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THE INTERPLAY OF LOCAL CLUSTER DEVELOPMENT AND GLOBAL INTER-CLUSTER BRAIN CIRCULATION: A GOVERNANCE PERSPECTIVE IN EMERGENT ECONOMIES

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Tese submetida ao Programa de Pós-Graduação em Engenharia de Produção da Universidade Federal do Rio Grande do Sul, como requisito parcial à obtenção do título de Doutor em Engenharia na área de concentração em Sistemas de Produção.

Orientadora: Prof. Istefani Carísio de Paula, PhD

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Esta tese foi julgada adequada para a obtenção do título de Doutor em Engenharia e aprovada em sua forma final pelo Orientador e pela Banca Examinadora designada pelo Programa de Pós-Graduação em Engenharia de Produção da Universidade Federal do Rio Grande do Sul.

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I dedicate this thesis to my lovely kids and wife who

motivated and supported me during this

long and grateful journey!

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ABSTRACT

High-tech clusters are important hubs of innovation and production in an increasingly interconnected global economy. There has been an increasing interest from scholars in the embeddedness of local cluster development, in particular of high-tech industries in emergent economies, and global connectivity, in particular in the dynamics and role of inter-cluster brain circulation (IBC). IBC denotes knowledge, technology and practice diffusion and translation through individual networks between emergent and typically more established clusters that are globally interconnected through these network ties. Of particular interest to this study is the controversial role of IBC in stimulating the growth and upgrading of larger/growing versus smaller/nascent clusters. Using the lens of network governance, this study aims to propose forms of IBC governance for steering these processes. The empirical context of investigation is composed of (a) two prior studies of IBC in the cases of Bangalore (IN) - Silicon Valley and Hsinchu (TW) - Silicon Valley connections and (b) two original empirical cases examining the Sinos Valley (BR) - Korea connection and Daedeok Innopolis (KR) - US connection. A qualitative research method strategy is employed in these two original cases using 26 in-depth interviews across both cases as a source of evidence. Based on the studied cases, it is possible to argue that for larger-scale growing clusters, IBC-growth dynamics may unfold as an 'organic process' through self-reinforcing market forces, whereas small-scale embryonic clusters depend on a 'coordinated effort' of this process because they lack initial market attractiveness for both individuals and firms. Further, focusing on the effectiveness of IBC in steering the growth and upgrading of clusters, it can also be argued that IBC governance changes through a gradual decreasing in the intervention to stimulate IBC, from a 'coordinated effort' in the early stage to a spontaneous increase in the market-driven process of IBC as an 'organic process' in the mature stage of cluster development. This study has important implications for understanding cluster connectivity, the role of governance in cluster growth and upgrading, and the effective catch-up strategies of emerging economies.

Keywords: high-tech industries, cluster development; emergent clusters, global connectivity, network governance, brain circulation, diaspora network, reverse brain drain.

RESUMO

Clusters de alta tecnologia são vistos como importantes centros de inovação e produção em uma economia atual global e interconectada. Observa-se um maior interesse da comunidade acadêmica pela relação entre o desenvolvimento de clusters de alta tecnologia em economias emergentes e suas conexões globais através da 'circulação de talentos entre os clusters' (em inglês, IBC). IBC representa, tipicamente, a difusão e transferência de tecnologias, conhecimentos e práticas através de redes individuais entre clusters emergentes e clusters já estabelecidos, os quais estão globalmente interconectados através dos laços destas redes. O foco deste estudo está no papel controverso da IBC no estímulo ao crescimento e melhoria de clusters maiores/em crescimento versus clusters menores/nascentes. Este estudo tem como objetivo propor formas de governança da IBC para conduzir estes processos nos seus diferentes estágios de desenvolvimento. O contexto empírico investigado está baseado em (a) dois casos consolidados da literatura: as conexões de Bangalore (IN) - Vale do Silício e Hsinchu (TW) - Vale do Silício; e, (b) dois casos originais: as conexões de Daedeok Innopolis (KR) – EUA e Vale dos Sinos (BR) – Coreia. O método de pesquisa utilizado é qualitativo com a aplicação de 26 entrevistas em profundidade como fonte principal de evidência. Com base nos casos estudados, é possível argumentar que os clusters maiores/em crescimento se beneficiam de uma IBC orgânica, estimulada pelas dinâmicas e forças do mercado, enquanto os clusters menores/nascentes dependem de um esforço coordenado devido à falta de atratividade inicial para empresas e indivíduos. Além disto, com vistas à eficácia da IBC no estimulo ao crescimento e melhoria de clusters, também se pode argumentar que a intervenção nas dinâmicas da IBC se reduz ao longo da evolução dos clusters, passando de um esforço coordenado nos estágios iniciais de desenvolvimento do cluster para um processo orgânico da IBC guiado pelo mercado em estágios mais avançados de desenvolvimento. Este estudo tem implicações importantes no entendimento da conectividade de clusters, do papel da governança para o crescimento e melhoria de clusters e das estratégias efetivas de *catch-up* para economias emergentes.

Palavras-chave: empresas de alta tecnologia, desenvolvimento de clusters, clusters emergentes, conectividade global, governança de redes, diásporas, circulação de talentos.

FIGURE LIST

TABLE LIST

ACRONYMS LIST

ABDI: Agência Brasileira de Desenvolvimento Industrial

ABINEE: Associação Brasileira da Indústria Elétrica e Eletrônica

AGDI: Agência Gaúcha de Desenvolvimento e Promoção do Investimento

AIB: Academic of International Business

BC: Brain Circulation

BNDES: Banco Nacional de Desenvolvimento Econômico e Social

CAPES: Coordenação de Aperfeiçoamento de Pessoal de Nível Superior

CDMA: Code Division Multiple Access

CEITEC: Centro Nacional em Tecnologia Eletrônica Avançada

CEO: Chief Executive Officer

CNPQ: Conselho Nacional de Desenvolvimento Científico e Tecnológico

CTO: Chief Technology Officer

CIR: Chief Institutional Relations

DRAM: Dynamic Random-Access Memory

ETRI: Electronic and Telecommunication Research Institute

EURAM: European Academy of Management

FDI: Foreign Direct Investment

Finep: Financiadora de Estudos e Projetos

GCC: Global Commodity Chain

GDP: Gross Domestic Product

GNP: Global Network Production

GRI: Government Research Institute

GSM: Global System for Mobiles

GVC: Global Value Chain

HSP: Hsinchu Science Park

IBC: Inter-cluster Brain Circulation

iBegin: International Business, Economic Geography and Innovation

IC: Integrated Circuit

ICT: Information, Communication and Technology

IP: intellectual property

ITRI: Industrial Technology Research Institute

KAIST: Korean Advanced Institute of Science and Technology

KI: KAIST Institute

KIST: Korean Institute of Science and Technology

KIST: Korean Institute of Science and Technology

KOSIS: Korean Statistical Information Service

KRISS: Korean Research Institute of Standards and Science

MCTI: Ministério da Ciência, Tecnologia e Inovação

MIT: Massachusetts Institute of Technology

MNC: Multinational National Corporation

NCTU: National Chiao Tung University

NIS: National Innovation System

NTHU: National Tsing Hua University

OECD: Organization for Economic Co-operation and Development

OEM: Original Equipment Manufacturers

PADIS: Programa de Apoio ao Desenvolvimento Tecnológico da Indústria de Semicondutores

PC: Personal Computer

PITCE: Política industrial, Tecnológica e de Comércio Exterior

R&D: Research and Development

RD&B: Research, Development and Business

RFID: Radio Frequency Identification

S&T: Science and Technology

SIA: Semiconductor Industry Association

SKKU: Sungkyunkwan University

SME: Small and Medium Enterprise

ST&E: Science, Technology and Engineering

SwB: Science without Borders Program

THE: Times Higher Education

TSIA: Taiwan Semiconductor Industry Association

TSMC: Taiwan Semiconductor Manufacturing Company

UMass Boston: University of Massachusetts Boston

VC: Venture Capital

Y2K: The Year 2000 Problem

TABLE OF CONTENTS

1 INTRODUCTION

The first section of this chapter introduces the research context, specifies the research question and reviews the relevant debate in the literature. The research design and the investigated empirical context are discussed in the second section. The objectives of this research are then defined in the third section, followed by a presentation of the research contributions and limitations in section four. The structure of the PhD dissertation is presented in section five.

1.1 Research context and the research question

Clusters are seen as a competitive advantage for countries (Porter, 2000). They generate more efficient industry operations, in particular for knowledge-intensive industries, by sharing common infrastructure, technology, knowledge, supply and demand in a regional agglomeration of firms and related institutions (Delgado, Porter, & Stern, 2012, 2016; Porter, 1998, 2000). Clusters are important hubs of innovation and production in the increasingly interconnected global economy (Amin & Thrift, 1992; Pouder & St. John, 1996). Because cluster development is a complex matter, the question of how clusters come into being and grow over time has been the subject of long-standing debate (Bresnahan, Gambardella, & Saxenian, 2001; Manning, Sydow, & Windeler, 2012; Menzel & Fornahl, 2010; Pouder & St. John, 1996; Sydow, Lerch, & Staber, 2010).

The mechanisms behind cluster development are not fully understood by scholars, in particular those operating at the initial developmental stages. At this emergent stage, clusters appear to rely much more on initial resource conditions, such as the availability of labor, favorable infrastructure and policies, connections to markets, and the location decisions of foreign firms and entrepreneurs (Bresnahan et al., 2001). Moreover, those factors that stimulate the latter – firm and individual decisions – is still little understood. Some scholars even argue that 'luck' or 'coincidence' may 'explain' the often unpredictable entrepreneurial events leading to initial cluster growth (Pouder & St. John, 1996). Additionally, many studies show tendencies toward circular causality – the 'chicken-and-egg problem' (see also Bresnahan et al., 2001). For example, while firm investment decisions often rely on the availability of skilled labor markets (Pouder & St John, 1996), the latter typically only fully emerge as employment opportunities arise (Bresnahan et al., 2001). Not surprisingly, it has been difficult for policy-makers to effectively promote initial cluster development (Sydow et al., 2010).

More recently, however, scholars have started investigating in more detail how clusters are interconnected and how these connections may impact their development (see, e.g., Bresnahan et al., 2001; Lorenzen & Mudambi, 2013; Zaheer, Lamin, & Subramani, 2009). There is increasing consensus, for example, that global ties may complement local cluster ties in stimulating knowledge transfer, innovation, and upgrading (Bathelt, Malmberg, & Maskell, 2004; Humphrey & Schmitz, 2002; Owen-Smith & Powell, 2004). The importance of global connectivity has in particular been emphasized in the context of cluster development in emerging economies (Humphrey & Schmitz, 2002; Lorenzen & Mudambi, 2013; Manning et al., 2012).

Prior research has typically distinguished organizational from individual ties between (as well as within) clusters (Lorenzen & Mudambi, 2013). The majority of studies to date have focused on the role of global organizational ties in stimulating cluster growth, in particular those established through multinational corporations (MNCs) (Enright, 2000; Patibandla & Petersen, 2002) and global value chains (GVCs) (Humphrey & Schmitz, 2002). Less known are the effects of individual ties, in particular those established through diaspora networks and transnational communities (Kenney, Breznitz, & Murphree, 2013; Lorenzen & Mudambi, 2013; Saxenian & Hsu, 2001; Zaheer et al., 2009).

In the latter context in particular, the concept of brain circulation (BC), or reversed brain drain, has gained prominence (Saxenian, 2005). BC denotes processes of knowledge, technology and practice diffusion, and translation through diaspora network ties between emergent and typically more established clusters, e.g., Silicon Valley, Taipei and Bangalore (Bresnahan et al., 2001; Saxenian, 2005; Saxenian & Hsu, 2001). BC includes the permanent move of 'returnees' back to their home countries after gaining educational and professional experience abroad (Kenney, Breznitz, & Murphree, 2013), but it also relates to continuous workforce mobility between globally dispersed locations. Importantly, the focus here is on BC through the movement of people between particular emerging and/or established clusters – in short, IBC. While there is a rather long tradition of research on IBC (see, e.g., Bresnahan et al., 2001; Saxenian & Hsu, 2001), we still know surprisingly little about the conditions under which IBC can occur and effectively stimulate cluster growth and upgrading.

