, coordinating and maintaining the new relationships until SMEs are becoming capable of leading the new relationships.

7.4 Public Intermediaries: Specificities and an Unresolved Issue

7.4.1 An Effective Mechanism in the KNIS

Public intermediaries function as effective mechanisms to remove the barriers to innovation described in Section 7.2. Section 7.3 further examined characteristics of functions in the knowledge-interaction process, discerning how public intermediaries facilitate innovation of SMEs at the systems level. This section explores some national specificities behind the choice of public intermediaries as linkage organisations between firms and other actors in the KNIS: performing as resources with impartiality, facilitating innovation at the early stages. Public intermediaries have been the innovation partners of firms for several decades. SMEs can access

other types of intermediaries (i.e. GRIs, IF, SMBA, or private intermediaries) through public intermediaries. For example, in the case of Firm K, the IF aligned the private intermediary (see Figure 6-2) to provide overseas market information but services of the private intermediary were funded and monitored by the public intermediary—IF. From an SME perspective, working with public intermediaries decreases risks and costs involved in the early stages of innovation. How do public intermediaries become innovation facilitators in the KNIS? National specificities seem to influence on the choice of public intermediaries.

First, the role of public intermediaries supporting industries links closely to the historical path of relationships between government and industries. Professor SS Seol at the Economic Department of Hannam University explained:

The majority of Korean firms have a short history and have not been able to accumulate sufficient infrastructure for innovation. Furthermore, people are reluctant to pay for information services [one of the distinctive feature of the Korean business environment] and therefore small private consultancies yield little profit⁶⁸ [without public support]. Small Korean private consultancies should receive more service fees than they do at present, but SMEs do not feel the value of it. Especially, innovative SMEs expect a high level of knowledge services provided by multinational consultancies, but this is too expensive to afford. There has been a mismatch between the price they would like to pay and the value of the services they receive. It is likely to take a long time for private consultancies to build such a huge S&T infrastructure since government-funded organisations have been building those infrastructures since the 1960s.

This unwillingness to pay for the costs of services is found especially at the early stage of innovation where SMEs have not yet yielded any profits and are reluctant to pay for *ex ante* services. Moreover, outcomes of four functions of public intermediaries are complicated to measure due to the vagueness (or intangibility) of the end result of the innovation process. As analysed in Chapter 6, the outcomes vary

⁶⁸ The majority of SMEs were established as a result of strong government policy (Chapter 5), and many programmes, from funding to consultation services, were provided on a free basis. Furthermore, small private consultancies are often involved in government programmes, as they get certified by public intermediaries. In this regard, one private consultant, Dr. KH Baek, the CEO at PSMB said, “Yes, we are limited in our resources compared to global consultations and public intermediaries. My firm makes a profit by joining the programmes of government bodies such as the Small and Medium Business Corp.”

from firm to firm; outcomes are not just technological progress but also building innovation networks, acquiring new sets of technological and nontechnological knowledge, and creating new markets. Those outcomes are not just S&T innovation but rather wider dimensions of the NIS; the so-called DUI mode of innovation.

Activities associated with supporting innovative SMEs is that the often long lead time to the realisation of the innovation process makes it difficult to recover the costs incurred, and firms may require more time and effort than anticipated. Such complexity relating to the wide range of service provision and knowledge interaction may require the participation of credible intermediaries equipped with experts and expertise. Innovative SMEs, in particular, that have experienced turbulent periods, are well aware of the complex characteristics of innovation, which entail unexpected events and failures. These situations increase dependency on public intermediaries.

Second, the impartial position of public intermediaries play a crucial role in aligning resources and innovation players on behalf of SMEs. Public intermediaries involved in the knowledge-interaction process are capable of developing preferred potential partners, other public and private intermediaries to dovetail their services with government policies or to overcome the functional weaknesses of public intermediaries (e.g. the speed of service and limited roles).⁶⁹ Mr. S. J. Lee at the IF emphasised the participation of various types of intermediaries: ‘We have been linking two different types of services from public and private intermediaries to increase the level of success in the process of innovation.’

This linking is possible due to their impartial position, far removed from representing the interests of specific parties. Dr. H. J. Kim at KTVF said,

The impartial image and the not-for-profit structure of the Foundation play a more important role in Japan than in Korea. The Japanese are more conservative than [Koreans]. Japanese firms that visit us feel at ease. Especially, they feel comfortable when public intermediaries participate as mediators [in knowledge interaction]. This situation may be different among American [and many other Western firms].

⁶⁹ In general, intermediation is just one of several roles played by an entire organisation (e.g. GRIs). Different organisations may have different expertise, which may result in strengths or weaknesses in specific areas.

In addition, past experiences that SMEs have had with private investors may lead them to depend on public intermediaries that maintain impartial positions without pursuing profits for their own or specific parties involved in the innovation process. Dr. H. J. Kim at the KTVF added,

In early 2000, stocks of many venture businesses became completely worthless; this brought wrong learning effects. Since then, angel investors have been reluctant to invest in risky areas even though those areas require long-term investment. In Korea, the SMBA established the Angel Investment Association because it does not work [for private investors to refrain from long-term investment].

Both parties seemed to disappoint each other, losing credibility, and many SMEs have been unwilling to receive private investment since then. Dr. Kim continued,

The name value may be the most important thing for SMEs. It can be a source of pride. One of our firms [residing in the KIST incubating centre] used to say that they were the first venture firm certified by KIST.

Last, the dependence on public intermediaries relates to the characteristics of the innovation process at the early stage. The process requires ongoing efforts to mobilise various resources, relationships, expertise, and experts interacting with components and actors in the system. However, knowledge interaction at this stage does not always bring measurable outcomes and therefore intermediaries have difficulty aligning potential buyers. Private intermediaries may refrain from involvement in the early stages where it is difficult to make a profit due to uncertainties and high risk. SMEs face unexpected barriers but do not have effective functions to address constraints. In this case, public intermediaries are quite efficient when diverse barriers (e.g. internal discrepancies, lack of infrastructure, or relational gaps) tend to arise in uncertain innovation processes.

Public intermediaries increase learning opportunities and innovative capabilities of SMEs by maintaining long-term relationships with them as external knowledge linkages in the NIS. These linkages are the conduits for facilitating knowledge interaction between public intermediaries and SMEs, removing internal and external barriers; thus, firms can compensate for their lack of innovative capabilities and achieve innovation (e.g. rebuilding knowledge infrastructure, expanding

relationships, and any organisational or individual change). Furthermore, public intermediaries are not motivated to undermine services to increase profits, because increasing the overall efficiency of the innovation system is the most important role of public intermediaries, as explained in Section 3.2.2.

The outcomes of knowledge interaction may not bring a ‘quantum leap’ but rather diverse (invisible) outcomes: a wider dimension of innovation. Establishing a new decision-making process or expanding relationships can be outcomes of innovation in providing the sustainable growth of SMEs over time. However, functions of public intermediaries facilitating the innovation process are often underestimated in spite of their contribution to the innovation of SMEs. In this vein, the following section compares the complex nature of the innovation process with the simplistic view of SME policy described in Chapter 5, and further criticises the mismatch between policy and the heterogeneous demands of innovative SMEs.

7.4.2 Does Policy Reflect the Wider Dimension of Innovation?

The previous section explicated the national specificities behind the roles of public intermediaries in supporting SMEs. Public intermediaries have been the partners of innovative SMEs addressing the uncertainties and complexities in innovation processes; linking them with other actors and creating dynamism in the KNIS. To minimise the risks and time involved in exploring new business areas, SMEs tend to rely on the credibility and reputation of public intermediaries; a safer choice in advance purchase and *ex ante* assessment of a knowledge service. The knowledge interaction may not yield quantitative outcomes in a short period of time, but may bring various innovative outcomes from technical achievement to organisational changes. As Section 7.2.2 revealed, public intermediaries provide a wider and more holistic role for firms in their innovation process than have been identified.

From this perspective, innovation needs to be interpreted in a broad sense—a wider DUI approach—but the concept of innovation is often narrowly determined by policymakers (or intermediaries), who overlook the dynamic interaction process and heterogeneous nature of innovative SMEs and their demands. The effects of knowledge interaction pervade various activities and outcomes from which the

returns of knowledge use are difficult to measure in a quantitative sense. It may take a long time to digest this knowledge—a long learning process is involved in absorbing and using it—and it requires follow-up services to maximise business opportunities. As a result, four functions increase over time, as analysed in Section 7.2.2. However, the linear view of innovation or a narrower approach seems to have prevailed in policymaking spheres that do not reflect diverse knowledge requirements of innovative SMEs (see Chapter 5).

Policymakers have a tendency to identify success factors and measure outcomes of support programmes based on a simplistic view of innovation.⁷⁰ However, success factors may not apply to all firms, due to the localised context of interactive learning and innovation, as analysed in Chapter 6. Micro-level factors that affected successful (or less successful) innovation differed from firm to firm. Firm K was not considered a successful case because the R&D funding did not result in sales growth in 2 years time. The quotation below illustrates the misaligned perspectives towards innovative outcomes between policymakers and SMEs.

The CEO at Firm M conceded:

It is ironic that the government has been emphasising ‘innovation’ (which takes a long period of time) but always measures success in terms of sales growth soon after they have provided us with some support. ... We collaborated on a joint R&D project with Google this year which will take a long time to yield profits. The contract with Google changed everything, such as our vision, our relationships with big corporations in Korea, and the new biz plan for the future etc. That is innovation [even though we have not had any visible outcomes].

Going back to Chapter 2, the NIS is not a concept that only aims to achieve technical innovation but rather a practical device to remove barriers that need to be understood as a tool to facilitate the innovation process and stimulates new-knowledge creation related to a specific innovation. A mismatch might occur between policy and SMEs; policymakers lacking a wider DUI approach tend to skew to the linear view of innovation (see Chapter 5). As a result, supporting programmes designed by

⁷⁰ The idea that investment in R&D results in increased profits has prevailed in measuring support programmes. Sponsoring organisations are likely to measure overall performance by quantitative indicators such as commercial success, sales growth, number of contracts, and contracted price.

policymakers often overlook interaction and interactive learning in the innovation process, and therefore hardly reflect the heterogeneous knowledge demands of innovative SMEs. This lack may threaten intermediaries' provision of diverse services and their facilitation of knowledge-interaction processes to enhance the innovative capability of firms, and as a consequence, may decrease the quality of the KNIS over time.

In particular, the paradoxical situation may arise when intermediaries find themselves trapped between the narrow view of innovation (i.e. STI-based approaches) prevailing in policymaking spheres and the diverse demands of innovative SMEs that require wider dimensions of services (i.e. DUI-based approaches). The trap makes public intermediaries avoid *innovation facilitation processes* and mislead intermediary staff to focus on producing visible outcomes, as can be seen in cases H and M. Public intermediaries and SMEs tried to bridge technological barriers, based on the assumption that technological capabilities might bring commercial success directly. As a result, SMEs could not overcome barriers that arose between the R&D stage and commercialisation stage.