Of particular interest to scholars is the role of governance in affecting IBC, for example, by collective processes of deliberate intervention. Whereas some have argued that incentives for returnees can be crucial to cluster growth (see, e.g., Kuznetsov, 2006), others are skeptical about the effectiveness of steering such processes (see, e.g., Kenney et al., 2013). One central problem with prior studies on IBC and governance is that they neglect size and the stage of cluster development. Research on cluster governance in general suggests that size mediates the effectiveness of steering, as a large number of players may complicate collective action (see, e.g., Manning et al., 2012). At the same time, clusters that are already growing may have little need for governance, as further growth is stimulated through self-reinforcing dynamics (see, e.g., Pouder & St John, 1996). Against this background, it may be less surprising that the role of governance in stimulating IBC has been questioned in cases such as Bangalore and Hsinchu (see, e.g., Kenney et al., 2013), both representing clusters where IBC started when the focal cluster was already sizable and growing. By comparison, our knowledge of IBC in the case of smaller, nascent clusters has been fairly limited. This work thus seeks to further investigate the role of governance in stimulating IBC with a focus on the effects of cluster size and of the stage of cluster development in this process (see figure 1).

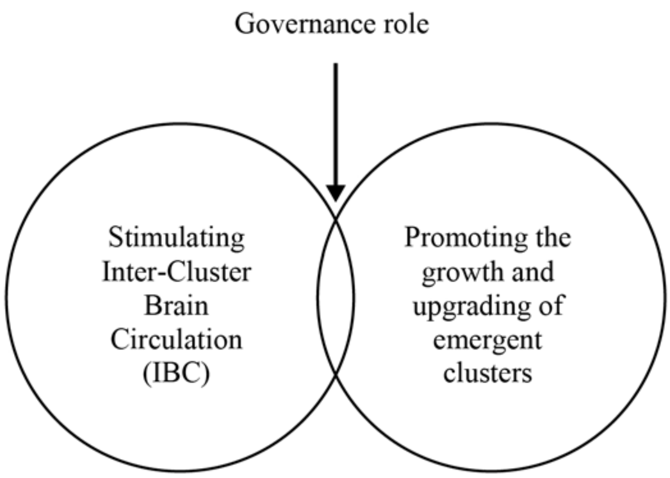

Figure 1. Role of governance in stimulating IBC and promoting the growth and upgrading of emergent clusters

'Governance' is considered to be deliberate processes of intervention in cluster development and in its network processes through policies, third-party strategies or a combination of the two (see, e.g., Powell, 1990 and Provan & Kenis, 2008 in general; and, e.g., Sydow et al., 2010 and Schüßler, Decker, & Lerch, 2013 from the cluster perspective in particular). A governance perspective emphasizes the potential role of agency, shared goals and coordination in addressing the complexity of initial cluster growth (see, e.g., Schüßler et al., 2013). Arguably, most cluster research, especially in the US tradition, has not paid much attention to the potential role of governance. Instead, most studies on cluster development, including those analyzing the interplay of local and global ties, follow an evolutionary paradigm (see, e.g., Pouder & St John, 1996). For example, notions regarding the agglomeration effect, path dependencies, and location competition for talent and firm investment fall within this paradigm. In fact, 'luck' and 'circular/reciprocal causality' are seen as 'legitimate elements' of evolutionary dynamics. In contrast, European scholarship has taken the role of governance, 'cluster leadership' and cluster administrative organizations more seriously (Schüßler et al., 2013; Sydow et al., 2009, 2010). Arguably, governance has been found to play a critical role in the processes of cluster upgrading and transformation under resource constraints (Altenburg & Meyer-Stamer, 1999). It is thus assumed that governance plays an important role in stimulating IBC effectiveness as well.

To investigate the role of IBC governance in promoting cluster growth and upgrading, in particular in the context of small and nascent clusters, the following research question is addressed: ***What type of IBC governance might promote the growth and upgrading of clusters in emerging economies?***

1.2 Research design and the empirical context of investigation

The research problem is investigated in the context of cluster connectivity (based on the concept of Lorenzen & Mudambi, 2013), in particular, of the IBC dynamics between emergent and typically mature clusters (see, e.g., in Saxenian, 2006; Kenny et al., 2012). More specifically, the role of governance efforts in stimulating IBC and cluster growth is explored in the case of larger/growing clusters versus smaller/nascent clusters. Based on this context, the research is designed to start with a critical review of prior literature addressing the relationship between local cluster growth and global inter-cluster connection and then with a review of the two prior studies on IBC between Silicon Valley and Bangalore and between Silicon Valley and Hsinchu. Particular focus is on the role of IBC governance in promoting the growth and upgrading of both clusters, introducing a governance perspective to complement the prior mostly evolutionary approaches. These cases are examples of successful clusters that sparked decades ago (starting in the 1960s) in emergent economies and subsequently became important innovation hubs in the global production system of high-end markets.

After reviewing these two prior studies and better understanding the development of Bangalore and Hsinchu and their connection with Silicon Valley, an exploratory study of the nascent and small cluster called Sinos Valley (Southern Brazil) is conducted. Within this empirical context and using the lens of the network governance literature (following Provan & Kenis, 2008), different forms of IBC governance are proposed for cluster growth and upgrading. Based on these forms of IBC governance, propositions are developed and further tested in the case study of Daedeok Innopolis. The distinct forms of IBC governance are thereby analyzed in greater detail in the case study over time. Daedeok represents an established and mature high-tech cluster that also sparked in the 1960s in an emergent economy and that became a national symbol of the rapid growth of South Korea (henceforth Korea) from an agrarian region (in the 1960s) to a region currently characterized by high-end technology development. The context for all of these cases combines larger/growing clusters and smaller/nascent clusters, which allows the relationship between local cluster growth and global IBC to be explored through the governance perspective.

More concretely, the research design is defined by analyzing the dynamics of IBC over cluster evolution in the two prior studies related to knowledge-intensive industries: first, the connection between Bangalore and Silicon Valley as based on existing empirical studies (see, e.g., Bresnahan et al., 2001; Kenney, Breznitz, & Murphree, 2013; Lorenzen & Mudambi, 2013) and second, the connection between Hsinchu and Silicon Valley also based on existing empirical studies (see, e.g., Kenney, Breznitz, & Murphree, 2013; Saxenian, 1999, 2005; ; Saxenian & Hsu, 2001). Further, two original empirical cases are analyzed: first, an exploratory study is conducted on the connection between the nascent and small cluster Sinos Valley (Brazil) and Korea in its emergent developmental stage; second, a case study is conducted on the connection between the successful Daedeok Innopolis cluster and the US over the cluster's evolution (from the emergent to the mature developmental stage). Figure 2 illustrates the research design, emphasizing the research context and workflow.

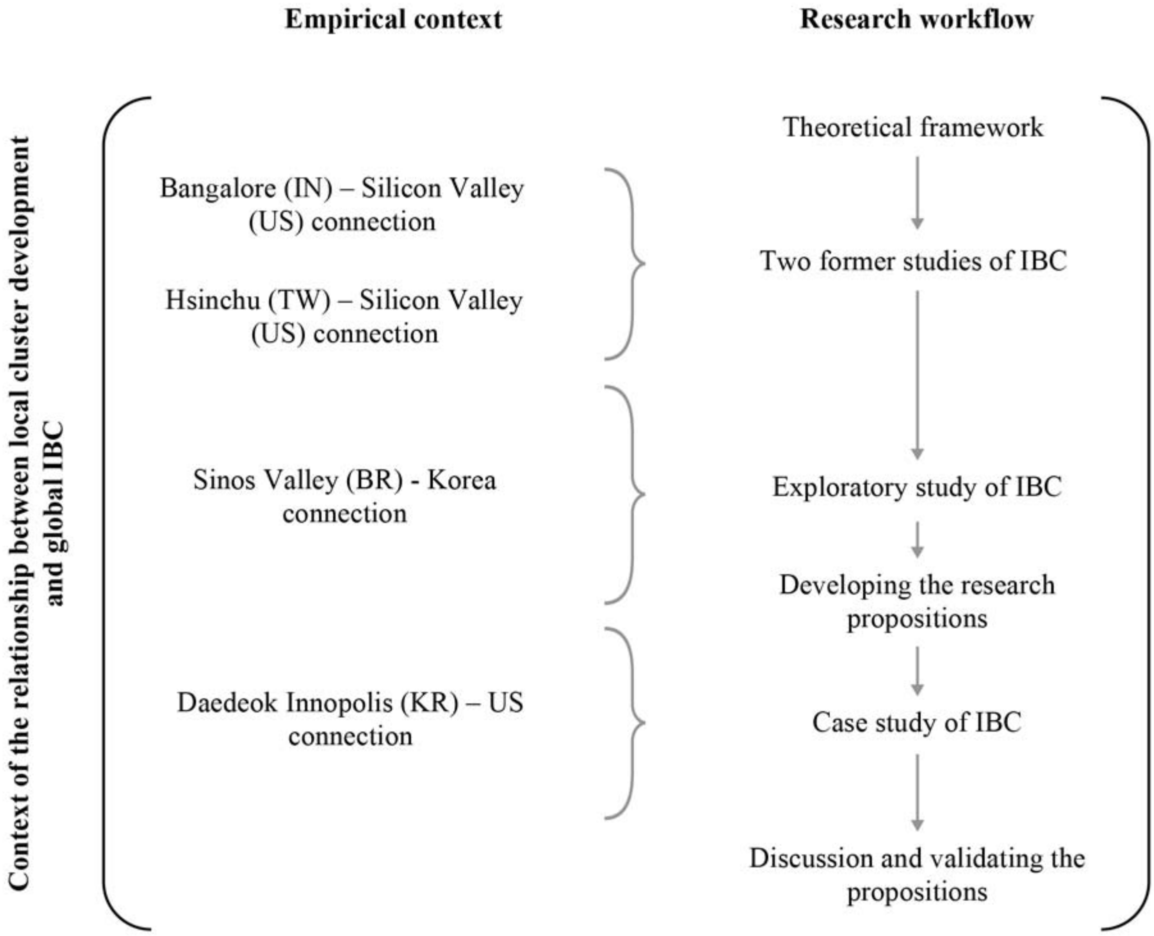

Figure 2. The research context and workflow

Based on this context, this study focuses on knowledge-intensive industries in emergent economies. Because clusters represent a competitive advantage for this context (Porter, 1998, 2000) and because IBC plays a critical role in cluster development (see, e.g., in Lorenzen & Mudambi, 2013; Saxenian, 2005; Saxenian & Hsu, 2001) by stimulating knowledge transfer, innovation, and upgrading (Bathelt et al., 2004; Humphrey & Schmitz, 2002; Owen-Smith & Powell, 2004), the central element of analysis of this study is defined as the development of high-tech clusters in emergent economies taking the IBC perspective. More specifically, IBC governance is explored in this context.

It is important to note that the theoretical framework, research question and propositions were presented at the doctoral student consortium held by the AIB Northeast Chapter Conference in Providence, Rhode Island, on November 13th, 2014. The feedback from the doctoral consortium was important for establishing and refining the theoretical framework and research focus. Additionally, a working paper regarding the exploratory study and propositions was developed and presented at three international conferences (AIB 2015 – Bangalore, India; EURAM 2015 – Warsaw, Poland; and iBegin 2015 - Philadelphia, US). After including the feedback from these conferences, this paper will be submitted to a policy journal. In addition, a new working paper is under development regarding the case study that will target upcoming international conferences and subsequently journal publication.

1.3 Objectives of the research

To answer to the research problem, this study aims to ***propose forms of IBC governance that promote the growth and upgrading of clusters in emerging economies***. As additional contributions, the study seeks to comprehend the following:

a) Local cluster development, in particular the growth and upgrading of clusters in emerging economies.

b) How clusters are globally interconnected, in particular through IBC dynamics.

c) The role of IBC, particularly in stimulating knowledge transfer, innovation, and the upgrading of clusters.

1.4 Contributions and limitations of the research

This study primarily contributes to three interrelated theoretical debates. First, it adds nuance to understanding the relationship between local cluster growth (see, e.g., in Pouder & St. John, 1996; Bresnahan et al., 2001; Menzel & Fornahl, 2010; Sydow et al., 2010; Manning et al., 2012) and global IBC (see, e.g., in Saxenian & Hsu, 2001; Bathelt et al., 2004; Kuznetsov, 2006; Saxenian, 2005; Kenney, Breznitz, & Murphree, 2013; Lorenzen & Mudambi, 2013), including the effects of IBC dynamics in steering the growth and upgrading of clusters in different developmental stages. Second, it adds to the growing research on the role of governance versus market dynamics in cluster development (Schüßler et al., 2013; Sydow et al., 2010) by contextualizing when governance intervention-driven approaches are likely to be effective and what their limitations are. Third, it contributes to the long-standing interest in the catch-up strategies of emergent economies (see, e.g., Humphrey & Schmitz, 2002; Altenburg, Schmitz, & Stamm, 2008; Lorenzen & Mudambi, 2013) by emphasizing the role of IBC in complementing cluster insertion in GVCs (Humphrey et al., 2002) and in stimulating knowledge transfer, innovation, and upgrading (Bathelt et al., 2004; Humphrey & Schmitz, 2002; Owen-Smith & Powell, 2004).

Because the scope of this study is on a global scale, covering different social, political and economic contexts, there are three main limitations to this research. First, because the institutional context of each cluster studied differs at the micro-level over time, there are limitations to comparing different location contexts from an evolutionary perspective (due to, for example, changes in social and political environments over time). Although the institutional dimension is not directly included in the scope of this study, it is important to note its effect on cluster development and on IBC dynamics. Second, at the same micro-level of the institutional context, the cultural dimension is not directly included in the scope of this study. Cultural aspects also have an effect on cluster development and, particularly, on IBC dynamics. Cultural features affect the personal and organizational relationships between different locations. The effectiveness of IBC is related to cultural features such as building mutual trust relationships and interacting face-to-face. These features thus affect, for example, the processes of knowledge learning/diffusion, transfer technology and translation. Third, at the macro-level, this study does not address the geo-political dimension of the nations in which the studied clusters are inserted. Because the global economy is increasingly interconnected, there is interdependence between different locations in particular in the volatile high-end markets of knowledge-intensive industries. Although this study does not include all of these micro- and macro-level contexts directly in its scope, representing a limitation in studying the relationship between local cluster development and global inter-cluster connection, it is assumed that they do not affect the results and main contributions of this research. In contrast, these limitations open further research perspectives that are later explored.

1.5 Structure of the dissertation

The structure of this research is reflected in the six chapters. The first chapter introduces the research and its question, objectives and design. Additionally, this chapter presents the contributions and limitations of this study as just described. The second chapter explains the theoretical framework used to capture the relationship between local cluster development and global inter-cluster connection. The third chapter presents the exploratory study of the connection between Sinos Valley and Korea as well as the research propositions. The fourth chapter presents the case study of the connection between Daedeok Innopolis and the US, and the fifth chapter discusses IBC governance in the studied cases and the validation of the research propositions. Finally, the sixth chapter draws the conclusions of this study.

2 LOCAL CLUSTER DEVELOPMENT AND GLOBAL INTER-CLUSTER CONNECTION

Given the goals of this study, this chapter develops a theoretical framework to capture the relationship between local cluster development and global inter-cluster connection. The first section illustrates the local and global contexts in a globalized and knowledge-based economy. In this section, particular attention is given to the insertion of industries into GVCs through catch-up and spillover processes (Mudambi, 2008) and governance systems (Gereffi, Humphrey, & Sturgeon, 2005) for cluster upgrading (Porter, 1990). Also in this section, innovation systems (Freeman, 1995) are explored at the national level, differentiating the challenges confronted by advanced versus developing countries that compete in high-end markets. These frameworks aim to contextualize the interdependencies between local and global economic dimensions and the idiosyncrasies of each to encourage further discussions about local cluster development and global networks.

At the local level, the second section addresses local cluster development. This section explores the definition (Porter, 1998), elements and determinants (Menzel & Fornahl, 2010), stages and mechanisms of cluster development (Bresnahan et al., 2001). At the global level, the third section focuses on global networks in particular for defining IBC. This section thus explores the concept of cluster connectivity (Lorenzen & Mudambi, 2013), in particular to understand the global linkages that can facilitate upgrading and catching-up processes for cluster development in emerging economies. IBC (Saxenian, 2005) is embedded in both the pipelines and the personal relationship channels of the cluster connectivity concept (Lorenzen

& Mudambi, 2013). To investigate the role of IBC in stimulating cluster growth, this section first explores the dynamics and role of IBC in cluster development (Kenney, Breznitz, & Murphree, 2013; Saxenian, 2006) and then explores its governance. The network governance framework (Provan & Kenis, 2008) was used to build the two forms of IBC governance: organic versus coordinated IBC. Finally, the third and fourth sections explore the prior literature cases on IBC.

2.1 Local and global contexts

Global and local contexts are interdependent when considering the geographical dimension of globalization (Dicken, 1994; Dicken, Kelly, Olds, & Yeung, 2001; Dicken & Lloyd, 1997), and both contexts (global and local) have become even more closely networked through the complex mutual interactions of the global economy (Dicken, 2008; Ghemawat, 2011; James, 2009). Such complex macroeconomic interactions have implications for industries and even single companies at the microeconomic level. The global economy has become increasingly integrated throughout the Digital Revolution (Brynjolfsson & McAfee, 2014). US-, Japan-, Korea- and Taiwan-based companies interact through global networks, for example, US-based Apple´s iPod being manufactured in Southern China for export to world markets (Linden, Kraemer, & Dedrick, 2007). This example illustrates well the integrated global economy and its network interactions based on a GVC. All of these network interactions are embedded in both the micro- and the macroeconomic levels.

Over the last decade, scholars have recognized that the forces of globalization have increased competition while simultaneously increasing the potential gains from greater resource flows (capital, goods and people) between firms located in different clusters (Lorenzen & Mudambi, 2013). Technology, in this case high technology, changes and becomes obsolete faster than ever in volatile markets. High-tech companies are inserted into GVCs to grow, access knowledge, and enhance learning and innovation, allowing them to compete internationally (Pietrobelli & Rabellotti, 2011). In an emerging context, as in developing countries, it is a challenge to develop a national innovation system (NIS) and become network linked to a GVC (Pietrobelli & Rabellotti, 2011).

2.1.1 Globalization in the Digital Revolution

There is an ongoing structural change that has had remarkable consequences for the functioning and organization of individual companies as well as of the entire economic system (Guerrieri, Iammarino, & Pietrobelli, 2001). This structural change can be seen as an increase in world economic integration. James (2009) argued that the integration of the world through large flows of goods, capital and people, known as "globalization", is irrevocable and irreversible. Hirst and Thompson (2010) endorsed this tendency towards globalization. James (2009) argued that globalization involves not only international movements such as these flows but also the transfer of knowledge and shifts in technology. In fact, globalization changes both the concept of proximity and the scope of competition. Globalization can reshape the upgrading options of industries by providing a variety of international knowledge linkages (Guerrieri et al., 2001). The development of local and global networks and new interactive modes of knowledge creation, which have co-evolved as a result of globalization, have provided the necessary conditions for competitive survival (Guerrieri et al., 2001).

To better understand the globalization process, James (2009) offered a historical analysis of the cycles of globalization. Focusing on the dynamic of global trade, economically, globalization dates back to the second half of the nineteenth century and the early twentieth century. Archeologically, there is evidence that trade had a global reach during the Roman Empire (late fifteenth and early sixteenth centuries), with Roman coins being traded in the coastal regions of Sri Lanka and Vietnam. There was a subsequent expansion of global trade and finance. All of these (and other) earlier globalization episodes ended usually with wars that were accompanied by highly disruptive and contagious financial crises. Because the globalization of goods, capital and people often leads, historically, to the globalization of violence, there has been a tendency to subsequently draw back from the global setting and to look instead for protected areas for safety (James, 2009). This does not reflect an anti-globalization movement dilemma, where globalization is essentially understood as the globalization of capitalism – a nationalism concept (Hall & Soskice, 2001). Globalization is neither the equal integration of world economies nor their homogenization (Gray, 2009).

Ghemawat (2011) endorsed this idea, arguing[1] that only 20% of global Gross Domestic Product (GDP) is related to international trade and that the Foreign Direct Investment (FDI) across borders is only 10% of all fixed investments[2]. This suggests that approximately 90% of all fixed investment in the world is still domestic. Although these numbers have oscillated over the years, and they can be viewed taking other perspectives, Ghemawat (2011) argued

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[1] The numbers used in this argumentations refer to the average of past years based on Ghemawat's (2011) studies. International trade refers to global exports, and FDI is defined as a company from one country making a physical investment in building or buying operations in another country.

[2] The term "fixed investment" is usually called "gross fixed capital formation" by economists (Ghemawat, 2011).

that the world is not becoming more integrated. The world is not flat, as he (Ghemawat, 2011) said when arguing against Friedman's (2007) theory. But, the same author (Ghemawat, 2011) also took another point of view, noting that world integration has been even further exaggerated through technology. This more complex multidimensional concept of globalization, which considers it to be operating in the economy simultaneously and interrelatedly through technology, is in fact relatively uncontentious (Tomlinson, 2003). Brynjolfsson and McAfee (2014) noted the technology eras[3] (or "machine ages", in their words) within globalization, and they endorsed this concept of an economy interrelated through technology for this current century.

The global impact of Information and Communications Technology (ICT) on the later twentieth and early twenty-first centuries' economy can be compared to the effect of the steam engine in the Industrial Revolution on the economy in the second half of the eighteenth century (Brynjolfsson & McAfee, 2014). They (Brynjolfsson & McAfee, 2014) called the Digital Revolution[4] the "second machine" age. The Digital Revolution (of the later twentieth and early twenty-first centuries) was technologically initiated by the invention of the transistor in the 1930s, followed by the development of an operational version in Bell Labs (US). This technology enabled the invention of the modern computer (1939), the first email sent (1971), the first computer with a graphical user interface, keyboard and mouse (1973), the first home computer (1975), the global internet (1983) and web surfing (1994). The

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[3] (Ghemawat, 2011) referred to the Industrial Revolution as the first machine age. However, "the machine age" is also a label used by some economic historians to refer a period of rapid technological progress spanning the late nineteenth and early twentieth centuries. Other authors refer to this latter period as the Second Industrial Revolution.

[4] Some authors also call the Digital Revolution the Third Industrial Revolution.

transistor is the key active component in practically all modern electronic devices. It is in almost every integrated circuit (IC) for these electronic devices, and it is in advanced technologies such as robotics, for example. The amount of technological innovation that has occurred during this period is astonishing. Nevertheless, just as it took generations to improve the steam engine to the point that it could power the Industrial Revolution, it has also taken time to refine the "digital engines" in this current revolution (Brynjolfsson & McAfee, 2014). The Industrial Revolution had a profound impact on global and local contexts over time. For many thousands of years, human progress followed a very gradual upward trajectory. Progress was slow—almost invisible. However, just over two hundred years ago, the Industrial Revolution sharply bent the curve of human history through its effects on population and social development (Brynjolfsson & McAfee, 2014). The Industrial Revolution encompassed more than the history of steam power; it led to modern life. It led to factories, mass production, railways, and mass transportation by overcoming the limitation of muscle power. It is also possible to say, taking another perspective on the Industrial Revolution, that it led to modern capitalism (Hall & Soskice, 2001). The structural change to the world economy in terms of interactions between the flows of goods, capital and people was profound during that time.

Considering the impact of the Industrial Revolution on modern human life, it is perhaps possible to forecast the astonishing impact of the current Digital Revolution on human life. Between the twentieth century and today, according to Aquino (2011), it is already possible to see some important structural changes to the economy and society. From Newton's mechanics and physics in the twentieth century to Einstein's relativity and Planck's quantum physics in the current century. Relativity and quantum physics made the development of ICT possible.

They allowed technology to move from low to high technology. With these changes, society moved from an authority-based hierarchical society to a network-based interactive society. Economically, society moved from a local to a global economy. In fact, there has been an ongoing structural change in the global economy in terms of goods, capital and people driven by the Digital Revolution and how it has been reshaping the global and local contexts.

2.1.2 Global value chain

Companies have been increasingly faced by the challenge of international competitiveness in the context of the global economy. Companies in all countries, developing or developed, are under these pressures (Delgado, Ketels, Porter, & Stern, 2012). Porter (1990) suggested that the most viable response for this competitive pressure is to upgrade: to make better products, to make them more efficiently, or to move into more skilled activities. This *upgrading* in the context of the global economy is intrinsically dependent not only on the internal linkages but also, and in particular, on the global ones. These networks can be more linked and efficient if they are functionally integrated in the global economy (Gereffi, 2005).