This outcome highlights the importance of innovation-facilitation processes that should address a number of barriers occurring in the innovation process. The problem still remains that the knowledge interactions do not explain how intermediary functions and related activities can lead to economic application and thereby innovation of firms. As evidenced in Chapter 6, public intermediaries rarely show the impacts of services in absolute terms, due to the invisible nature of facilitation processes; therefore it has been difficult to identify whether intermediaries affect the innovation of firms in a short space of time. For that reason, adopting a wider dimensions of innovation in the policymaking sphere seems to have limitations, though there has been some positive changes. In recent years, public intermediaries have become aware of the complexity of the innovation process and the dynamic nature of innovative SMEs. Mr. S. J. Lee at the IF said,

The government policies focused on R&D funding should be changed. R&D funding is important but it can spoil the venture spirit of SMEs. They do not know how to explore business opportunities after they complete R&D. If we provide them with consultation services

(knowledge) such as market, technology, competitors, and regulations prior to investing in R&D, SMEs can increase the possibility of success in developing business opportunities. We can also target promising areas (firms) before we provide R&D funding, which will also increase the success rate of R&D investment.

To fill the gap between policy and innovative SMEs, a theory or conceptual tool to underpin diverse activities in the innovation process needs to be examined to understand the nature of complex innovation processes and address heterogeneous barriers in designing supporting programmes.

7.5 Conclusion

Public intermediaries have been effective mechanisms for linking national policies to industries, removing barriers to innovation, and thereby enhancing the efficiency of the KNIS. Public intermediaries have strengths in their knowledge infrastructure and experience in collaborating with Korean industries over a long period, maintaining an impartial position, and providing services at the early stage of innovation. SMEs define innovation as a process that may involve several failures and various types of outcomes; the single type of services delivered by intermediaries at a specific point in time is insufficient to solve all the problems or achieve the innovative heights to which SMEs aspire. In this regard, answering the first research question, this chapter emphasises how and why public intermediaries facilitate innovation processes in the KNIS (Figure 7-3).

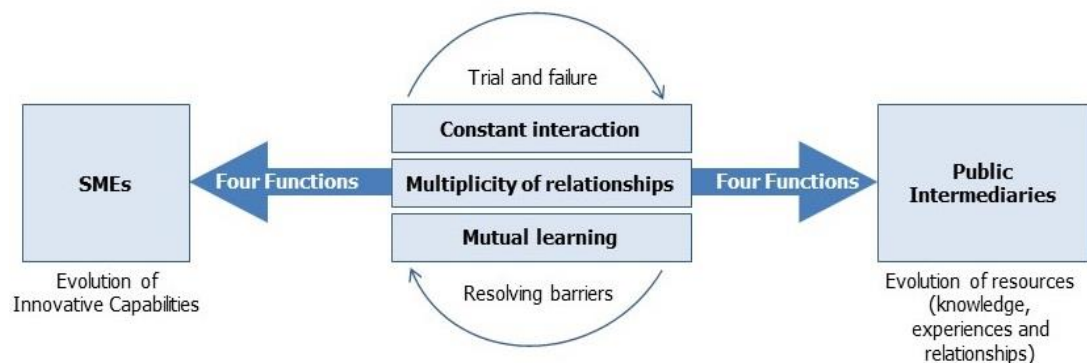


Figure 7-3 Knowledge interaction at the systems level.

Although Chapter 5 provided the rationale, based on a historical perspective of relationships between public intermediaries and SMEs, this chapter answers the question by demonstrating the innovation-facilitation process between public intermediaries and SMEs and linking it to four functions of public intermediaries that have not been fully explained in the NIS framework. In particular, this chapter analyses how public intermediaries manage four functions addressing the uncertainties in the innovation process of each SME. The functions may increase from facilitating innovation to delivering traditional services along with the evolution of a multiplicity of relationships. The four functions are performed based on a constant process of interaction, multiplicity of relationships, and mutual learning.

This chapter also highlights the concept of innovation as a process of achieving sustainable growth of firms. On this point, outcomes of innovation vary from technological progress or sales growth to organisational changes. As a consequence, innovation does not always bring visible outcomes in a short space of time and often fails to yield any profits. This leads SMEs to rely on public intermediaries to address the cost, effort, and risk involved in the uncertain innovation process. However, some mismatches may emerge between the supporting programmes and heterogeneous demands of SMEs. As indicated in the previous section, an intermediary's functions in the knowledge-interaction process may be hard to formalise and quantify, and taking into account *ex ante* services in the process is often neither easy nor planned, due to the contingency and complexity of the innovation process.

However, policy tends to overlook a wider dimensions of innovation rather skewed to the linear view of innovation, which is too simplistic to explain innovative outcomes of SMEs (Chapter 6). To summarise, in this chapter, I presented and discussed empirical findings relating to the rationale and involvement of public intermediaries in the KNIS. Along with Chapters 5 and 6, Chapter 7 discussed the main research problem of the study, which is to determine the limitations of the roles of intermediaries and SMEs in the NIS. The final chapter aims to suggest policy directions in knowledge interaction between intermediaries and SMEs.

8 Chapter 8. Discussion and Conclusions

8.1 Introduction

This study began with the aim of examining how public intermediaries facilitate innovation of SMEs through interactions. The more ambitious objective was to offer insights that can be applied to build on the existing NIS concept, improve understanding of key actors (public intermediaries and SMEs), and provide an account of how knowledge interactions and relationships can facilitate innovation in SMEs by decreasing the barriers described in Chapters 2 and 3.

Thus, this study addresses a combination of issues that cannot be answered by research using only existing NIS concepts. Chapter 8 discusses shortcomings of the NIS approach to answer the research questions and the necessity of incorporating other approaches to address the questions. These include how relationships between the public intermediary and SMEs are evolving and the interactions that occur at multiple levels, how individuals affect learning and innovation, and how the various barriers specific to firms may be overcome. The results of this study show that the NIS concept may fit specific contexts, but only if combined with intermediary studies and the social dimension to delineate the knowledge-interaction process that is supported by the extensive empirical evidence presented in the five case studies of Korean SMEs.

This chapter concludes the study by providing an overview of findings and a recapitulation of its contribution to debates around the NIS. Four key functions are presented: first, I examine the research problems; second, I present the implications discerned from theories, policies, and SMEs, and the generalisations of these findings; third, I discuss the research strengths, limitations, unresolved questions, and suggestions for future research; and finally, I present concluding remarks for the study.

8.2 Research Problems

As discussed in Chapter 2, the NIS has been a popular concept in policymaking and academic spheres for several decades. Debates continue about its intellectual

coherence and policy relevance, even amongst its founding authors. Lundvall supported the usefulness of a loose-umbrella concept as a policy tool for a wider application in different contexts, whereas Edquist emphasised the need for more systemic conceptual development. Indeed, the conceptual approach of the NIS contributes to providing increased visibility to S&T policies and stimulates the emergence of other literatures such as RSI, SSI, and Regional Industry Systems: analytical tools that can be complementary to each other or combined (Edquist, 1997; Lundvall, 2007c). However, important criticisms have been advanced about the NIS approach; in particular, the conceptual framework it offers is rather abstract and rhetorical (Godin, 2006, 2009; Sharif, 2006, 2010; Song, 2009; Woolthuis, Lankhuizen and Gilsing, 2005) and has shortcomings that apply in specific institutional settings (OECD, 2002). The conceptual framework revolves around a somewhat schematic account of institutions and interactions that overlook the different characteristics of the social setting of states, firms, and their patterns of interaction and relationships.

In the NIS approach, the roles of various actors and their different capabilities in knowledge generation are not sufficiently well defined, although those differences may result in barriers to innovation, as shown in the five cases. The role of SMEs and public intermediaries in Korea cannot be effectively explained with the NIS concept (Fig 2-1 in Chapter 2). Sharif (2010) also criticised the NIS concept for failing to accurately emphasise the role of firms. By providing an incomprehensible NIS framework, it does not demonstrate the extent to which SME needs are met by government support and the key barriers that KNIS must overcome to increase their deficiencies: that is, weak SMEs. The simple framework does not indicate SMEs as active knowledge generators, which contrasts with the central role of firms at the heart of the NIS, provided by OECD reports (Sharif, 2010).

In the same vein, the loose nature of the framework does not seem to distinguish between individual firms, groups of firms, or capabilities of firms in the system (Lankhuizen and Woolthuis, 2003) or the level of knowledge among firms or between large corporations and SMEs. For example, the COSTII index described in Chapter 5 indicates the low level of cooperation between firms but does not delineate

the characteristics of weak SMEs and the barriers they face. Furthermore, the NIS emphasises national institutions and economic growth at the macro-level but pays remarkably little attention to the character and distribution of knowledge itself (Godin, 2006), despite its presumptions about access to knowledge being the crucial condition to increase the amount of innovative capabilities (David and Foray, 1995). This macro-level approach has shortcomings in addressing some problems, as I now describe.

First, the NIS framework presented in Figure 2-1 has limited ability to reflect national characteristics that have different historical, social, and political settings. Somewhat paradoxically, although the whole idea of the NIS is to attempt to address cross-national differences in innovative performance (Borrás and Edler, 2014), the concept does not have analytical tools (Godin, 2006; Sharif, 2010) or indicators to capture why performances are different, and how specificities of NIS can be analysed (Smith, 2001). Lundvall (2007a) criticised the distortion of the NIS concept, which has been applied in a narrow understanding of the concept by policymakers (i.e. international organisations) and scholars, compared to the original versions from Freeman and the IKE-group in Aalborg that emphasised national characteristics.

As discussed in Chapter 2, reports from OECD highlight the differences among nations,⁷¹ based on the same criteria, regardless of the specificities of institutional settings in every nation. For example, as outlined in Chapter 5, industry–academia interaction was uncommon in Korea because, for the nation’s education system, the most important role was in providing a supply of trained engineers and applied scientists to assist manufacturing firms to catch up (Mazzoleni and Nelson, 2007) rather than building R&D capabilities in universities.

Instead, Korea’s economic development exhibits some unique features, in particular through the strong coordinating role of the state similar to the ‘controlled competition’ in Japan discussed in Chapter 3. GRIs were the major mechanisms actively involved in fostering the development of indigenous national R&D

⁷¹ The OECD scoreboard, which is published every 2 years, includes a series of economic, science, and technology indicators, ranking countries on different dimensions, with a brief analytical text (Godin, 2006).

capabilities and interacting with industries for several decades. However few studies addressed GRIs as important actors in the NIS. Therefore, a lack of local variation, the particular circumstances, and dynamics of particular settings call for another line of inquiry, which I propose here: that is, a focus on the dynamics of knowledge interaction among particular actors, public intermediaries, and SMEs. As Lundvall, Intarakumnerd and Vang (2006), and Lundvall (2010) have suggested, a need persists for more empirically based research of Asian innovation systems. The NIS literature and much of the innovation literature generally does not yet recognise diversities and cultural legacies in Korea, Japan, Taiwan, and China (Dodgson, 2009), although institutional approaches cannot be separated from sociopolitical and cultural contexts (Godin, 2009). This specificity cannot be fully explained by the macro-level approach that leads to the second problem.