The GVC can be seen as a pragmatic and useful framework for exploring questions about the global economic dynamics of clusters and industries (Sturgeon, Van Biesebroeck, & Gereffi, 2008). It can be seen as a framework for perceiving and evaluating network linkages in terms of the value creation from clusters and industries. In this respect, clusters can also be considered to be part of a GVC (Humphrey & Schmitz, 2002). The GVC concept is embedded in two perspectives, which place products or companies in the center. The products in the center perspective describes all of the activities that make a product, from its conception to its end use and beyond. These activities can be contained within a single company or divided among different companies. Value chain activities can involve goods or services, and the value chain can be located in a single geographical location or spread worldwide. This perspective of the GVC seeks to understand the value chain of products as divided across multiple companies and spread across wide geographic locations. The companies in the center perspective was used by Porter (1985) to describe the activities within and related to companies to analyze their competitive strength. A company is more than a random compilation of equipment, people and capital. It is an arrangement of all of these things together into a system and into systematic activities. Porter (1985) argued that the ability to perform particular activities and to manage the linkages between these systematic activities is a source of competitive advantage.

Both of these perspectives are embedded in the GVC concept, and they differ from but are still relevant to the older concept of the global commodity chain (GCC) (Gereffi, 1994). There is an academic notion that the GVC is a more developed (or upgraded) concept than the GCC. The GCC highlights the importance of coordination across firm boundaries. It also highlights the importance of new global buyers as key drivers in the formation of globally dispersed and organizationally fragmented production and distribution networks (Gereffi et al., 2005). However, both the GVC and GCC frameworks neglect the institutional and political contexts in global network interactions. This limitation is highlighted in the literature on Global Production Networks (GPNs), which emphasizes how the chain actors in different network structures are embedded in different locations. Yeung and Coe (2014) defined GPNs as "an organizational arrangement comprising interconnected economic and non-economic actors coordinated by a global lead firm and producing goods or services across multiple geographical locations for worldwide markets". This concept includes the geographical dimension from the national to the local scale in global network platforms. All of these frameworks (GCC, GVC or GPN) include global network interactions, and they stress the importance of tight interdependencies between geographically clustered companies. In this sense, governance plays an important role in understanding the control mechanisms behind the network interactions between value chain actors.

Value chain governance can be differentiated by many factors, from the nature of companies' activity, to their networks, to value chain dynamics. Gereffi et al. (2005) extended the network category within the governance conceptualization to include three distinct types: (i) modular, (ii) relational, and (iii) captive. The modular network category refers to production systems that rely on turnkey suppliers as modular production networks. It allows highly competent suppliers to be added and subtracted from global production arrangements on an as-needed basis (Sturgeon, 2002). The relational category refers to network relationships between firms that cooperate because they possess complementary competencies (Gereffi et al., 2005). Captive networks correspond to the relationship between suppliers in quasi-hierarchical relationships with buyers (Humphrey & Schmitz, 2002). These network types are related to the complexity of the information exchanges between companies and to the degree of asset specificity in production equipment (Gereffi et al., 2005).

Based on these distinct types of networks, the same authors (Gereffi et al., 2005) identified and classified five basic types of GVC governance: (i) markets, (ii) modular value chains, (iii) relational value chains, (iv) captive value chains, and (v) hierarchy. The complexity of information exchange in the market type is lower than that in the other types. In the market type, transactions can be governed using little explicit coordination. In a market exchange, buyers respond to specifications and prices set by sellers. The transactions in the market type are easier to codify than those in the modular value chain governance type. In the value chain governance type, the product architecture is modular and information can be easily exchanged through technical standardization. This allows complex information to be exchanged with little explicit coordination, and the buyers can directly control the information flow. If the product specification cannot be codified, and tacit knowledge must be exchanged between buyers and sellers, the governance type is then classified as a relational value chain. In this type, the transactions are complex and depend on reputation, social and spatial proximity, family and ethnic ties, and other similar aspects. The exchange of complex tacit information is most often accomplished by frequent face-to-face interactions and governed by high levels of explicit coordination. Captive value chains can be seen when the suppliers' competence is low in the face of complex products, and when product specifications require a great deal of intervention and control on the part of the lead company. In this type of value chain, the ability to codify information is very high. The final type, hierarchy, can be seen when highly competent suppliers cannot be found, and the lead firms then become vertically integrated. The product specification cannot be codified, products are complex, and information is driven by tacit knowledge exchanges between value chain activities. All of these types of governance and their key determinants (summarized in figure 3) are important when addressing the information and knowledge exchanges accompanying different value chain interactions.

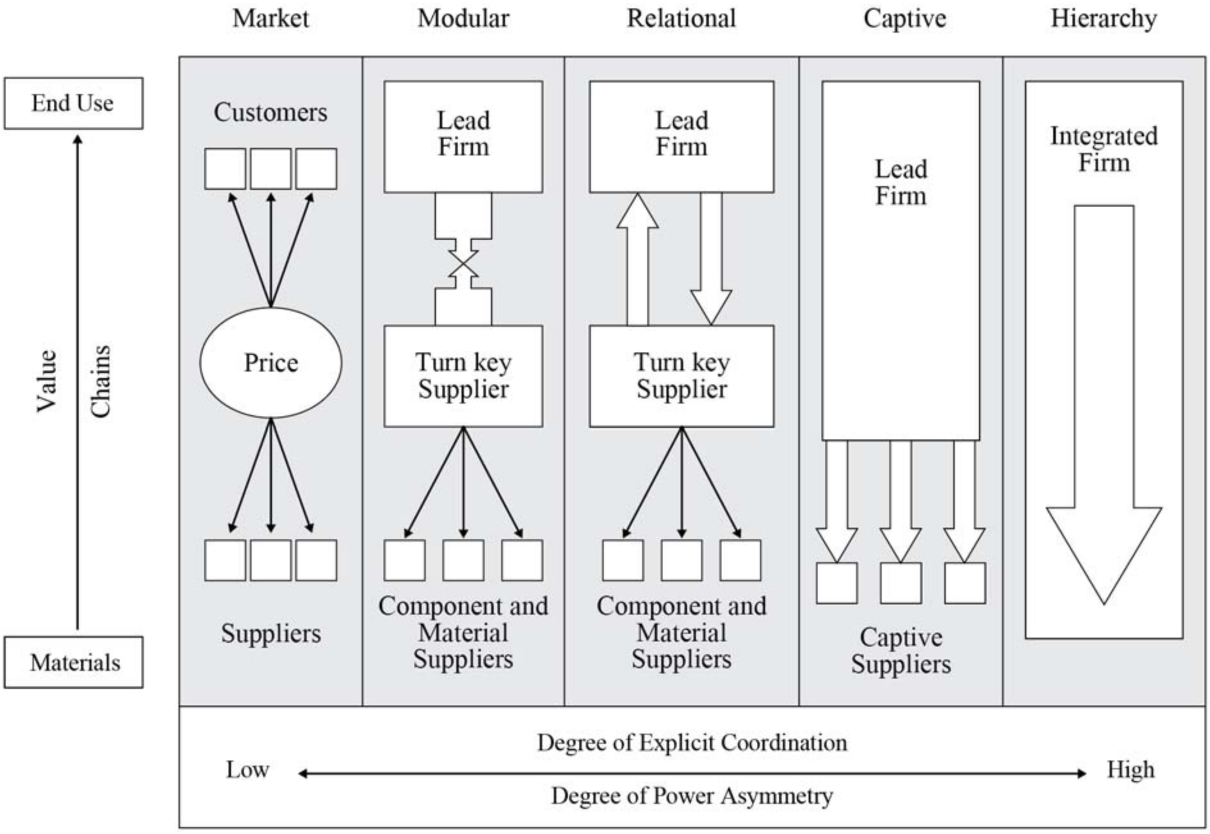

Figure 3. The five global value chain governance types of Gereffi et al. (2005)

These different network linkages allow local industries to become more integrated in the global production and innovation system. This integration, following Mudambi (2008), can be distinguished by two divergent global strategies: vertical integration and specialization. A vertical integration strategy takes advantage of network linkages, whereby controlling multiple value chain activities can enhance the efficiency and effectiveness of each activity. Specialization strategy, in contrast, focuses on identifying and controlling the heart of the value chain while outsourcing all other activities.

Companies can control their activities in a GVC using these two strategies. Regardless of the strategy, Mudambi (2008) argued that in a GVC of knowledge-intensive industries (his empirical case being the global mobile handset industry), high value-added activities are largely performed in developed countries, while in contrast, low value-added activities are performed in developing countries. In developing countries, companies seek to develop competencies in high value-added activities (the catch-up process). In developed countries, companies seek to standardize sections of their high value-added activities and to cut costs by relocating these sections to developing countries (spillover process). Moreover, some knowledge-intensive activities, such as R&D and marketing operations, are located in developed countries to increase the company's (and countries') absorptive capacity for added value. He refers to the processes involved with these activities as industry creation. Mudambi (2008) plotted the patterns of value-added activities along with the value chain created by these processes (catch-up, spillover and industry creation) in a curve that he calls the 'smile curve' (see figure 4). Although this graph cannot illustrate the entire complexity of global market dynamics (and it is not his intention), this simplistic view is a good representation of these processes, and it indicates the strategic importance of geographic location in GVCs.

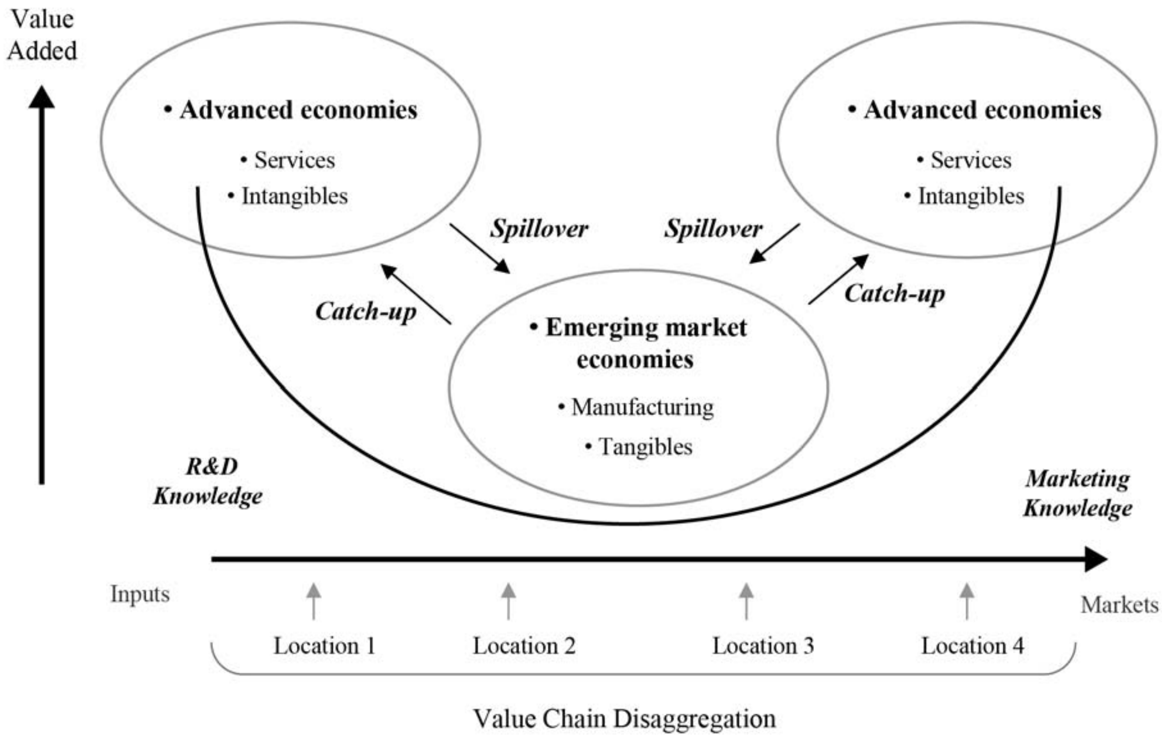

Figure 4. The catch-up, spillover and industry creation processes in global value chains for developed and developing countries - adopted from Mudambi (2008)

As illustrated in figure 4, high value-added activities appear at the ends of the value chain. Although there has been an enormous effort by companies in developing countries to develop their own brands based on knowledge-intensive R&D and marketing activities, these companies compete globally mostly on the basis of low cost (Mudambi, 2008). The catch-up process pressures companies in developed countries to continually innovate to maintain their high level of value-added. Although there is high international competition along global value chains, according to Mudambi (2008), both developed and developing countries conform to this ‘smile of value creation’. Nevertheless, global high-end market dynamics are complex and volatile. Regardless of a company’s strategy (vertical integration or specialization), there are many good reasons to disaggregate its value chain across different locations. This location decision can be made based on political aspects of the countries (and regions), by the availability of labor skills in that specific location, or based on many other factors.

2.1.3 National innovation system

Whereas the GCC, GVC and GPN frameworks address global level interactions, the national innovation system (NIS) framework was conceptualized by Freeman (1995) to focus on the national level of science and technology infrastructure and the systemic network interactions of institutions and organizations in a national economic system. The NIS plays an important role in the international competitiveness of a country (Freeman, 2004), and the country's innovation capacity is a key element of its competitive ability (Pietrobelli & Rabellotti, 2011). The success histories of Japan, Korea and Taiwan in global markets, for example, illustrate a long-term science and technology strategy of promoting indigenous innovation capacity (Feinson, 2003). These histories are intimately associated with these countries' capacity to acquire, absorb, disseminate, and apply updated technologies (Feinson, 2003). All of these processes of technical innovation are crucial for the competitiveness of a country (Freeman, 2004).

The NIS is classically defined by Freeman (1995) as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies". In other words, the NIS can be seen as the complex regulations, institutions, human capital, and government programs involved in the process of linking science and technology to the economy (Feinson, 2003). In this respect, "innovation is seen as the processes by which firms master and put into practice product designs and manufacturing processes that are new to them. A wide range of factors, organizations, and policies influence the capabilities of a nation's firms to innovate. Technology and pure science are distinguished, and the social institutions that play a role in innovation are examined. These include industrial and government research laboratories, research universities, and industrial policy agencies. These institutions provide the core for the analyses of NIS" (Nelson & Rosemberg, 1993).

There are many actors, linkages and flows that make an innovation system function in its environment (Feinson, 2003). They must all be functionally integrated to strengthen the innovation capacity of a country. There are two distinct analytical concepts used to describe the NIS. First, the "narrow" NIS concept includes the institutions and policies directly involved in scientific and technological innovation (Nelson & Rosemberg, 1993). Second, a "broad" NIS concept takes into account the social, cultural, and political environment of the country being examined (Lundvall, 1996). The knowledge and resource flows are intrinsically dependent on the NIS linkages at both the narrow and broad levels and among the institutions and organizations via both formal and informal routes. These linkages are determinants of the NIS, and they reflect the absorptive capacity of the entire system (Feinson, 2003).

According to the OECD (1997), the measurement and assessment of a NIS centers on four types of knowledge or resource flows: (i) interactions between enterprises, primarily joint research activities and other technical collaborations; (ii) interactions between enterprises, universities and public research institutes, including joint research, co-patenting, co-publication and more informal linkages; (iii) diffusion of knowledge and technology to enterprises, including industry adoption rates for new technologies and diffusion through machinery and equipment; and, (iv) personal mobility, focusing on the movement of technical personal within and between the public and private sectors. All of these different knowledge and resource flows contribute to improving the innovative capacity of companies. Moreover, these flows link to company performance through high levels of technical collaboration, technology diffusion and personal mobility. They can improve the innovative capacity of the firm in terms of products, patents and productivity (OECD, 1997). The innovation capacity depends not only on the structure and functionality of the NIS but also heavily upon the development of human capital. Most authors in the NIS literature strongly agree that human capital is a fundamental condition for an effective NIS. Nelson and Rosemberg (1993) argue that strong human capital requires a well-developed educational system. This educational system lays the necessary foundations at all levels.

The NIS framework was initially created for developed countries (Freeman, 1995), mainly because the processes of technical change in developing countries are extremely different from those in developed countries (Viotti, 2001). Developed countries occupy the role of technological leaders, whereas developing countries act as technological followers in general (Feinson, 2003; Pietrobelli & Rabellotti, 2011). In the current globalized economy, developing countries rarely adopt and create NIS to strengthen their innovation capacity. While developed countries have been maintaining or improving an already established level of competitiveness and growth, developing countries have engaged in the process of 'catching-up' (Feinson, 2003; Mudambi, 2008).

There are many reasons why applying the NIS concept to developing countries is not straightforward. Pietrobelli and Rabellotti (2011) summarized the issues in three main arguments. First, the innovation process in developed countries differs from that in developing countries. Developed countries are usually at the frontier of an innovation, while in developing countries; most innovation is based on operationalizing technology. Second, the science and technology organizations (such as universities, R&D laboratories, and research institutes) of a developed country differ from those in developing countries. This difference does not relate to the nature of these institutions, although they may not exist in some developing countries; they particularly differ in developing countries because they are characterized by weak or inadequate network linkages with each other and especially with local companies. Third, the policies and institutions of developing countries have implications for the inflows of knowledge and technology from external sources. These flows are essential components of the innovation process, and they are affected by policies and institutions.

To mitigate these barriers, Pietrobelli and Rabellotti (2011) argued that companies in developing countries must be, although not exclusively, network linked to a GVC. The goal is not just to obtain new market opportunities but especially to access knowledge and enhance learning and innovation (Pietrobelli & Rabellotti, 2011). In other words, to catch up in terms of technology and innovation (Mudambi, 2008). The relationship between a GVC and a NIS is nonlinear, endogenous, and mutually affecting (Pietrobelli & Rabellotti, 2011). Based on these characteristics of the GVC and NIS relationship, a well-structured and efficient NIS can help to reduce transaction complexity and enable transactions based on different forms of GVC governance.

2.2 Local cluster development

Clusters have a long history of scholarly discussion. Early references are, e.g., Marshall (1920), Myrdal (1957) and Perroux (1950) and some classical references such as Krugman (1991) and Porter (1998); Saxenian's work (1994, 2005, 2006, 2007) is also included among the classical and contemporary references. Clusters are essentially understood as geographic agglomerations of firms and associated institutions that are more or less interconnected and that typically belong to a particular industry (Porter, 2000). Cluster research is a broad research field studied from many different perspectives, such as economics, economic geography, sociology, business and international studies. The academic debate on clusters is rich, with decades of published papers and books (see an overview in Sedita & Lazzeretti, 2012). Because of this broad debate, several definitions of clusters coexist, and there are also various applications of the term in diverse socio-economic contexts (Lazzeretti, Sedita, & Caloffi, 2014; Martin & Sunley, 2003; Sedita & Lazzeretti, 2012).

Industrial clusters are probably the most well-known cluster type (Delgado et al., 2016; Marshall, 1920; Porter, 1998). They can belong to a knowledge-based industry (see high-tech clusters in the US) or to a low-cost manufacturing producer (see electronics manufacturing clusters in China). Both of types of cluster are seen in different industries, such as electronics and clean energy, and they can emerge and grow during the different development stages of a country. In all of these cases, the geographic location matters. The advantages of cluster location have been the subject of a long-standing debate by scholars along with both specialization (Marshall, 1920) and diversity (Boschma & Frenken, 2011). These advantages can be created by some natural resource (wine clusters in Chile), by a specialized talent pool (ICT clusters in Taiwan), or by other spontaneous phenomenon (the automobile cluster in Detroit, US). It can also be a combination of locational features embedded in a dynamic process and an evolutionary perspective.

Because of these many influencing conditions, cluster development dynamics is a complex matter. The question of how clusters can come into being, grow and be sustained over time has been subject of a long-standing debate (Bresnahan et al., 2001; Manning et al., 2012;

Menzel & Fornahl, 2010; Pouder & St. John, 1996; Sydow et al., 2010). The mechanisms behind cluster development are not fully understood by scholars. On the one hand, these mechanisms have been studied, though not yet sufficiently, in developed countries (see, e.g., Delgado et al., 2014, 2016; Rosenfeld, 2002; Porter, 1998), where there are many cases of well-established and successful high-tech clusters (Silicon Valley in Northern California, US). On the other hand, few studies have addressed the developing country context (see, e.g., in Manning, 2013; Stoerring, 2007; Saxenian, 2006, Altenburg & Meyer-Stamer, 1999). In this sense, cluster development has become of keen interest not only to policy-makers in advanced economies but increasingly to those in developing countries (see, e.g., Manning, 2013; Altenburg et al., 1999). Moreover, most clusters emerged several decades ago and there have since been changes in basic conditions such as political, technological and economic changes (as explored in section 2.1).

2.2.1 Cluster definition

There are several definitions of ‘cluster’ in the literature, and Delgado et al. (2014, 2016) argued that there is not a single best way to define them. Their definition depends on many factors such as the academic background of the research and often the purpose of the study. Some authors (such as Lazzeretti et al., 2014; Martin & Sunley, 2003; and Sedita & Lazzeretti, 2012) have studied the definition of ‘cluster’ over time, and they concluded that many definitions for ‘cluster’ coexist among different schools and that there are also several applications of the term in diverse socio-economic contexts. In this sense, following Martin and Sunley (2006), Ingstrup, Freytag, and Damgaard (2009), and Stoerring (2007), the ‘cluster’ definition literature can be organized into five dominant schools: (i) Alfred Marshall, (ii) Italian industrial districts, (iii) economic and industrial geography, (iv) Michael Porter, and (v) regional innovation systems and learning regions. These different schools are part of a heterogeneous and large group of theoretical contributions. Table 1 shows the variety of 'cluster' definitions by school applied in the literature and their main related authors.

Table 1. Cluster literature schools, definitions of a cluster and related authors

Literature school	Related authors	General understanding of the definition of a cluster
Alfred Marshall	Enright Ffowcs-Williams (1996); Swann and Prevezer (1996); Rosenfeld (1997); Swann, Prevezer and Stout Prevezer (1998); Crouch and Farrell (2001); Oakey et al. (2001); Brenner (2004)	Clusters are groups of establishments belonging to the same industry within regional geographic boundaries. The focus is on the direct benefits of co-location.
Italian industrial districts	Perry (2005); Guerrieri, et al. (2001)	Industrial districts are characterized by particular social relationships and interactions among the firms involved. These relationships consist of a mixture of both cooperation and competition. The innovative capacity of SMEs belonging to a particular industry in the same region is highlighted as a primary driver behind development.
Economic and industrial geography	Feser (1998); Roelandt and den Hertag (1999); Simmie and Sennett (1999); Van den Berg, Braun and Van Widden (2001)	Clusters are based on the general idea that regions develop different types of inter-firm networks, specific institutional structures, and specific forms of economic, cultural and political practices over time.
Michael Porter	Porter (1998); Cooke and Huggins (2002); Feser and Lugar (2002); Giuliani (2005); Delgado et al. (2014, 2016)	Clusters are geographic concentrations of interconnected firms and institutions in a particular field. Clusters encompass an array of linked industries and actors important to competition and cooperation both up- and downstream in the value chain, e.g., suppliers, customers.
Regional innovation systems and learning regions	Gault (2002); Dicken (2003)	Clusters are perceived to be learning and knowledge constructions, which add to localized adjustment and innovation processes in favor of knowledge creation.

Source: adopted from Martin and Sunley (2006), Ingstrup et al. (2009), and Stoerring (2007)

The three schools of Marshall, economic and industrial geography, and Porter are dominant (Martin & Sunley, 2003). First, Marshall (1920) challenged the economists at that time to adopt a new research focus, shifting attention from the individual location of firms (relative to other factors) to the direct benefits of the co-location of firms. He (Marshall, 1920) identified knowledge spillovers, labor pooling and cost advantages as the triad of external economic factors through which the co-location of firms could increase returns to scale in the long run. Second, the economic and industrial geography school is based on the work of economic geographers (Berg et al., 2001; Feser, 1998; Roelandt & den Hertog, 1999; Simmie & Sennett, 1999), and it focuses on regional development and agglomeration and covers all political, economic, institutional and social issues (Martin, 1999). These include trade relations (e.g., commercial input and output) and other relationships (e.g., social interplay) through which regions develop different types of inter-firm networks, standards, norms and institutional and economic structures. Third, the Michael Porter school contributed by refocusing on the innovative nature of competition; it stresses that the success of clusters also relies on several factors outside of the individual firm and cluster (and not only on its inter-firm networks and trade relationships). The well-known 'cluster' definition from Porter (1998) is "a geographic concentration of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g. universities, standard agencies, trade associations) in a particular field that compete but also cooperate". In his definition (Porter, 1998), clusters encompass an array of linked industries and other institutions important to competition but also characterized by cooperation both up- and downstream in the value chain (e.g., suppliers, customers). Porter argued that clusters affect competitiveness within countries as well as across national borders (Delgado et al., 2014, 2016; Porter, 1998).