The second shortcoming concerns the simplistic perspective adopted in mainstream NIS studies on the interaction and knowledge flows between players. Firms are conceived primarily as a recipient of innovation inputs and the qualitative nature of interaction is ignored in the NIS (Sharif, 2010). However, I argue, innovation interactions occur at multiple levels⁷² and relationships evolve through the process because of the heterogeneous characteristics of firms in ways that are not effectively addressed by the schematic NIS framework. Firms have different levels of knowledge demand that may require different levels of knowledge interaction, illustrated by the five case studies. New knowledge is not produced in a formalised way and knowledge interaction does not occur in a vacuum. Often, knowledge does not flow if there is asymmetry of knowledge and thus constellations of actors may coalesce into an interaction process to overcome barriers. Knowledge interaction has to be seen as a highly contextual social process.

As a result, different patterns of interaction and relationships are shaped and many factors affect this shaping. However, the NIS framework is somewhat devoid of micro-level factors, especially social dimensions in the interaction process, and is

⁷² Lundvall emphasised the importance of interactive learning, while contending the usefulness of a loose-umbrella approach. The loose concept does not deliver methodology on how to identify a mixture of rationality and facilitate learning (Sharif, 2010). Lundvall (2004, 2007c) provided a brief guideline on how to analyse the NIS based on four steps.

unable to fully account for multiple levels of interaction processes, learning processes, and influences of individuals in specific circumstances. These factors make it difficult for the NIS concept to account for the complex knowledge interaction that affects innovations of firms. Lundvall (2007c) also welcomed the adoption of a social dimensions, emphasising the importance of meso- and micro-level approaches.⁷³ Here STS perspectives have emphasised micro-level analysis in examining the detailed dynamics, local learning, and contingencies in the innovation process that differ among firms, scholars, and regions (Russell and Williams, 2002).

To recapitulate, the limitation of the NIS approach to fully account for the innovation process of SMEs is partly due to the lack of attention paid to social dimensions with their embedded complex relationships and interactions. This is the crux of this study, focusing attention on different patterns of relationships, evolution of relationships, multiplicity of interactions, and micro-factors that affect innovation of firms.

Third, this study found that knowledge interaction is the process of circumventing knowledge and relational barriers at each stage.⁷⁴ A nascent knowledge-flow approach to the NIS framework also has shortcomings, as described above: how interactions and relationships can bridge the barriers, and what factors make this feasible. It seems that the conceptual framework of the NIS approach only offers a view of the elements and framework conditions that determine and affect innovation processes in general. Numerous innovation processes exist in firms, technologies, sectors, and regions. Each process has its own specific (sub-) system of actors, organisations, and institutions with their own specific relationships and interactions, determining and affecting how they function. Without customisation of the framework to a specific context, it may not be possible to examine the interaction process where actors can identify specific relational or capability failures of SMEs for further support.

⁷³ Woolthuis, Lankhuizen and Gilsing (2005) highlighted that micro-level analysis gives room to analyse the value of individual behaviour.

⁷⁴ Facilitating innovation of firms is not just a matter of interaction and knowledge flow, as suggested by an NIS framework, but rather a complex process of overcoming barriers and bridging the gap while also outlining the mediating mechanisms and activities of intermediaries.

To more specifically grasp the characteristics of an NIS, the conceptual framework has to be ‘operationalised’ at an appropriate level (Edquist, 2001; Lankhuizen and Woolthuis, 2003; Woolthuis, Lankhuizen and Gilsing, 2005)—for example interaction between SMEs and big buyers or between SMEs and public intermediaries—to investigate innovation processes. The conceptual framework of the NIS approach can be used as a ‘focusing device’ that puts interactive learning and innovation at the centre of analysis (Lundvall, 2002) rather than an *ex ante* policy tool. This study, therefore, developed and applied the conceptual framework proposed in Chapter 4, which attempts to address these limitations, in the case of SMEs in Korea, with a specific focus on interaction with public intermediaries under which heterogeneous actors—SMEs, multiple intermediaries, and buyers—may coalesce to bridge the barriers in the innovation process. The research explored the relationships and influences in the process of complex innovations, focused specifically on exploring the roles of intermediaries through their specific activities (Chapter 3) in bridging the barriers at each stage of the innovation process.

The empirical aspect of the study was undertaken in two stages. The first involved gathering information on SMEs and intermediaries to map the landscape of the innovation process through interaction. The information identified public intermediaries that represented the state, regions, and different ministries, and I selected those innovative SMEs that interacted with those intermediaries for the first round of interviews. Based on the interviews, I selected five SMEs for in-depth interviews for further analysis. I reported and analysed the evidence gathered from this second stage, through semi-structured comprehensive interviews.

8.3 Contribution and Findings of the Research

Whereas knowledge interaction and learning focus more on the meso- and micro-levels, with interaction between actors in the economic system as its level of analysis, the elements taken from evolutionary theories focus more on the macro- level. According to empirical findings, interaction does not occur only between industry and academia. Lundvall (2007c, p112) also indicated,

There is a need to understand how the core of the innovation system is embedded in the wider set of institutions that shape people and the

relationships between people. Without knowledge of the micro-structures, we might get little out of attempts to manipulate institutions and organizations at the meso- and macro-level.

To do so, it is necessary to incorporate social dimensions to uncover the relationships and the role of individuals, and provide intermediary studies to examine the process of bridging the barriers.

This study developed a conceptual framework anchored in the knowledge interaction and intermediating nexus, highlighting the barriers in knowledge and relationships at early stages of innovation. By focusing on the exploration of how public intermediaries might influence the innovation of SMEs, the study was able to consider the micro-factors in interaction processes, the need for knowledge facilitation and learning, and the importance of knowledge enabling and managing interfaces. The intermediary functions developed in Chapter 3 provide understanding of the process by which intermediaries interact with SMEs and organise actors at multiple levels to circumvent the barriers posed by innovation processes.

In this vein, the framework builds on insights about constellations of actors in the knowledge-interaction process, which is evolving over time, and the importance placed on multiple levels of interactions and actors in the studies of the evolution of complex systems (Lundvall, 1992; Molina, 1994; Nelson, 1994; Williams, Stewart and Slack, 2005). This approach also provides a way to explore the micro-level factors and multiple-level interactions that are mostly neglected in NIS and in intermediary studies, that is, a productive combination of competing rationalities, the importance of reflexive individuals, redefinition of firms and their capabilities, and social learning.

First, a productive combination of competing rationalities by engaging heterogeneous actors in the knowledge-interaction process is crucial not only for knowledge generation but also for ensuring the quality of that knowledge at an early stage, when actors and technologies have not yet been identified. Along with the quality of knowledge, the NIS concept overlooks the role of public intermediaries linking all the activities and relationships (Watkins et al., 2014). 'Pre-dominating rationality' (Lundvall, 2002) tends to rule organisations, hindering absorption of new

knowledge and learning. As several interviewees indicated, in Chapter 6, involvement of a credible third party is crucial to persuade employees at all levels in a firm to facilitate self-interaction to decrease discrepancy of views on innovation. In combining multiple rationalities, embedded in individuals having different ideas, experiences, and knowledge, intermediaries link different spaces and actors, and by doing so, accommodate competing rationalities for new knowledge creation.

Intermediaries combined the technical and nontechnical knowledge through interactions with different organisations and experts to address the heterogeneous barriers of SMEs. In the cases of Firms K and T, researchers from public intermediaries contacted big buyers and GRIs not only to access in-house knowledge, but also to combine insights from experts on future technology markets. Researchers in public intermediaries and experts were often from the same university and shared the same social world, which seemed to have a positive impact on knowledge enabling.

In this regard, Williams, Stewart and Slack (2005, p81) indicated the requisite intermediating role of having the ability to cross different spaces—between different organisations and different departments within organisations—and between different knowledge communities. Yet, these authors did not distinguish between public and private intermediaries. Woolthuis, Lankhuizen and Gilsing (2005) asserted these relationships not only involve big buyers, but also the government, public intermediaries, and third parties, but do not explain why and when the participation of public intermediaries is important. The role of public intermediaries are not well defined or identified in the NIS literature and the macro-level focus of earlier NIS studies tends to emphasise university–industry linkages (Watkins et al., 2014). Empirical analysis shows the role of public intermediaries as important actors, especially when the firm does not have capability, and the technology is vague and malleable at an early stage. It takes a long time to cross over ‘death valley’ and the ‘Darwinian Sea’ (Auerswald and Branscomb, 2003; Branscomb and Auerswald, 2002; Dalziel, 2010).

Although causal links, interactions, and relationships between actors in the NIS are central elements to the analysis (Nelson 1992, 1993), the NIS concept limits

delineating why and how other actors become involved and how patterns of relationships vary, based on the snapshot of the framework at one point. It is difficult to understand what effort has to be made to overcome the barriers without reference to linkages or relationships in the NIS (Sharif, 2010). The study demonstrates that various actors participate in the knowledge-interaction process rather than just two parties, where relationships are evolving and factors for success and failure differ from case to case (Chapter 6). Often, success or failure of knowledge interaction comes not only from the capability of firms to interact with external knowledge infrastructures, but also with individuals from intermediaries, which relates to the second finding. Existing literature on intermediaries rarely addresses the weaknesses of functions or activities.

Second, even though the NIS and intermediary studies emphasise individual learning, they have shortcomings in how these individuals create knowledge and contribute to bridging the gap. In the NIS framework, little explanation exists of a particular mechanism for learning that facilitates the innovation that is often missing (Watkins, et al., 2014). However, the empirical findings from this study suggest that individuals must be considered when analysing the knowledge-interaction process, especially at the early stage. In this vein, Williams, Stewart and Slack (2005) emphasised that particular individuals or groups often emerge as intermediaries in the course of ICT projects, although this role is not always formally recognised and often is not a result of a formal designation of roles, but instead arises in the interstices of an organisational structure. Other intermediary studies also indicate the role of brokers, researchers, and private consultants (as discussed in Chapter 3), but make insufficient progress towards opening the black box of knowledge interaction among heterogeneous actors and institutions. In this regard, Balzat and Hanusch (2004) argued that extension of the NIS study has to do with still-limited knowledge of dynamic properties of the NIS.

In the case of SMEs, four CEOs from successful and less successful cases fulfil the role of spanning boundaries, by actively learning and delivering feedback to intermediaries, as discussed in Chapters 6 and 7. These individuals have long periods of R&D or marketing experience in specific areas and some have successful business

relationships with big buyers in global markets. They are capable of replicating the existing interaction process with big buyers to the new interaction process with intermediaries more easily than other CEOs without this experience. Interestingly, most also have failure experiences in R&D, but they regard these as a part of the learning process. Along with competitive technological knowledge, these experiences contribute to their adaptive skills, making them more reflexive than others.