In addition to these different nuances in the definition of 'cluster', the concept of a cluster and that of an industrial district have long competed (Lazzeretti et al., 2014). Becattini framed the early industrial district research using Marshall´s theoretical background (see one of his works in Becattini, 1989). Both concepts, cluster and industrial district, overlap, in particular by focusing on the impact of firm agglomeration on economic performance. Some scholars use the terms ‘industrial district’ or ‘cluster’ interchangeably (see, e.g., Schmitz, 1995; Tallman et al., 2004; Bell, 2005), while others identify the industry district more precisely as a particular type within the more general category of clusters (see, e.g., Markusen, 1996; Gordon & McCann, 2000; Porter & Ketels, 2009). Industrial districts in this sense are typically described as agglomerations characterized by social relations and inter-firm cooperation and competition (Dahl, 2003). As a result of this competition, there is strong local division of labor in a district, and firms specialize in different parts of the value chain (Brusco, 1990). In this respect, generically, an industrial district is seen as a spatial agglomeration of firms that tend to be complementary in terms of specialization. The inter-firm interaction is emphasized based on its narrow definition, whereas the economic and industrial geography and Porter schools have typically used a broad definition with some few exceptions such as the narrow definition of Simmie and Sennett (1999)[5].

Porter´s definition underlines the previous statement that the research on clusters is broad and covers studies of the geographic co-location of firms and related institutions and their network relationships. The distinction between the narrow and broad definition of clusters is important for studying cluster development: a narrow definition assumes a firm-driven development process, whereas a broad definition assumes an endogenous process in which all actors are systemically involved. In the Italian industrial districts school, e.g., Perry (2005) assumed a narrow perspective, defining a cluster as “a locality where firms are locked together in various

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[5] Simmie and Sennett (1999) defined “an innovative cluster as a large number of interconnected industrial and/or service companies having a high degree of collaboration, typically through a supply chain, and operating under the same market conditions”.

forms of interdependence, like organisms in a biosphere”. In his narrow definition, the central element is the firm, whereas in Porter´s broad definition, the central element is both inter- and intra-firm networks, and not only the firms in the center but also associated, supporting, and specialized institutions are included. Stoerring (2007) argued that the narrow cluster definition perceives all of these institutions (e.g., universities, R&D centers) as external mechanisms. In this case, on the one hand, having a competence and a specialized university base in a region would not yet represent a stage in cluster development. In a broad definition, on the other hand, this would be a germinal stage of cluster emergence (see Stanford University´s role in the early emergent stage of Silicon Valley in Bresnahan et al., 2001). Based on these interpretations, it is more common to see the narrow cluster definition applied in the analytical literature, whereas the broad definition is mostly used in the normative stream of literature (Rosenfeld, 2002; Stoerring, 2007). Both approaches (narrow and broad) assume that the cluster definition mainly concerns firms and their linkages. These linkages are conceptually explored further in this chapter (see item 2.3).

Based on the scope of this research, a broad cluster definition is assumed to be more appropriate in particular because it includes the context of the relationship between local cluster development and global inter-cluster connection. This relationship is distinguished by an endogenous process, in which more than one institution is systemically involved and embedded. On the one hand, the narrow definition (as described above) is more appropriate to use when addressing a firm-driven development process. In a broad definition, on the other hand, both inter-firm and firm-institution networks are emphasized. These latter two types of networks are the primary focus of this research, thus, the scope of this research follows Porter´s broad definition.

2.2.2 *Elements and determinants of clusters*

Among the broad cluster definitions, in particular Porter´s definition, the determinants of a cluster are defined by the nature of how a cluster is defined. According to the perspective adopted here, three main elements can determine a cluster (following the scheme of Menzel & Fornahl, 2010). First, a cluster consists not only of firms but also of institutions such as universities and technological institutes that are the basis of innovation networks and a source of human capital. Because their respective development processes are closely related, both firms and institutions are the basic elements of a cluster.

Second, the outer boundary of a cluster is geographically determined by the co-location of certain firms and institutions that belong to a particular industry, typically with technological proximity (Menzel & Fornahl, 2010). There is no geographical border, in terms of the maximum or minimum distance between the firms and institutions, when determining a cluster (Stoerring, 2007). Hence, there is no size specification to determine the outer boundary of a cluster. Menzel and Fornahl (2010) distinguished between spatial and thematic boundaries to specify the focal point of a cluster. In this respect, on the one hand, the thematic boundary represents firms and institutions that are in the same field. One cluster differs from others by its field. Firms that address other fields are outside of this boundary, even if they share the same location. On the other hand, the spatial boundary separates the cluster from its industrial environment. This boundary is represented by firms and institutions in the same thematic field that are located elsewhere. Hence, the focal point of a cluster is seen as the overlapping of these two boundaries (see figure 5). In other words, this focal point is determined by the co-location of firms and institutions that are embedded in a common technological knowledge base and in a common pool of specialized labor.

Third, the linkages among firms and institutions are also a central element in determining a cluster. They (firms and institutions) can be network linked by commonalities and complementarities (Martin & Sunley, 2003) in both traded and un-traded interdependencies, such as the market exchange of goods and services, labor market mobility (national and international), social networks, and face-to-face interaction and cooperation (Menzel & Fornahl, 2010). The focal point of a cluster exists where there is a high density of these interconnections, which are limited by their intensity and are unevenly distributed within a cluster. Other activities can also take place at the same focal point and represent 'sub-clusters' (Menzel & Fornahl, 2010). The storage media, software, and semiconductor clusters in Silicon Valley, e.g., are focal points (or sub-clusters) of the greater ICT cluster (Menzel & Fornahl, 2010). In this respect, the focal point of a cluster is related to the density of the interconnections of firms and institutions within both its thematic and spatial boundaries. Figure 5 illustrates these elements.

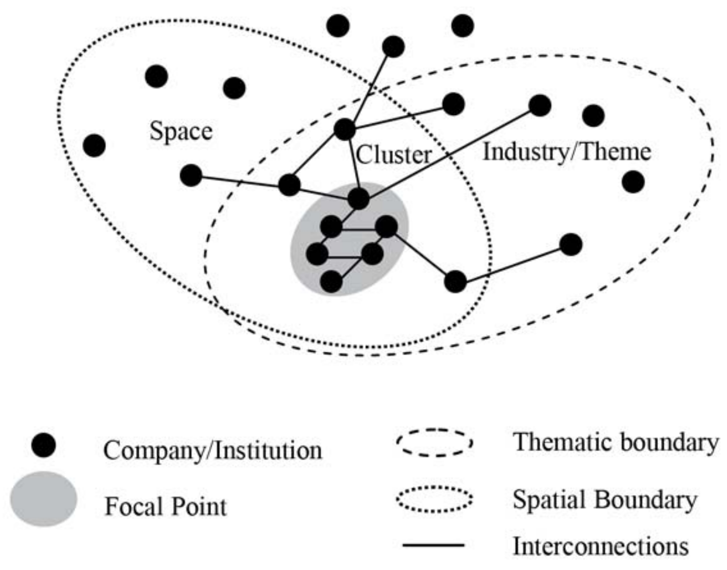

Figure 5. Elements of clusters (Menzel & Fornahl, 2010)

Following Porter´s broad definition within the scheme of Menzel and Fornahl (2009), a cluster is determined by the co-location of firms and institutions interconnected in the same thematic field (see figure 5). There are four types of firms and institutions in this model: (i) those that belong to the same thematic field, (ii) those that share the same location, (iii) those that are both in the same thematic field and the same location and hence constitute the cluster, and (iv) firms and institutions that belong to different industries in different locations (Menzel & Fornahl, 2010). For a dynamic approach to clusters (as highlighted by Menzel & Fornahl, 2010), some changes in the cluster´s elements must be considered, in particular, how the spatial and technological boundaries and the center of the cluster change, how the interconnections change, and finally, how the companies and institutions change as the cluster evolves. In this sense, those factors and an overarching developmental logic must be included to achieve a dynamic approach. This evolutionary perspective, as is discussed further below, distinguishes between the stages and the mechanisms behind the development of clusters.

2.2.3 Stages and mechanisms of cluster development

The innovative and entrepreneurial phenomena that have occurred in the southern portion of the San Francisco Bay area have captured the attention of the academic world since the 1960s. These phenomena have been studied by several scholars (see, e.g., in Saxenian, 1994; Pouder & St. John, 1996; Porter, 1998; Bresnahan et al., 2001; Manning, 2013), in particular in an effort to understand their developmental process as a potential source of competitive advantage for regions and nations. Silicon Valley is the most successful worldwide case of a high-tech cluster. The region is a geographic agglomeration of ICT-related and interconnected companies, suppliers, and research institutions. This cluster was sparked forty years ago, mainly due to the investment of human capital (Stanford University´s central role) and firm-and market-building processes[6], all of which took place over a long period, accompanied by enormous effort and risk (Bresnahan et al., 2001). Since then, several attempts have been made to create new "Silicon Valleys", such as the failed initiative in New Jersey in the mid-1960s (see, e.g., Leslie &c Kargon, 1996) and the successful Route 128 in Boston, Massachusetts (see, e.g., Saxenian, 1994). On the one hand, there is a consensus by scholars and policy makers that the Silicon Valley model is unique and inimitable and thus cannot be recreated inside or outside of the US (Bresnahan et al., 2001; Manning, 2013). More generically, there is territory specificity, such as the path dependence of local institutions and particular regional production and innovation systems, that does not allow a successful cluster model to be replicated elsewhere (Asheim, Cooke, & Martin, 2006). On the other hand, there have been some potential regularities (or similarities) among successful clusters, such as those in emerging regions, notably in India, Israel and Taiwan, and in more advanced areas such as Northern Virginia (US), Cambridge (UK), and Scandinavia (Bresnahan et al., 2001). These regularities provide a better understanding of the cluster phenomenon itself and (in particular for this study) the mechanisms behind the emergence and growth of clusters from an evolutionary perspective.

The question of how clusters can come into being and grow over time has been the subject of long-standing debate (Belussi & Sedita, 2009; Martin & Sunley, 2006). Many scholars distinguish the mechanisms behind clusters by their different development stages (see, e.g., Pouder & John, 1996; Bresnahan et al., 2001; Asheim et al., 2006; Menzel & Fornahl, 2010).

[6] The firm-building process refers to entrepreneurial initiatives such as Hewlett-Packard and Intel. Market-building refers to new technological opportunities (and niches), such as integrated circuit technology. Both of these processes were embedded in the early emergent stage of cluster development in Silicon Valley in the 1960s (according to Bresnahan et al., 2001).

The mechanisms that support the development of clusters in their early emergent stages differ from those supporting mature stages of development. On the one hand, some scholars argue that the developmental stages of clusters resemble the business life cycle (see Tan, 2011), and other scholars identify some similarities with the industrial life cycle (see Taeube & Sonderegger, 2009). On the other hand, Menzel & Fornahl (2009) argue that clusters move through different developmental stages and that these developmental stages differ from those for the development of their respective industries and firms. Although the stages resemble each other in many aspects (according Menzel & Fornahl, 2010), they have nuanced differences primarily driven by the diversity and heterogeneity of knowledge[7] inside of clusters and the complex production and innovation systems that provide a systemic dimension to clusters. These systems (production and innovation) both influence and are influenced by other firms and institutions as the clusters grow to maturity.

Based on the cluster life-cycle, some scholars (following the scheme of Feldman & Francis, 2009) have considered three stages of cluster formation and development. The first stage is the *emerging* stage, which basically occurs when an entrepreneurial innovative initiative is sparked by a confluence of exogenous events. In this stage, the region can have assets in terms of universities, government labs, and firms, but it is inert in terms of the entrepreneurial activity in the industry that the cluster will be related to. After it is sparked, the cluster moves

[7] Menzel and Fornahl (2010) distinguish the quantitative and qualitative dimensions of clusters. The quantitative dimension basically refers to the economic development of the cluster in terms of the number of active companies and employees. The qualitative dimension refers to the cluster firms´ inherent technological competencies. The heterogeneity of knowledge in a cluster increases in the early emergent stages because every new firm ventures into new technological areas of the cluster. There is no specific technological focus in the developmental stage. After this emergent stage, as the cluster is growing, the technological path becomes increasingly focused. Hence, the heterogeneity of knowledge decreases until the cluster has matured and a distinct development path has taken shape. Based on this process, the heterogeneity of knowledge here refers to the qualitative dimension of clusters related to their technological path over their developmental stages.

from the emergent stage to the *growing* stage through a self-reinforcing process among entrepreneurs, enterprises, institutions and resources. In this second stage, the firms and institutions in different locations have different cluster formation processes. Some regions experience an exogenous shock, characterized by corporate mergers and acquisitions (or other business growth strategies) that move the latent cluster to the growing stage, as occurred at the beginning of the New Jersey electronics cluster (see Leslie & Kargon, 1996). After growth, in the *sustaining* stage, the industry reaches maturity as a well-functioning, richly innovative and entrepreneurial system with a critical mass of resources in a particular geographic location. At this point, this location establishes a reputation as the place to be for a particular technology, such as the biotech cluster[8] in Massachusetts. After this point, some scholars (such as Menzel & Fornahl, 2010) also consider a fourth stage, adding the *decline* stage. This stage is defined by a decrease in the number of companies and especially of employees due to failures, mergers, and rationalizations, as occurred in old industrialized regions such as the Ruhr Valley[9] in North Rhine-Westphalia, Germany. The particularities of the diversity and heterogeneity of knowledge embedded in the singularities of the location (such as regional production and innovation systems) at each stage of development create a

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[8] The biotech cluster is located in Massachusetts, in the northeast of the US, where there are more than 550 biotech and pharmaceutical companies and 122 colleges and universities. Altogether, this group received 2.3 billion USD from the National Institutes of Health for funding basic research in 2013 (http://www.massbio.org, accessed in 6th January 2015). Based on this critical mass of resources, the biotech cluster of Massachusetts established a good reputation in this particular technology (biotech and pharmaceutical) and attracted new investment from large companies.