In the case of Firm H, the first knowledge interaction with KISTI did not bring any changes to the firm that gave the CEO an opportunity to reflect on why he was not able use the knowledge and how he used government support programmes next. The CEO analysed and produced the government support map for a future business and actively delivered feedback regarding new requirements in the new business area. The CEO also was able to make better use of different types of services (e.g. the supercomputing centre and the technology commercialisation centre) by accessing multiple intermediaries. Reflexive CEOs have a tendency to become quick learners and actively forward their demands to intermediaries, helping to build a virtuous cycle of ongoing knowledge interactions that facilitate learning and strengthen routine momentum.

In the case of intermediaries, reflexive individuals from successful and less successful cases had experiences in different sectors and different firms from which they accumulated high levels of specialised knowledge and related expertise. These individuals are capable of integrating knowledge from different disciplines and reconfiguring them as competitive new recipes of knowledge for specific firms, described as ‘cross-pollination’. They also strongly build trust because they are capable of producing high-quality knowledge, identifying and enlisting potential actors to the innovation space based on their impartial position and consistent manners, as analysed in Chapter 7.

As Williams, Stewart and Slack (2005) indicated, critical to successful intermediation is the ability of reflexive individuals to mobilise knowledge and resources inside and outside their organisations: they are the crucial factor to integrate and adapt new knowledge. The four CEOs created a sense of urgency inside

their firms to facilitate coordinated action of employees towards the innovation and actively used public intermediaries as legitimate facilitators to construct new knowledge infrastructures. Firms K, I, and H established new departments or processes to replicate the knowledge-interaction process with public intermediaries that became new routines of integrating and adapting external knowledge. In the case of Firm T, the CEO integrated knowledge outside the firm for a long period of time, crossing boundaries of multiple GRIs (i.e. KIST, KIOST, and KISTI) and the ministry, which resulted in establishing the standardised technology and creating the new market. During the innovation process, the CEO accessed a neighbouring firm to learn about new technology and the KIOST to try out the system at the test site.

This is noteworthy in a knowledge-interaction process where SMEs have difficulty entering new business relationships, due to problems with the asymmetry of knowledge. In this case, with relational capital and credible images, individuals have a direct impact on linking relational gaps of SMEs, as evidenced in Chapter 6. Lundvall (2004, 2007c) described them as ‘interactionists’ whose roles are important activities at an early stage because embedded knowledge flows best through individual relationships. They can be perceived as boundary spanners (Friedman and Podolny, 1992) who act as conduits for knowledge interaction and may strongly impact successful knowledge interaction and thus innovation.

In contrast, lack of reflexivity of individuals often leads a firm to fail in adapting new knowledge, as shown in Firm M. The CEO of Firm M received knowledge from multiple intermediaries without delivering feedback to intermediaries. The CEO had good relationships with potential buyers when the firm was established, leading the firm to overlook the multilevels of interaction in knowledge enabling. The CEO did not collaborate with employees (or intermediaries) to solve the problems the firm faced and, as a result, knowledge was not adapted to the firm’s particular context. Carlsson and Jacobsson (1997) described this situation as strong network failure, where individual actors are guided by other network actors in the ‘wrong direction’ and consequently fail to supply each other with the required knowledge. The authors averred failure is caused by a lack of information exchange with actors who perform a bridging role, that is, those who tap into new knowledge and question existing

routines. However, empirical analysis shows that guidance in the wrong direction can be used as a way of learning by failure, if there is a reflexive individual.

Third, operationalisation of an abstract concept at appropriate levels contributes to the understanding of SMEs by addressing issues not well tackled by the generic NIS concept. To be able to innovate, firms must constantly access new knowledge sources that lie outside the firms or even outside the existing field of knowledge (Burt, 1992). However, the capability to access external knowledge sources depends on the capability of firms that are often overlooked in innovation studies. Figure 2-1 in Chapter 2 describes firms as recipients of innovation input, playing a very small role in generating innovation (Sharif, 2010). Compared to large corporations, SMEs in general have resource disadvantages due to a lack of highly qualified employees and financial resources (Auerswald and Branscomb, 2003; Freel, 2005; Lankhuizen and Woolthuis, 2003; Massa and Testa, 2008; Nooteboom, 1994, 1998).

As described in Chapter 3, exploring new businesses entails considerable costs for SMEs. In addition to the costs of properly safeguarding their interactions and relationships, and of enhancing learning, the specialist knowledge required to fill the barriers may be absent. The case studies I developed here indicate that most innovative SMEs possess competitive knowledge in existing business areas; however, exploring new business areas requires them to identify barriers and build new routines in a short space of time (i.e. new relationships and knowledge). Often, innovative SMEs lack the capability to address the problems they face and build new routines with the speed needed to address these problems. CEOs tend to look for intermediaries not just because of the need to acquire new information and relationships, but because of the desire to formalise the new knowledge-interaction process inside firms.

As analysed in Chapter 6, differences often exist in views between CEOs and employees towards exploring new businesses. Employees are not as motivated as CEOs for a better future and are easily locked in their own routines. They pursue stability rather than changes, as the CEO at Firm K contended. Thus, it might be difficult for CEOs (or firms) to decrease the barriers in a short space of time without external innovation facilitators. In addition, the old knowledge infrastructure and

decision-making processes in the existing business area are unsuitable for new areas because of different sociotechnical settings, different requirements of knowledge, and different innovation players. Especially when dealing with big buyers, this lack of knowledge infrastructure may be a problem. Whereas a large corporation will often have specialised knowledge 'in house', SMEs often lack this knowledge and thus either have to build the knowledge infrastructure (which is costly), or depend on big buyers not to exploit their vulnerability. Although innovative SMEs have qualified employees and technological capabilities, the empirical analysis in this study shows that knowledge asymmetry hinders cooperative interactions with potential buyers. Existing informal and formal relationships may not be helpful in building necessary networks in new business areas.

This phenomenon contrasts with the assumption about knowledge flow between industry and academia and learning by interaction (Kline and Rosenberg, 1986; Lundvall, 1992, 2005; Nelson, 2002). According to the empirical analysis presented here, SMEs that need cooperation, in theory, rarely enter cooperative relationships because they cannot get the advantages of interaction to gain access to knowledge resources and to raise their innovation if they do not have knowledge to offer in return. Hence, knowledge does not flow between SMEs and potential buyers. Only if there are formal mechanisms established between SMEs and potential partners can SMEs leap the barriers, and by doing so, form equal partnerships and further interactions (Lankhuizen and Woolthuis, 2003).

Evidence from this study also suggests another characteristic of SMEs: they are not necessarily passive recipients of knowledge in interaction processes, as described in most intermediary literature that focuses on the supply side, viewing the delivery service to customers and its impact on innovation. SMEs might be very active in conveying feedback and reconfiguring knowledge to their own contexts, especially when they have routines built by interaction with business partners and external experts. It is rather easy for these SMEs to adapt new knowledge and to build new routines required in new business areas, based on accumulated experiences and capabilities. Along with the capabilities, reflexive individuals in firms and intermediaries (Chapter 6 and 7) play an important role in three ways: 1) constantly

translating and reconfiguring the knowledge, 2) building new learning routines inside firms and new relationships with external experts, and 3) co-shaping a favourable innovation environment with actors involved in a multiplicity of interactions (i.e. potential buyers and multiple intermediaries).

Last, another key contribution of this study is that it links the enabling knowledge and networking activities of intermediaries with social learning. SMEs do not only bridge the gap or acquire knowledge; they also build new knowledge infrastructures, relations, and skills through interactive learning. Case studies in Chapter 6 show that SMEs built new knowledge infrastructures, established new departments, designated a person in charge of knowledge management, and explored new relationships. Interviewees considered these infrastructural changes that ensure sustainable growth as success, rather than defining success by immediate growth in sales.

In this vein, this study highlights managing the interfaces, one of the main functions of intermediaries provided in Chapter 3, which means more than accessing knowledge and brokering services described in the existing intermediary literature. These roles in intermediary studies have an image of a particular service, overlooking that learning and building relationships may take a long period of time. Evidence presented in Chapters 6 and 7 shows intermediaries actively facilitate relationships and learning by managing interfaces where ‘heterogeneous constellations of actors’ facilitate not only business relationships in a short space of time, but also constant learning. Because relationships, demands of buyers, or social settings (e.g. regulations) may change over time during innovation, managing interfaces is important for ongoing interactions and reshaping the innovation space to address changes, as evidenced in Chapter 6.

Boundary spanners play a crucial role in linking different actors and translating sticky knowledge into their innovation context, which is rarely accomplished by accessing or brokering activities on a single occasion. SMEs were not just passive recipients of knowledge, as Sharif (2010) argued that the NIS framework seemed to fail to accurately emphasise the roles of firms; intermediaries were not merely passive knowledge transporters. As analysed in Chapter 7, public intermediaries also accumulate experiences and renew their knowledge repositories. Intermediaries are

reflexive actors in the way they reconfigure their knowledge and identify which elements of knowledge and experience can be applied in a new setting. They also learn from knowledge interaction with SMEs and apply learning experiences in other settings.

8.4 Critiquing the Research Findings

8.4.1 Potential for Generalising the Results

Here, I reconsider the findings from this study to ensure the robustness of the conceptual framework, research findings, and implications derived from them. A commensurate question regarding the results is whether these cases be generalised for all kinds of innovations. As discussed in Chapter 4, one concern about case studies is the issue of generalisation: to generalise, results need to be sufficiently implemented over different settings and contexts and provide consistent results.

This study aimed to obtain ‘insights’ rather than ‘generalisations’ about the role of public intermediaries facilitating the innovation of SMEs; others may use the results to build on existing NIS and intermediary theories. Chapters 5 and 6 demonstrate how Korea built its own NIS and how the particular Korean setting differs from other settings, linking to the general criticism of NIS in Section 8.2, because it does not have indicators to explicate national specificities and the richness of individual situations. Early NIS studies have strong focus on country-specific features, but broad empirical cross-country analysis that draws on OECD data does not reflect the multifarious factors of each nation (Balzat and Hanusch, 2004; Mahroum and Alsaleh, 2012). During the process of diffusion of the NIS, the original concept has been distorted in policymaking spheres by applying narrow understanding of the concept, leaving significant elements of innovation-based economic performance unexplained (Lundvall, 2007a).

One missing part of the main NIS literature was any real attempt to identify and clarify institutional intermediaries or bridge institutions in specific industries whose function needed to solve problems for individual firms (Watkins et al., 2014).⁷⁵ As

⁷⁵ Viotti (2002) contended the narrow understanding of the NIS limited to encompassing institutions and relationships that influence innovation processes.

discussed in Chapter 3, knowledge interactions between public intermediaries and SMEs can only be examined when the NIS framework is operationalized. Yet, case studies align with analysing emerging phenomenon: how relationships evolve over time, why they evolve in a particular way, and how they can be intentionally formed. Comprehensive research provides insights about particular institutional settings occurring in some Asian countries and cultural specificities embedded in innovation.

Adopting an appropriate meso- and micro-level approach, the results based on the interviews provide evidence of how knowledge interactions at multiple levels might influence innovations of SMEs and how social dimensions play crucial roles in successful knowledge interactions (Chapter 6). Microsociological factors such as reflexive actors, relational capital, and the evolving characteristics of relationships and knowledge have significant importance in the innovation process. These insights on knowledge interaction represent crucial elements (see section 8.3.) that can be generalised to other innovation contexts of SMEs. For example, the literature on functions of public intermediaries and empirical findings supports these insights. The public intermediary engages in knowledge interaction, knowledge enabling, facilitation of learning and relations, and managing the interfaces that might influence the different processes of innovation of SMEs, as analysed in Chapter 6.

Although the findings may not be applicable to all kinds of innovation at this stage, as there is a need for further research, the results presented in Chapters 6 and 7 provide insights that are rich enough to draw tentative implications for theories and policies (see section 8.5.). The empirical basis of the study is, however, robust enough to provide a foundation for conclusions: first, the NIS framework needs to be operationalised at an appropriate level to examine interactions and relationships; second, micro factors (e.g. social dimensions) should be considered to analyse different patterns of knowledge interaction and relationships; and third, as discussed in Chapter 3, intermediaries facilitate interactions and relationships through the four functions evidenced in Chapter 6. The process contributes to building a new knowledge infrastructure and thus innovation of SMEs at early stages.

8.4.2 Effects of the Research Context

What lessons can be drawn from the Korean experience for the rest of the world? Did the location of the study in Korea have wider application, given contextual differences? Despite factors specific to Korea, these peculiarities may have implications for generalisation of the findings. In this regard, Chapter 3 demonstrated the important elements of Asian industrial development, indicating that most developed Asian countries traditionally possess non-market modes of coordination such as the key role of active government support (Dodgson, 2009; Fransman, 1990, 1991; Gu, 1996; Hu, Lin and Chang, 2005; Mazzoleni and Nelson, 2007; Wong, 2004; Yusuf, 2008). Thus, the Korean context might apply to other Asian countries, based on the analytical generalisations discussed in section 4.2.2. Processual understanding developed for this study might provide diagnostic tools for a better understanding of what happens in Japan or Taiwan, enabling policymakers to identify similar settings and processes in other countries: that is, the role of governments that are actively involved in shaping favourable environments of firms.

For example, in Korea, the role of the strong state and five-year economic-development plans between 1962 and 1997 were major driving forces for rapid economic development. Since then, GRIs have been a major policy tool to implement government policies, as described in Chapter 5. The role of the strong state is not limited to Korea, as many examples come from the international arena, as explained in Chapter 3. Underlying the history of catching up and achieving economic development in a short period of time, Korea, Japan, Taiwan, and more recently China, have strong government intervention as the state fostered a small number of large firms or many small firms. Intervention related closely to cultural and historical contexts, characteristics of people, and social norms (Dodgson, 2009). In a similar vein, public intermediaries (e.g. GRIs) are not a unique phenomenon to Korea; they have been acting as innovation facilitators for firms in other Asian countries.

This situation is likely to be the same in some other developing countries as they try to catch up with advanced countries where firms are incapable of pursuing innovation by themselves. The evidence from this study suggests that public intermediaries do

appear to facilitate innovation in SMEs in a short period of time through the functions suggested in Chapter 3. In particular, the public position of intermediaries is crucial in some countries where organisations struggle to enter cooperative relationships, due to secrecy issues and low levels of trust (Xiaoyuan and Yanning, 2011). For firms that are less capable and have fewer resources, engagement of public intermediaries in knowledge interaction, learning, and facilitation may accelerate innovative capability of SMEs. Thus, focusing the study on Korea might have some implications for others.

8.5 Implications of Findings

8.5.1 Implications for Theories

The NIS concept has been considered a useful framework that helps explain differences in how countries manage and enhance innovation, but has limits in depicting the complex nature of innovations in numerous subsystems, with various actors and factors. Although several researchers (Edquist, 1999, 2001; A. Johnson and Jacobsson, 2000; Liu and White, 2001) tried to define functions and determinants, they did not account for exactly what happens in the interaction process,⁷⁶ as pointed out in Section 8.2. Evidence reported in Chapter 2 supports the claim that an NIS is an abstract framework that needs to be complemented by other disciplines and subsystems (i.e. public intermediaries and SMEs); the instruments of innovation policy are rarely used alone in decision-making processes (Borrás and Edquist, 2013).

The empirical evidence highlights how constellations of heterogeneous actors under different subsystems interact to configure the knowledge and innovation environment while they are affected by individuals, levels of trust, and social capital. Thus, additional micro-level factors, especially social dimensions, institutional aspects, and their functions must be considered in the knowledge-interaction process at the early stages to encompass specific characteristics of a subsystem and the evolving nature of interactions and relationships. This amalgamation of multiple levels of interaction

⁷⁶ Lundvall (2005) criticised that some activities are difficult to see as organised by any specific type of organisations, and several other factors influencing innovations could be listed.

and micro-level sociological factors contribute to the production of high-quality knowledge to reduce gaps in knowledge interactions, learning facilitation, and relations. This dynamic of interaction processes is likely to impact the process of innovation significantly. As Borrás and Edler (2014) argued, the disciplinary tradition of sociological dimensions of STS and evolutionary economists continue to echo the wider contexts of S&T and innovation systems, focusing on the sociocultural context of sociotechnical innovation systems. They bring potential synergies by linking the sociological background of STS and innovation studies.

In contrast, Martin (2012a) attempted to find a missing link between Science Policy and Innovation Studies (SPIS) and other fields of study and emphasises a move to forge closer links among SPIS, STS, historians, and philosophers of science. Martin (2012b) further suggested that innovation studies need to avoid disciplinary sclerosis by bringing other disciplines as an ‘intellectual melting pot’. These scholars try to bridge the gulf between disciplinary fields. This can be seen as the ‘double movement’, bringing innovation studies into science, technology, and innovation studies based on STS; and vice versa, bringing STS into SPIS; in this study, I have tried to link STS and innovation studies. This incorporated approach could provide a robust way to explore the knowledge-interaction process when the limitations of the NIS concept are unmet.

For intermediary theories, most researchers seem to adopt a supply viewpoint, focusing on specific functions that intermediaries deliver to customers unidirectionally rather than interactions and relationships where the role of the demand side can also be emphasised. Heterogeneous demands required at the early stages of innovation facilitate interactive learning and thereby innovation. In this case, four functions of public intermediaries facilitate the DUI-mode of learning rather than the STI-mode of learning. The relationships and interactions between SMEs and intermediaries bring learning opportunities and infrastructural changes of knowledge not only in SMEs but in intermediaries (Chapter 7); the innovative outcomes of four firms are often invisible—so-called ‘dark innovation’. Facilitating dark or invisible innovation entails diverse activities that require collaboration of multiple intermediaries or flexible application of intermediary functions. Evidence

from Firm T illustrates that multiple public intermediaries provide the knowledge SMEs need through collective actions with other intermediaries (e.g. consultants) to complement what the intermediary lacks in services.

KTVF was able to monitor the firm at BIC and provide necessary services in cooperation with KIST and consultants in Japan. In a similar vein, KISTI aligned GRIs to generate new knowledge in the early technology market and the IF linked KISTI service with the private consultancy (e.g. Frost and Sullivan) to provide Firm K with global-market information. As S. J. Lee at the IF remarked, the foundation has been linking different types of services from public and private intermediaries to address various demands such as knowledge service, providing test sites, and technology transfer (Section 7.4.1).

In this case, the specific intermediary monitors all activity and service during the interaction process, which gives the intermediary a learning opportunity to build and renew the knowledge repository. Findings suggest a need for the augmentation of demand-side actors (SMEs) in intermediary studies to consider their engagement in relational innovation. In this case, it may be difficult to define the functions of innovation intermediaries at one point because the role changes over time, which seems to contrast with the literature distinguishing traditional from innovation (systemic) intermediaries (Chapter 3).

Another crucial implication from this study is the usefulness of the public intermediary in the NIS: a constant process of interaction, multiplicity of relationships, and mutual learning. These activities are crucial but not explicit, and this is why the area of public intermediaries has been undertheorised. Actually, states are active, as evidenced in Chapter 5. My empirical evidence suggests that public intermediaries might play a crucial role in knowledge interaction with SMEs, based on their impartial position and resources, neither of which was given much theoretical attention in intermediary literature. It is especially important in emerging technological fields, when innovation is unpredictable in the early stages, that constant efforts are required to mobilise the necessary resources due to contingency and complexity in the innovation process, and SMEs tend to depend on reputation and the credibility of intermediaries under uncertainties. Evidence shows (Chapters 6

and 7) that the capability and credibility of intermediaries are crucial to provide cohesion between capabilities of SMEs built in the past and the capabilities required in a new business. Old routines and relationships built in the past guide innovation in SMEs and SMEs may be locked into their accustomed knowledge.

Smith (1999) and Malerba and Orsenigo (1997) referred to the phenomenon that small firms may lack the capability to learn rapidly and effectively and hence may be locked into existing technologies, and thus unable to jump to new technologies. Central to the argument is that small firms are unable to make the leap from an existing to a new paradigm that is beyond the capabilities of SMEs. This is illustrated as system failures in Chapters 2 and 7. Thus, reliance on credible third parties to engender interaction, knowledge enabling, facilitating relations, and learning is important to address barriers at the systems level. Borrás and Edler (2014) argued that knowledge production and innovation comprise an uncertain process that technological advance would direct. In addition, changes not only come from technological advancement but from a process of problem solving and identifying opportunities that lead to new problems and solutions. More importantly, this long process may not produce any profits; thus, for-profit organisations tend to refrain from participation in the innovation process of SMEs, as discussed in Chapter 7. For SMEs, the involvement of public intermediaries is a safer choice, in advance of the purchase of knowledge and sharing risks.

To conclude, the public intermediary has rarely been studied in the NIS framework, despite their important role as innovation facilitators in NIS. Most intermediary studies do not give much attention to the role of public intermediaries in addressing uncertainties at the early stage of innovation or the role of innovation facilitators of SMEs. The approach developed in this study demonstrates, through analysis of the empirical evidence, the essential role of public intermediaries in coordinating the necessary actions and actors, facilitating learning of SMEs who have to address different sets of knowledge (e.g. social settings, technology, and potential customers) and thereby the DUI-mode of innovation.

8.5.2 Implications for Policymakers

Crucial to the NIS is that the system is in constant flux and does not reach equilibrium based on the evolutionary approach. Hence, neither products nor the economic system ever reach a perfect state of equilibrium (Edquist, 1999). For government policies, this implies that policy measures should not be aimed at achieving a set goal, but rather should aim at facilitating the process of novelty creation, variety, adaptation, and selection, shifting away from a search for ‘cook book’ recipes for success towards *a processual approach* (Clark and Staunton, 1989; Lankhuizen and Woolthuis, 2003; Williams and Edge, 1996). To do so, policymakers should move away from seeking to make strong generalisations about the role of particular policy settings and all-purpose programmes, considering the heterogeneity of the local contexts of SMEs and contingencies in innovation processes, as analysed in the empirical findings.