[9] The Ruhr Valley is located in in North Rhine-Westphalia, Germany, and is considered part of the larger Rhine-Ruhr metropolitan region, with more than 12 million residents. The region has a long industrialization history starting in the 1950s and is considered an established and large industrial cluster (or industrial district by some scholars) in the coal and steel industries. The region was at the center of the German economic miracle of the 1950s and 1960s, accumulating high rates of growth. However, later (around the 1970s), these companies went into a sharp decline due mainly to prices being undercut by lower-cost foreign suppliers (such as Japan). Many companies reduced their labor force at that time and began to concentrate on high-profit specialty items (see more details of this decline process in Grabher, 1993).

complex process that makes it difficult to clearly identify the limits of each stage. Additionally, a cluster does not develop evenly or as a single entity; hence, firms and institutions within the cluster can remain at an earlier stage while others advance along the trajectory. Although these limits are not precisely defined, Menzel & Fornahl (2009) identified some determinants[10] that they used to distinguish each stage (see figure 6).

[10] The determinants are based on the foundations of the cluster life-cycle model (proposed by Menzel & Fornahl, 2009), which considers the following dimensions of a cluster: quantitative, qualitative, direct, and systemic. The dynamics of the cluster refer to the heterogeneity of knowledge, and the absorptive capacity refers to the ability of a firm to recognize the value of new external information, assimilate it, and apply it to commercial ends (for more detail, see Menzel & Fornahl, 2009).

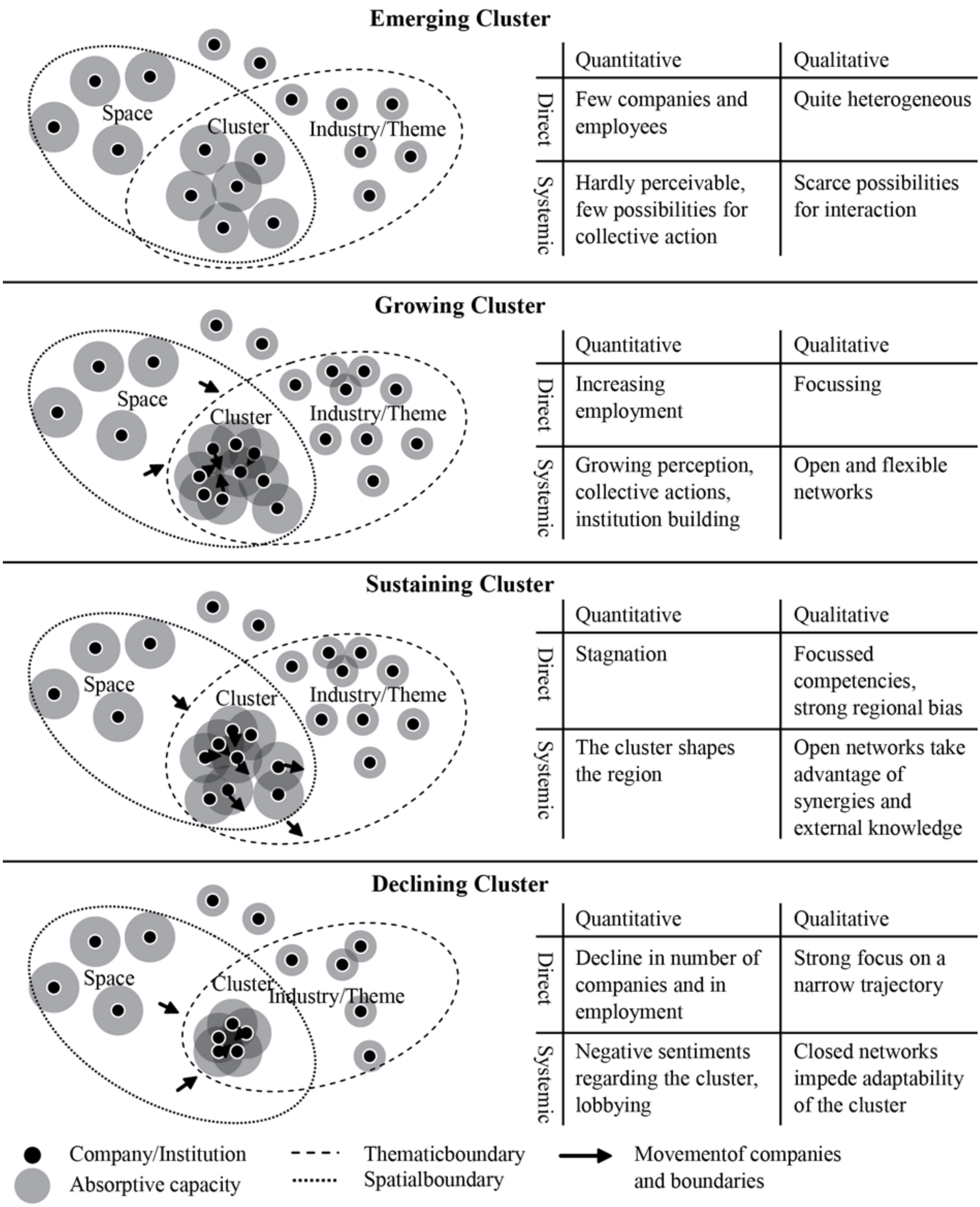

Figure 6. The developmental stages of a cluster and their determinants (Menzel & Fornahl, 2010)

Because the research focus of this study addresses the emerging (prevailing) and growing stages, particular attention is given to these developmental stages according to the cluster life-cycle model (proposed by Menzel & Fornahl, 2010). This is considered the growing stage because it is difficult to clearly identify the limits of the stages as described above. Although it is assumed that global networks play an important role in cluster development even in this early stage, a broader understanding of the mechanisms behind cluster development is the focus here, and the global networks perspective appears in the next section. Given that these mechanisms are not fully understood by scholars (Bresnahan et al., 2001; Orsenigo, 2001), the main emphasis in this section is on how clusters come into being (prevailing) and grow in a particular geographic location. Figure 6 summarizes these cluster's dynamics (in which the arrows represent the cluster development dynamics).

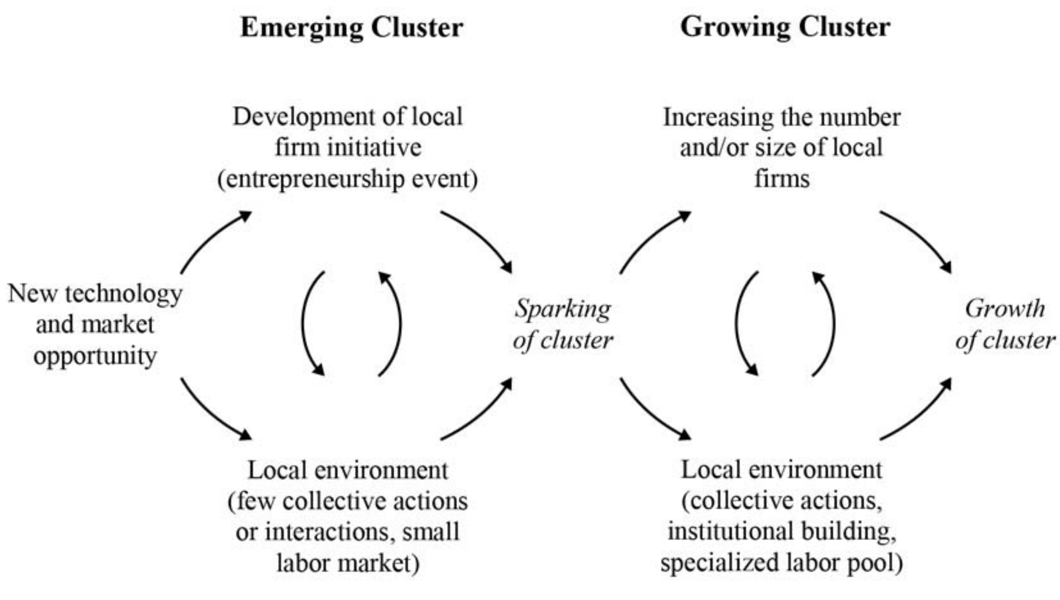

Figure 7. Clusters' emerging and growing dynamics

Initially, a region can have firms and institutions from different industries that are more or less equally dispersed. This is considered normal economic activity, and particular spatial and thematic concentrations of firms and institutional interconnections cannot be observed. This environment can be found in many regions, which means that there are several potential candidates for clusters. Emerging clusters, therefore, differ from locations with normal economic activity basically in two main interrelated features (Bresnahan et al., 2001; Feldman, 2001; Menzel & Fornahl, 2010). The first feature is an *entrepreneurial event* (Feldman, 2001; Shapero, 1984) motivated by new technology and market opportunity (Bresnahan et al., 2001). This event is defined by "the decision to engage in the formation of a company, and considers the way in which this decision can be influenced by the regional context" (Feldman, 2001). In this sense, entrepreneurship and new-firm formation are the central mechanisms for a cluster´s emergence. Bresnahan et al., (2001), Rosenfeld (2002) and Feldman (2001) observed these mechanisms in several successful and broad cases worldwide. Silicon Valley sparked in the late 1950s through a rich technological opportunity in the semiconductor business, followed by markets becoming available for technology niches (such as consumer electronics and defense) (Bresnahan et al., 2001). Frederick Terman (as Stanford's Dean of Engineering and Provost) encouraged faculty and graduates to start their own companies as spinoffs from Stanford´s research centers. Those spinoff companies were created around the Stanford campus and included high-tech firms such as Hewlett-Packard. This experience differs from the origins of several European and Asian clusters. Clusters such as Daedeok Innopolis (Korea) and other high-tech clusters in Finland and Sweden were carefully planned by local governments, firms and universities (Feldman & Francis, 2009). In Finland, on the one hand, the high-tech cluster in Oulu sparked around a technology park (created in 1982) with Nokia as an anchor firm. Later, many local firms participated in the park´s formation and shared the risk of failure (Feldman & Francis, 2009). On the other hand, in Korea, Daedeok Innopolis was also sparked based on a science and technological park model, but unlike in the Oulu cluster, the Korean government actively intervened in cluster formation (Oh & Yeom, 2012). The origins of entrepreneurship differ in those regions. These clusters established their firms based on (i) creating spinoffs from local research centers (such as Silicon Valley), (ii) attracting a MNC as an anchor company (such as Nokia in Finland), (iii) creating spinoffs from large local companies in technology niches (such as the electronics segment of Samsung in Korea), or (iv) establishing a MNC subsidiary to reduce market distance and to obtain easy supply chain access (such as Intel´s decision to locate a subsidiary in Haifa, Israel, to access both technologies and markets in electronics and defense).