However, this approach can only be supported when policymakers change from linear views of innovation and thus shift from a static system of measuring outcomes. Researchers tend to measure the success of services provided by public intermediaries by focusing on quantitative analysis (Bathelt and Zeng, 2010; Izushi, 2003; Kodama, 2008; Lin, 2009). In other words, performance indicators of knowledge interaction skew towards visible outcomes whereas the innovators I studied drew attention to the broader feature of the innovation process, including many informed activities: the process involves a number of failures and constraints, and covers a wide range of activities such as technological progress, exploring markets and customers, and organisational changes (refer to Chapter 7).

Several scholars (Carlsson et al., 2002; Freeman, 1995; Freeman and Soete, 2009; Godin, 2006, 2009; Lundvall, 2007c; Smith, 1995) discuss how the measurement of innovative outcomes⁷⁷ has been driven solely by quantitative STI indicators and need to move towards DUI (Lundvall, 2007c). In this regard, Martin (2012b) also argues that dark innovation (or invisible outcomes of innovation) has been

⁷⁷ “Another approach was used in where a great amount of data on the structure of production and the structure of R&D were pooled and analysed statistically in an exploratory way (Y.T. Park and Park, 2003). This conclusion seems to follow from a biased perspective on innovation where the STI side is emphasized and the DUI side is largely neglected” (Lundvall, 2007c, p111).

overlooked in the innovation process. This outlook may imply the importance of diverse activities that contribute to achieving successful innovation. In the same vein, a processual approach needs to emphasise processual knowledge, which might share the idea of ‘dark innovation’. According to the evidence provided in Chapter 7, this oversimplified view of innovation might result in a mismatch between the demands of SMEs and what intermediaries provide during the uncertain and complex innovation process.

In this case, intermediaries are likely to ignore early stage knowledge demands where it is difficult to deliver the outcomes listed earlier. This may lead intermediaries to focus on short term remedies for SMEs; however, this type of service does not help SMEs develop knowledge infrastructure: learning may not occur and thus the barriers may remain unchanged. Focusing on static outcomes, some important factors found in empirical analysis can be ignored. For example, relationships are not well understood by the parent organisation, which therefore finds it difficult to develop indicators for activities that involve the transfer of tacit knowledge (Lyall et al., 2004, p75). Although the history of relationships may strengthen easy use or access to the original recipe of knowledge and bridge the barriers by building a mutual knowledge base in the innovation processes (Izushi, 2003), static indicators do not address the importance of relationships in the innovation process. The processes just “tell a story readily understandable by generalists and the press” (OECD, 1998, p3).

Along with those limitations, it is difficult to expect contingencies, social changes, and individual behaviours of learning and motivation during the innovation process: “Changes in practice often appear to stem from a general ‘awareness raising’ or conceptual shift. Precise measurement of the impact of research upon a particular change in practice is likely to be unattainable” (Meagher, Lyall and Nutley, 2008, p170). Dalziel (2010) also contends that no such indicators can be accepted universally to measure progress in transforming new technologies to the status of commercial readiness.

Therefore, policymakers need to understand the specific characteristics of each case, which may be helpful in examining whether, and in what way, knowledge interaction would enhance innovative capabilities and thereby achieve innovation in SMEs. It

might be important to consider the policy environment that guides the activities of intermediary organisations and to overcome the policy deficits explained as system failures (Chapter 3). This specificity links to the implications for theories in Section 8.5.1 that different subsystems may have a complex mixture of actors, causes, and effects in various innovation contexts. If applied to the entire national innovation system, the design and implementation of policies will prove too complex.

By examining each case, one important issue can be addressed. Innovation processes may take a long time and even entail several failures along the way, before the overall success of the venture can be determined. Several interviewees assert that policymakers sometimes fail to see the whole picture of innovation when faced with such interim failures and are prone to make ill-considered reactions. As examined in Chapter 6, public intermediaries considered the knowledge interaction with Firm H as a failure because it did not bring any visible outcomes. However, failure experiences led the firm to find other business opportunities making them more reflexive actors. Policymakers tend to judge success or failure of innovation based on visible outcomes, although instead they should be judged on the wider outcomes from the innovation process as a whole.

Policymakers are unwilling to address the possibility of failure or risk taking in the innovation process. However, my empirical analysis supports that failure experiences contribute to learning, which can ultimately lead to successful innovation. This is especially true in the case of emerging or new technologies in which the innovation environment is vague with high uncertainty and risk, eliciting the necessity of designing a different measuring system for policy implementation with a long-term view.

8.5.3 Implications for Public Intermediaries

A crucial lesson from this study is the influence of public intermediaries in the innovation process of SMEs. As argued in Section 3.5, intermediary studies have been conducted in the context of static functions overlooking the relationships and interactions that involve intermediaries. In particular, public intermediaries in the NIS, which shapes relationships and provides collective knowledge to resolve the

barriers of individual firms, are not well identified. Evidence developed in Chapter 6 supports the claim that public intermediaries engage in knowledge interactions that might affect the innovation process through four functions: knowledge facilitation, learning facilitation, knowledge enabling, and managing interfaces.

The role of the public intermediary as an innovation facilitator is particularly important to identify and facilitate the circumvention of barriers during the innovation process when the risks and costs of undertaking innovation are high. Especially when the barriers emerge at the early stages of innovation, diversified responses and programmes may be necessary to provide different sets of knowledge and actors, collaborating to achieve the optimum opportunity for success. This places the issue of various long-term and diverse support to enhance innovative capabilities of SMEs on the policy agenda: flexibility of intermediary functions, the importance of monitoring activities, and consideration of heterogeneous demands.

The first agenda relates to limited functions of the public intermediary in addressing the diverse barriers that might intertwine (Chapter 2). Resolving the barriers may be challenging for a single public intermediary or the four functions may not be sufficient to meet the heterogeneous requirements. In this case, public intermediaries increased their roles, providing services directly to firms on a one-to-one basis that were considered functions of traditional intermediaries (Firms K, P, T, and H). For example, KISTI provided Firm H with not only four functions of innovation intermediaries but also the traditional role of intermediaries, providing technology-market information services and supercomputing simulation programmes that did not involve third-party collaboration. Once firms have received a wide range of services, they may no longer need four functions of innovation-intermediary services, but require little or particular forms of services instead; for example, four successful and less successful cases constantly received services through managing interfaces.

In the case of Firm T, the firm did not have any infrastructure, as a new startup faced with several internal and external barriers, and thus needed a wide range of extensive services for a long period of time. Ministries, multiple GRIs, and KTVF, whose expertise was diverse, ranging from pure R&D to matchmaking, were involved to address the unexpected barriers. In these cases, a single public intermediary may

have limits in undertaking all the services required by SMEs in a short period of time; thus, the public intermediary may need to align other intermediaries or private consultancies during the interaction process. In the case of Firm K, the company required extensive and specific services, focusing on a new set of knowledge in the early technology market, rather than a wide range of services (e.g. R&D funding, marketing activities, or technology transfer).

In practice, the knowledge-interaction process is more flexible and complex than public-private interactions, as shown in the NIS framework (Appendix 2). Therefore, as indicated in Section 3.5.1, public intermediaries should not restrict themselves to innovation intermediary functions and need to consider a range of intermediary services. Functions might increase over time or could iterate, highlighting the importance of networking or collaboration among various types of intermediaries, and a flexible application of functions. In other words, support programmes should consider the dynamics of the innovation process and the dynamic interplay between multiple intermediaries and SMEs, rather than focusing on static functions.

The second agenda is how to coordinate and manage the knowledge interaction process when the interaction process involves multiple intermediaries and actors to address different types of internal and external barriers. In this case, networking with other intermediaries calls for monitoring activities that regulate and restrict flows of knowledge and influence governance, rather than facilitating knowledge interactions (Lyll, 2007). Public intermediaries must focus on monitoring activities that integrate services, provide coherence, and control the process by facilitating ‘associativeness’ among participants; otherwise success can be hampered. The failure case of Firm M (Chapter 6) supports the importance of the gatekeeping role where a ‘lack of cohesion’ among multiple intermediaries results in one-way knowledge flow from intermediaries to the firm in the knowledge-interaction process. As a consequence, the service of each intermediary was not linked to the others and the firm was unable to obtain a productive combination of competing rationalities through multiple levels of interactions.

The third agenda is the consideration of heterogeneous demands of SMEs in designing the support programme; each SME has different barriers that entail

different levels of complexity and uncertainty. Understanding the capability levels of SMEs that have different business relationships, technological competences, qualified employees, and learning potential is crucial in developing programmes. The heterogeneous nature of SMEs may result in different knowledge demands, different involvement of actors, and different interaction processes. Evidence collected from this study suggests that SMEs who have had business relationships with global buyers or other intermediaries seem to have greater chances to establish learning capabilities inside firms that can be replicated by interaction with public intermediaries. Certain SMEs may find it more important to build learning routines than acquire the new knowledge required to explore new business areas; they would take more time to attain the knowledge interaction that needs to be considered in the programme-design process.

This study has demonstrates different SMEs need different approaches as illustrated in figure 8-1: different innovative capabilities, barriers, and uncertainties embedded in the innovation process. Depending on the level of uncertainty and barriers specific to each SME at the early stages of innovation, range-of-knowledge requirements and characteristics of services could vary. In this vein, a single standardised programme does not meet the heterogeneous demands of SMEs. Programmes designed for technologies of less innovative firms will differ from those aimed at articulating and attaining early involvement in innovation processes. In other words, the wide range of programmes, from one-off services to highly specialised and targeted activities, need to be considered in support-programme design. This study suggests that important policy targets are the facilitating innovation processes of firms and the role of public intermediaries that link policy and the needs of SMEs.

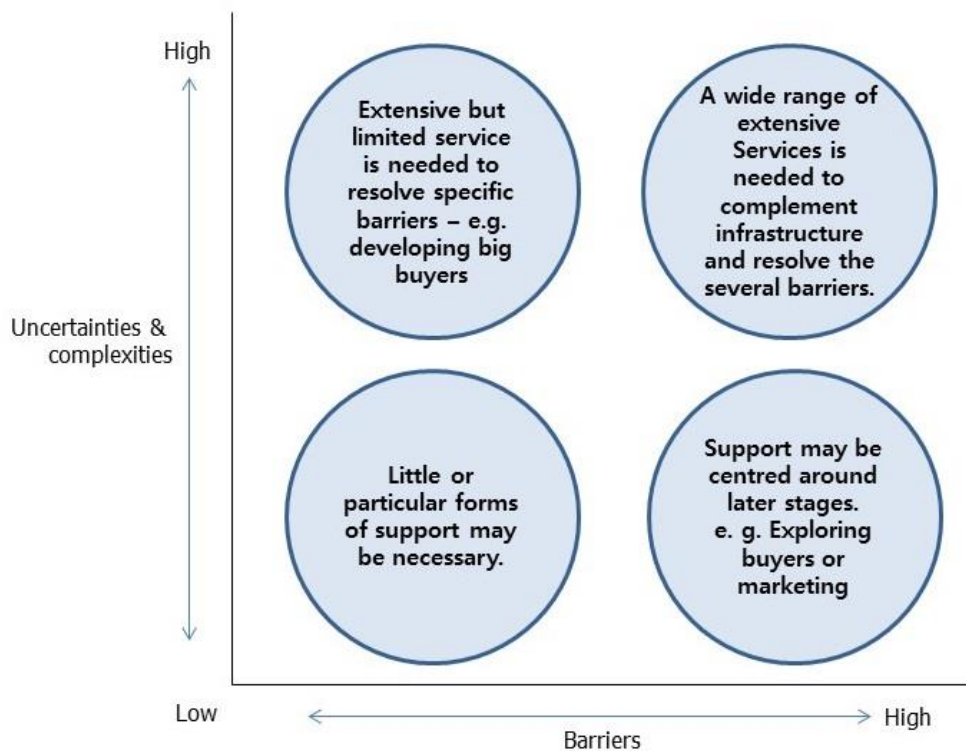


Figure 8-1 The types of services offered by (multiple) intermediaries.

8.6 Reflections on Research

8.6.1 Research Strengths

The NIS concept discussed in Chapter 2 does not address the issue of the heterogeneity of institutions and micro-factors in any substantial manner, based on its abstract framework. In the NIS literature, public–private interaction is important for knowledge flow and learning (Lundvall, 1992, 2010; Nelson, 1992, 1993) but little empirical attention has been given to public intermediaries. Researchers overlook the interactions between other system actors such as firms, intermediaries, and science (Lyall, 2007), whereas such a focus is appropriate especially for small firms, constrained by a lack of internal resources that impede the firms’ ability to engage in innovation (Rothwell, 1991). Exceptionally, intermediary literature has provided several accounts describing how intermediaries facilitate innovations. The conceptual framework attempts to synthesise the NIS concept and intermediary studies, rendering it feasible for this study to analyse institutions and their interactions at an appropriate level—public intermediaries and SMEs (Chapter 4).

Arguing that the NIS literature has paid little attention to the role of public intermediaries, this study provides systemic investigation of particular kinds of public intermediaries and their role, influencing innovation of SMEs in the Korean context, which has not previously garnered much attention.

A further conceptual contribution has been made using the NIS framework to analyse sets of actors, public intermediaries, and SMEs, little studied heretofore. Previous NIS studies largely focused on firms and universities with few focusing on intermediaries. By focusing on public intermediaries and SMEs, this study illustrated the utility of NIS, the importance of government organisations, and of SMEs in particular. Also, by defining firms, this study helps in understanding the heterogeneous nature of SMEs, which may cause knowledge and relational gaps at the early stages of innovation and, as a result, may affect the formation of different patterns of relationships.

The key strength of this study is the contribution to understanding public intermediaries by presenting a conceptual framework that attempts to analyse the knowledge-interaction process between public intermediaries and SMEs according to four functions. By categorising them, it becomes possible to explore the nature of the interactions and evolving relationships that have not been recounted in other literature, which tends to focus on knowledge flow from the supply viewpoint or interactions at macro-levels. Functions were based on the extent to which intermediaries and SMEs conjoin in knowledge interaction; where relationships and knowledge have evolving characteristics.

The conceptual framework helps to explore the links between meso- and micro-levels in NIS research by incorporating intermediary studies and STS perspectives. Although macro-level studies only show general patterns of interactions, this bridge, developed in this study, provides a way to analyse how institutions matter, how their relationships are evolving, and what specific characteristics and micro-factors contribute to the innovation process, based on the functions developed in Chapter 3. This study highlights the role of public intermediaries as reflexive actors, whereas most intermediary studies consider them to be service providers or suppliers and seldom reveal the weaknesses of intermediaries. Public intermediaries do fail and

have functional weaknesses (Chapters 6 and 7); however they also learn from interactions with various SMEs and other innovation players, and apply their particular experiences to other firms, acting as knowledge repositories. In the case of Firm H, KISTI focused on the demands of the firm rather than depending on locked-in knowledge, as KISTI did in the first knowledge interaction that failed. Evidence from Firms K and P illustrate how researchers interact with multiple levels of actors (e.g. GRIs, buyers, and policymakers) and this specific knowledge and experience can be used in other settings. From this viewpoint, public intermediaries can be risk takers as innovation partners of SMEs and these relationships further reinforce social learning.

Empirically, this study contributes to existing knowledge by collecting and analysing empirical data on this understudied field. As introduced in Chapter 3, a large number of intermediary studies focus on limited roles and activities at a specific point of time. Few studies address the process of knowledge interactions in which heterogeneous actors may be involved over time, the role of individuals is emphasised, and learning changes the knowledge infrastructure of SMEs. The qualitative data and semi-structured in-depth interviews of key actors of innovative SMEs provide rich evidence to support these findings and policy implications. In doing so, this study could reassert the neglected role of public intermediaries from the NIS concept and therefore facilitate the effective application of the NIS concept in different contexts.

8.6.2 Research Limitations and Future Agenda

Though this study achieved its broad objectives, some limitations and unresolved questions remain that in turn point to opportunities or needs for future research. First, though I have shown how knowledge interaction between intermediaries and SMEs affect the innovation process, this study does not indicate the strength of the impact of interactions and relationships. The research design is exploratory and mainly focuses on examining the interaction process between intermediaries and SMEs and how it impacts innovation processes. Larger scale methods may be needed to establish the wider applicability of these findings. Although it would be difficult to measure the impact using quantitative metrics, due to the nature of uncovering the

relationships and interactions, indicators could be developed based on interviews and applied to a large-scale survey to support interview-based empirical findings.

Second, though this study did highlight the importance of detailed qualitative analysis, the research design did not provide a basis for the kind of detailed ethnographic study that would be needed to explicate the role of a number of sociological factors such as power and trust, and how these might affect the interaction process. For example, the power aspect of relationships can affect willingness to share information and create new knowledge, and entering into trusting relationships, especially when multiple public intermediaries engage in the process, may complicate the process of achieving a convergence of interests. Conflicts and misalignment of interests may have negative impacts on innovation activities, leading SMEs in wrong directions. This study does not address this topic in depth because the aim was to identify the facilitating activities of intermediaries. Future research could deepen understanding by examining issues of economic and political power among multiple actors from the public side.

Third, the issue of governance of multiple intermediaries needs to be studied. This study provides some implications regarding the importance of monitoring organisations as gatekeepers (Section 8.5.2). However, interaction is not only important between SMEs and other actors but also among intermediaries, as well as between intermediaries and policymakers. Investigation of the policy network at multiple levels could contribute, for example, to integrating the related programmes provided by various organisations and ministries.

Fourth, another fruitful issue for future research concerns learning. A key implication of this study is the attention to knowledge interaction, which promotes social learning in agreement with the NIS literature (Edquist, 1997; Lundvall, 1992; van Mierlo et al., 2010). Researchers should compare how learning by firms under intermediaries and formal programmes differs from learning by firms in informal settings. Further study here could make an important contribution to the literature in discovering the factors facilitating interactive learning that may occur not only in SMEs, but also in intermediaries.

Finally, there is the need for a better understanding of how these types of knowledge interactions are created and how experiences may differ across sectors and countries. This study examined two different fields of technologies (IT and mechatronics); however, it has shortcomings in analysing the differences between the two fields due to the small number of cases and the multidisciplinary nature of the technologies of the five firms. Different technology fields and subfields seem to exhibit different challenges and dynamics. In spite of differences, each field has commonalities at the meso-level: length of interaction, number of intermediaries involved in the process, level of uncertainty about the future technology market, and types of services. Therefore, it will be useful to compare the actors and factors behind the formation of relationships in different technology fields and the role of the government in each field, based on large data sets.

Also, there may be marked differences between national economies in how innovation is supported and organized. Intermediation in particular is organized very differently. This particular type of public intermediary is quite common and important in Korea, but perhaps not as common in Western economies. In *laissez-faire* economies, those roles are played by private-sector actors or by people with a less stable institutional position. An opportunity exists for further systematic research to understand the very different formations and roles innovation intermediaries can play. A need persists to understand public intermediaries; they are tacitly important in some countries whereas they are explicitly important in other countries. Further study of other countries' experiences would be useful as supporting evidence, providing opportunities for comparison and learning.

8.6.3 Challenges for Public Intermediaries

This study suggests that four functions of public intermediaries can be expanded to cover the roles of traditional intermediaries by developing more functions in the single intermediary (KISTI or KTVF) or networking with other intermediaries (e.g. GRIs or a private intermediary). Multiple innovation intermediaries with different expertise may be involved in addressing the barriers of a single firm. Empirical evidence has emphasised the role of public intermediaries complementing each other by providing different functions that helped firms resolve different types of barriers

at the early stages of innovation and achieve innovation in a short space of time. Firm H shaped a network of multiple levels of public intermediaries whose strengths varied (i.e. KISTI as a knowledge provider, KETI as a R&D partner, and other two GRIs as proxy users). Sometimes, public intermediaries may not be enthusiastic about SMEs' business schedules or are not as desperate to make progress as CEOs, resulting in feedback delays. In this case, intermediaries can delegate some roles to other (private) intermediaries to address the rapid rate of market and technological changes, which, close to the later stage of innovation, allow SMEs to respond in a timely manner. In the case of Firm K, a private intermediary was involved in the innovation process that was organised and sponsored by the public intermediary.

The challenge may emerge in how public intermediaries do not limit their roles as innovation intermediaries at the early stages of innovation and expand their functions by shaping networks at multiple levels. In other words, public intermediaries could address how to identify, involve, and manage collaborative relationships, providing all organisations and individuals with motivation during the uncertain innovation process. Individuals may have interests that conflict with the organisational purpose of intermediaries. Multiple intermediaries may cause rivalry rather than cooperative relationships. Therefore, as indicated in Section 8.6.2, the role of monitoring organisations as legitimated facilitators may be crucial in controlling the process.

Although this study has examined the evolution of multiplicities of relationships, observing different organisations, it focused on public intermediaries at the early stages of innovation. The study was limited in showing the relationships between different types of innovation intermediaries, discerning how intermediaries get involved in the innovation process or whether relationships emerge spontaneously. Therefore, additional work is needed to understand not only the functions fulfilled by public intermediaries, but also other types of intermediaries presented in Section 3.2.1. Organisations such as incubating centres, universities, consultant firms and individuals may be needed. Identifying their strengths or fostering different types of innovation intermediaries in the Korean context may be helpful in organising networks of intermediaries in a broader innovation context.

8.7 Concluding Remarks: Towards an Interactive and Processual Approach

As previously stated, many Asian nations traditionally have turned to non-market modes of coordination as mechanisms to remove the barriers of innovation and improve the overall efficiency of the NIS. In Korea, public intermediaries played a crucial role in strengthening industries and facilitating the rate of innovation by linking policy to industries for several decades, however the government policy has failed to develop an effective infrastructure for SME promotion. 'Weak SMEs' still remains a chronic problem in the KNIS even though fostering innovative SMEs has been a major policy concern. An ongoing debate has ensued about whether policy and programmes would be useful for enhancing the innovative capabilities of SMEs.

However, in spite of the increasing concern about the mechanisms to correct failures, how public intermediaries facilitate innovation among SMEs and how knowledge-interaction process between SMEs and intermediaries could decrease the barriers have not been fully examined in the NIS literature. This was the key problematic when my study gained momentum. As discussed in Chapter 1, the central focus of this study was on the knowledge-interaction process between public intermediaries and SMEs occurring at multiple levels of interaction in the KNIS. In particular, this study sought insight into how barriers at the early stages of innovation could be removed through knowledge interaction under context-specific arrangements. In this case of SMEs in the KNIS, the institutional arrangements that shape the interaction process and decrease the barriers are far from general. These would be different in other nations, regions and types of firm.

Yet little is known about the interaction process between public intermediaries and SMEs, and a paucity of research has attempted to understand the role of intermediaries as linkage organisations in the KNIS. Based on the analysis of literature and empirical findings, two reasons could be inferred. On one hand, the NIS approach is a loose concept that does not have indicators to identify national specificities, interaction between specific actors, or problems for innovation in localised contexts. As the KNIS has grown in size and sophistication, it is difficult to analyse the system and identify barriers based on the loose framework. On the other

hand, the intermediary literature is fragmented, and tends to focus on specific functions of private intermediaries and far less on public intermediaries. However, this study is not a critique of the rationale of NIS but rather an attempt to analyse neglected parts of the framework to the literature, lack of substance and specificity, and the black box of interaction process. From this point, this study makes a broad investigation into the interaction process between SMEs and intermediaries, based on the conceptual framework to address research questions.

This study therefore draws on the NIS concept, intermediary studies and in particular SLTI perspectives to scrutinize the interactions among the heterogeneous actors and factors that affect different patterns of evolving relationships. As explained in the previous section, the multidisciplinary approach enables this study to analyse complex meso- and micro-dimensions of the relations and interaction processes between public intermediaries and SMEs that are mutually shaped. The perspective gives an analytical lens to look into the complexity and diversity of knowledge-interaction processes and their local contexts, which differ from firms.

Emphasising the hidden value of relationships and interactions between public intermediaries and SMEs, this study broadly investigated social aspects in the interaction process between SMEs and intermediaries, based on the conceptual framework in Chapter 4. As analysed in Chapter 6, the five SMEs studies are all heterogeneous due to the history of technological expertise and relationships, and these affect different requirements of knowledge and different patterns of relationships in new business areas. Knowledge interaction and facilitating innovation require long-term effort, cost, and risks; the process is lengthy, reflexive, and localised, involving several failures and unforeseen problems. Accordingly, the knowledge-interaction patterns of the five SMEs have evolved in different ways to address the specific problems each SME faced during their innovation process.

Empirical evidence in Chapters 6 sheds light on the importance of a productive combination of competing rationalities at multiple levels and the importance of reflexive individuals in successful knowledge interaction and social learning. Knowledge interaction at multiple levels provides learning opportunities for intermediaries and for SMEs. The knowledge-interaction process to decrease diverse

barriers can be seen as social learning, as SMEs constructed organisational and managerial processes by linking old and new skills, expertise, and relationships, rather than by simple acquisition of knowledge. This study highlights the role of reflexive actors who accumulate multidisciplinary knowledge through interaction with heterogeneous actors, learn from failures, and apply these experiences in different settings.

Furthermore, Chapter 7 provides a rationale of the role of intermediaries providing resources where resources are lacking and motivating forms of collaboration among diverse actors. Interaction can be seen as a social process that requires long-term system-level interactions to identify and interact with components and actors in the system, characterised as a constant process of interaction, multiplicity of relationships, and mutual learning. In this vein, public intermediaries play a crucial role in facilitating interaction with components and multiple actors, as their resources and capabilities specialise in identifying barriers and responding to the challenges faced by SMEs in the KNIS. The NIS concept, as a device to remove barriers, needs to be understood as a process of identifying and solving problems, which stimulates the creation of new knowledge related to a specific innovation.

In this vein, this study suggests the need for two approaches towards innovation facilitation. First is the processual approach. Empirical evidence supports the idea that innovation in its early stages entails several constraints and unforeseen barriers that are contextual and localised. Therefore, service provision and the period of knowledge interaction and relationships may expand and differ across firms. Second is the interactive approach. Knowledge does not flow from one side to another, but flows back and forth at multiple levels, which facilitates interactive learning. Considering that SMEs are heterogeneous in capabilities (e.g. in terms of level of knowledge, learning routines, and relationships) and innovation occurs in a localised context, understanding the dynamic nature of innovative SMEs is a prerequisite condition for knowledge interaction. From this viewpoint, this study suggests that support programmes should move away from one-size-fits-all models.

To summarise, knowledge interaction is a long learning process and the effects and outcomes, which are the products of knowledge use, are often difficult to measure in

a quantitative sense. Furthermore, success or failure of innovation at a specific point of time needs to be understood as flexible states in which firms are still learning and experiencing movement towards sustainable growth. In this vein, public intermediaries, as non-market mechanisms, have strengths in linking national policies to industries constantly, increasing learning capability of SMEs, removing barriers to innovation, and thereby enhancing the efficiency of the KNIS. This study demonstrated that public intermediaries—though still sometimes underappreciated—have a crucial role in the KNIS.

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Appendix 1. Definition of the NIS

“... is a set of institutions whose interactions determine the innovative performance of national firms” (Nelson, 1993, p4)

“... is constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful knowledge ... a national system encompasses elements and relationships, either located within or rooted inside the borders of a national state” (Lundvall, 1992, p2)

“... set of institutions that (jointly and individually) contribute to the development and diffusion of new technologies. These institutions provide the framework within the governments form and implement policies ... it is a system of interconnected institutions to create, store, and transfer of knowledge, skills, and artifacts which define new technologies “(Metcalf, 1995 in OECD, 1999, p24)

“... a set of interrelated institutions; its core is made up of those institutions that produce, diffuse and adapt new technical knowledge, be they industrial firms, universities, or government agencies.” (Niosi, 2002, p291)

“... adopted from the innovation and innovation learning theories, such as the belief that firms do not innovate in isolation, but are in constant interaction with other actors in the system, profit and non-profit actors” (Lankhuizen and Woolthuis, 2003, p12)

“... set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process” (Carlsson, 2006, p58)

Source: Compiled by the author

Appendix 2. Core knowledge flows in the NIS

Type of knowledge flow	Main indicator
Industry Alliances	
Inter-firm research co-operation	Firm Survey Literature-based counting
Industry-university interactions	
Co-operative industry/university R&D Industry/University co-patents Industry/University co-publications Industry use of university patents Industry/University information-sharing	University annual reports Patent record analysis Publications analysis Citation analysis Firm surveys
Industry-research institute interactions	
Co-operative industry/Institute R&D Industry/Institute co-patents Industry/Institute co-publications Industry use of institute patents Industry/Institute information-sharing	Government reports Patent record analysis Publications analysis Citation analysis Firm surveys
Technology diffusion	
Technology use by industry Embodied technology diffusion	Firm surveys Input-output analysis
Personnel mobility	
Movement of technical personnel among industry, universities and research	Labour market statistics University/Institute reports

Sources: OECD, National Innovation Systems, 1997, p45.

Appendix 3. Interviews conducted for the case study

Interviews conducted with actors in five firms

Interviewee by Affiliation	Interviewees	Roles
Firm K	CEO Executive director Manager	- Led collaboration with external organisations - Managed the internal knowledge-interaction process - Acted as a liaison between the CEO and employees, R&D departments, and management departments - Led the strategic-management team
KISTI	Dr. YJ Choi	- Project manager in charge of the knowledge-interaction process - Managed interfaces with Firm K
Firm P	CEO Executive director	- Led collaboration with external organisations - Conducted R&D - Managed joint R&D programmes
KISTI	Dr. HS Roh	- Project manager in charge of the knowledge-interaction process - Managed interfaces with Firm P
Firm T ¹	CEO	- Managed collaboration with external organisations - Conducted R&D
KTVF	Dr. HJ Kim Ms. JH Kwon	- Project manager in charge of the knowledge-interaction process - Managed interfaces with Firm T
Firm H	CEO 2 CTOs	- Managed collaboration with external organisations - Conducted R&D, managing joint R&D programmes
KISTI	Dr. CH Kim	- Involved in knowledge interactions - Managed interfaces with Firm H
Firm M ²	CEO	- Led collaboration with external organisations
KISTI	Dr. CH Kim	- Managed interfaces with Firm M

Note. ¹ For Firm T, I interviewed the CEO, the founder of the firm who served from 2000 to 2011. The CEO changed in 2011 due to the takeover; ² Firm M closed the business at the point of interviews and it was not possible to access key employees.

A list of Interviewees

Fields	Interviewee by Affiliation	Interviewees	Dates
Mechatronics	Firm K	CEO, Executive director, Manager	08 Oct. 2012 26 Oct. 2012 06 Apr. 2013
	Firm P	CEO, Executive Director	09 Oct. 2012 28 Mar. 2013
	Firm T	CEO	25 Jan. 2013 04 Mar. 2013
	Firm V VSI	CEO, Director, Senior Researcher KISTI	09 Jan. 2013
	Firm B	CEO	14 Feb. 2013
	Firm EE	President, Vice President	30 Jan. 2013
	Firm KD	CEO	24 Dec. 2012
	Firm KP	CEO	19 Dec. 2012
	Firm A	CEO KISTI	04 Dec. 2012
	Firm D	CEO	01 Nov. 2012
	Firm B	Director KISTI	30 Oct. 2012
Subtotal	11	17	
IT	Firm H	CEO, 2 CTOs	30 Oct. 2013 14 Mar. 2013 22 Mar. 2013
	Firm M	CEO	19 Oct. 2012 31 Oct. 2012
	Firm NR	CEO	30 Jan. 2013 17 Apr. 2013
	Firm C	CEO	16 Apr. 2013
	Firm ML	CEO	15 Feb. 2013
	Firm NV	CEO	02 Jan. 2013
	Firm S	Executive director	26 Dec. 2013
	Firm E	Executive director	04 Dec. 2013
	Firm KG	CEO	30 Oct. 2012
	Firm EP	CEO	18 Oct. 2013
	Firm ME	CEO	09 Oct. 2013
	Firm N	CEO	07 Nov. 2012
	Subtotal	12	14
Chemistry	Firm HD	CEO, Director	26 Nov. 2013
	Firm KC	CTOs (2)	24 Oct. 2012
	Firm MH	Executive director, Director, Manager	18 Dec. 2012
Subtotal	3	7	
Intermediary	KISTI	Dr. CH Kim	19 Oct. 2012 11 Apr. 2013
		Dr. YJ Choi	08 Oct. 2012
		Dr. HS Roh	28 Mar. 2013
	Innovation Foundation KTVF	Director SJ Lee	11 Apr. 2013
		Dr. HJ Kim	19 Apr. 2013
	Private consultancies (2)	Ms. JH Kwon	11 Dec. 2012
University	Dr. KH Baek	19 Dec. 2012	
	Dr. IS KIM	26 Mar. 2013	
Subtotal	6	9	
Total	32	48	