The second aspect in which emerging clusters differ from a location with normal economic activity is the *local environment* (Bresnahan et al., 2001; Feldman & Francis, 2009; Menzel & Fornahl, 2010). Local initial resource conditions are typically embedded in the path dependence of the firms and institutions (Feldman, 2005), the institutional context (Fromhold-Eisebith & Eisebith, 2005; Martin, Salomon & Wu, 2010) and the culture (Tomlinson, 2003). The previous hard work of firm-building and other long-term investments (such as education) create valuable assets for regional production and innovation systems (Bresnahan et al., 2001). Sometimes "these long-term investments in national or regional capabilities can grow for a long time in what seems like a low-return mode before the take off into cluster growth" (Bresnahan et al., 2001). Entrepreneurship is affected differently by each local environment over time, creating clusters with their own identities (Feldman & Francis, 2009). In this respect, the local environment consists of certain initial resource conditions, such as a strong scientific base or political support, which give the emerging cluster the potential to reach critical mass (Menzel & Fornahl, 2010). On the one hand, Bresnahan et al. (2001) argued that "apart from public investments in areas like education, governments played an important supporting (though not leading) role in making entrepreneurship easier in many regions, notably in Ireland, Taiwan, Virginia, and Israel". On the other hand, Fromhold-Eisebith and Eisebith (2005) argued that clusters can be promoted by top-down policies or they can be seen simply as a phenomenon organized and financed bottom-up by a group of firms without a policy strategy. In either of these cases, many scholars point to the importance of highly skilled labor as a precondition for emerging and growing clusters (Bresnahan et al., 2001; Feldman & Francis, 2009; Manning, 2013; Menzel & Fornahl, 2010; Rosenfeld, 2002; Saxenian, 1994, 2006; Stoerring, 2007). Bresnahan et al. (2001) argued that the supply of skills can come from different local sources such as universities (e.g., Tsing Hua University in Taiwan´s nascent Hsinchu Science Park) or training provided by local firms (e.g., managerial training skills promoted by Hewlett-Packard or Intel in the nascent Silicon Valley). Those skills can also come from outside of the region. The clusters in Taiwan and India have drawn heavily on US-educated Chinese and Indian engineers. In Israel as well, immigration (largely from Russia) has been an important source of skills. Similarly, the nascent Silicon Valley attracted engineers from all over the US.

In a subsequent stage, a type of industry concentration in a particular region can be observed, including an increase in employment as a result of the growth of existing companies and/or the high number of start-ups. This movement can clearly define cluster boundaries (both thematic and spatial) and, hence, differentiate the growing from the emerging stage (Menzel & Fornahl, 2010). "The growing density of companies and institutions within the boundaries of the cluster increasingly creates possibilities for innovation networks or customer–supplier relations and forms a specialized labor market" (Menzel & Fornahl, 2010). In this sense, the local environment increases the support infrastructure via collective actions and institution building. Entrepreneurship activities intrinsically and actively involve the local environment, where the heterogeneity of knowledge is decreased by increasing the cluster's level of technological specialization.

2.3 Global inter-cluster connections

The relationship between local cluster development and global networks is a critical factor. Most studies agree that in the context of early cluster growth, in particular in developing countries, global linkages can facilitate the upgrade and catch-up processes of cluster development (Bresnahan et al., 2001; Humphrey & Schmitz, 2002; Lorenzen & Mudambi, 2013; Manning, 2013; Saxenian & Hsu, 2001). Whereas clusters in advanced economies, in their early stage of development, benefited substantially from the favorable co-existence of local resource conditions, policies, entrepreneurial capacity and local/domestic product markets (see, e.g., Saxenian, 1994, for Silicon Valley; Porter, 1990, more in general), new emerging clusters in developing countries are typically latecomers within a much more competitive, globally dispersed landscape of innovation and production (Lorenzen & Mudambi, 2013; Manning, 2013). New local cluster development is therefore intertwined with understanding the dynamics of cluster embeddedness in global communities and production systems.

Most prior research has therefore focused on the role of global *organizational ties* in stimulating initial cluster growth (Humphrey & Schmitz, 2002; Lorenzen & Mudambi, 2013; Patibandla & Petersen, 2002). These so-called 'organizational pipelines' (Bathelt et al., 2004) facilitate the inflow of capital, knowledge, business practices and standards, thus promoting capability development in clusters (Humphrey & Schmitz, 2002; Reddy, 1997). Organizational ties are often established through foreign MNCs that establish and connect resource- or market-seeking subsidiaries across the world (Enright, 2000). The growth of many clusters in developing countries, e.g., Bangalore, Cordoba, and Guadalajara, has been linked to early MNC foreign investment decisions (Altenburg & Meyer-Stamer, 1999; Manning, Ricart, Rique, & Lewin, 2010; Patibandla & Petersen, 2002). Notably, organizational links may also become established through ties between local suppliers and global buyers in GVCs and production networks (Humphrey & Schmitz, 2002). However, one major limitation of relying on building global pipelines when developing new clusters is that the location decisions of foreign firms in particular are typically determined or at least facilitated by several competitive factors, including a sizable skilled labor market, a reasonably developed infrastructure, and prior knowledge and familiarity with the location (Patibandla and Petersen, 2002; Manning et al., 2010). Many nascent clusters do not possess these advantages, or they are not visible enough to foreign firms (Manning et al., 2010).

More recently, research has shifted from focusing on organizational ties to recognizing the criticality of transnational communities and networks of *individual professionals and entrepreneurs* in sparking cluster development (Lorenzen & Mudambi, 2013; Saxenian & Hsu, 2001; Zaheer et al., 2009). In this regard, in particular, the notion of 'brain circulation' has gained prominence (Saxenian, 2006). Introduced mainly by Saxenian and colleagues, BC denotes processes of knowledge, technology and practice diffusion and translation through diaspora network ties between emerging and typically more established clusters, e.g., Silicon Valley and Taipei (Saxenian & Hsu, 2001). Unlike 'brain drain', which describes the one-way departure of talent often from developing to more advanced economies, BC captures 'reversed brain drain' – the return of talented professionals and entrepreneurs to their home countries after receiving education and experience in work contexts abroad (Kenney et al., 2012; Saxenian, 2005). As individuals return, they combine their knowledge of global business practices and customer needs with their understanding of the local environment into generating globally oriented employment and entrepreneurial opportunities (Porter, Whittington, & Powell, 2012; Saxenian, 2005). Not surprisingly, the existence of such diaspora networks is an important pull for location and entrepreneurial investment decisions (Zaheer et al., 2009). Additionally, these networks arguably help 'insert' new clusters into GVCs (Saxenian & Hsu, 2001) while also being affected by the latter (Bresnahan et al., 2001). Successful clusters are effective at building and managing a variety of these (organizational and personal) channels to access relevant knowledge from around the globe (Bathelt et al., 2004). It is assumed thus that they can be more effective by taking a governance perspective on the role of stimulating cluster growth and on contingent effectiveness in general and IBC in particular as it is explored in greater detail in the following sections.

2.3.1 Cluster connectivity

Lorenzen and Mudambi (2013) developed the concept of cluster connectivity by integrating insights into different types of global linkages (centralized and decentralized network structures) consisting of both pipelines and personal relationships (in their empirical case of the Indian clusters of Bollywood filmed entertainment and Bangalore ICT). They developed the cluster connectivity concept based on the literature of both social networks and economic geography. Cluster connectivity is represented by the global network linkages that generate interplay between the local, global, individual and organizational cluster ties between emergent and typically more established clusters to promote and facilitate the upgrade and catch-up processes in developing countries (Lorenzen & Mudambi, 2013).

Lorenzen and Mudambi (2012) defined pipelines in their concept of cluster connectivity as channels designed and maintained by organizations to maximize the effectiveness of moving goods, capital, and people across geographical space. Value chain actors seek exchange solutions by building these pipelines to transmit uncodified information and tacit knowledge across clusters (Bathelt et al., 2004; Maskell, Bathelt, & Malmberg, 2006). Clusters can be quite specialized if linked to other specialized clusters through pipelines of codified information and knowledge exchanges (Sturgeon & Kawakami, 2010). These pipelines can facilitate tacit and codified information exchanges locally or globally, although the more spontaneous and fortuitous linkages of tacit information tend to remain highly localized in face-to-face interactions (Bathelt et al., 2004). In addition to organizational ties (through these pipelines), personal relationships are created and maintained by individuals based on their mutual social proximity in the form of kinship, friendship or other types of ties (Granovetter, 1973; Lorenzen & Mudambi, 2013). Lorenzen and Mudambi (2013) argued that these relationships are important for establishing global linkages and exchanging knowledge and technology, typically between emergent and more established clusters. Personal relationships lead to innovation activities that emerge from the bottom-up through the interactions of many independent actors who experiment, collaborate, merge, learn, spin-off and even steal from each other (Lorenzen & Mudambi, 2013). In fact, both types of global linkages (organizational and personal relationships) are crucial for developing and maintaining the innovativeness of clusters (Ter Wal & Boschma, 2011).

Using the lens of the social networks literature, Lorenzen and Mudambi (2013) defined two types of network structures in their cluster connectivity concept. In linkages with a centralized network structure, knowledge and information flow into and out of a cluster mediated by just a few gatekeeper actors. In linkages with a decentralized network structure, flows occur directly between many actors, all with comparable centrality. The aspect of such structures emphasized by Lorenzen and Mudambi (2013) is centralization. In a network of inter-related actors, the more relationships an actor has with other actors in the network, the higher that actor's centrality. When a few such actors with high centrality dominate a network, the structure of the network becomes centralized. In contrast, when all actors have a comparable number of relationships (e.g., nobody is central), the network is decentralized. Figure 8 illustrates these two types of network structures of global linkages.

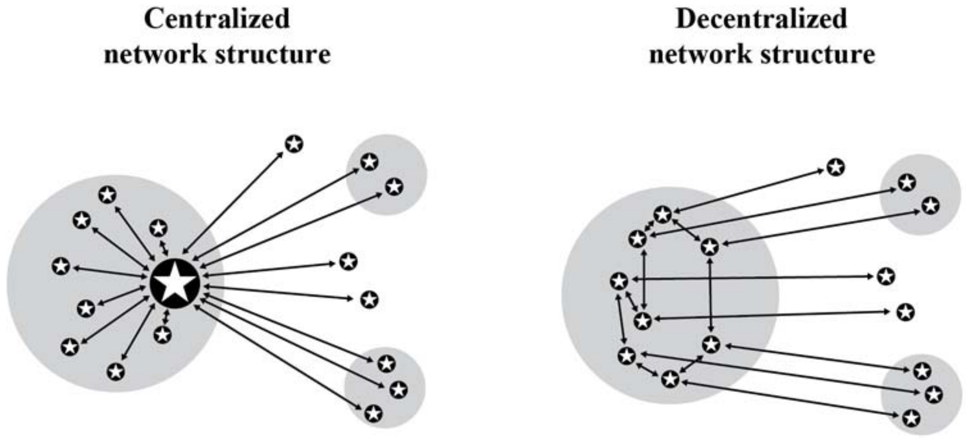

Figure 8. Network structures of global linkages (according to Lorenzen & Mudambi, 2013)

All of these global linkages and different network structures result in four archetypes for the cluster connectivity concept: (i) centralized pipelines (e.g., flagship MNC), (ii) decentralized pipelines (e.g., multiple MNE subsidiaries); (iii) centralized personal relationships (e.g., clans), and (iv) decentralized personal relationships (e.g., diaspora members). The Bollywood cluster, for example, has been moving from the decentralized personal relationships to the centralized pipelines network structure. However, it maintains a mixed form of connectivity that allows scale in value capture to be combined with innovation in value creation. In contrast, the Bangalore ICT cluster illustrates cluster connectivity in decentralized pipelines, and this has allowed them to catch up to global markets. Through these two empirical cases, it is possible to see the potential interdependence between personal relationships and pipelines in different types of network structures.

Cluster connectivity depends on the industry itself and has an evolutionary nature. It is possible that connectivity, like industry structure, evolves over the technology cycle, with a highly decentralized and competitive structure in the nascent phase, followed by re-modeling and consolidation that typically result in a highly centralized network structure in maturity (Lorenzen & Mudambi, 2013). However, growth and industry consolidation do not necessarily need to have a centralized network structure of connectivity. The concentration of network power (centralized structure) tends to be closed off from the innovation process in contrast to the decentralized networks, which can catch up in innovation and technology more easily. In the emerging economy context, Lorenzen and Mudambi (2013) argued that clusters linked to the global economy by decentralized pipelines have potential for in-depth catch up (focused on industry and technology), whereas clusters linked through decentralized personal relationships have potential for over-breadth catch-up across a range of related industries and technologies.

2.3.2 Inter-cluster brain circulation

According Lorenzen and Mudambi (2013), there is interdependence between pipelines and personal relationship channels through the global connectivity of clusters. Diaspora networks and transnational communities of individual professionals and entrepreneurs are intrinsically embedded in this global connectivity (Lorenzen & Mudambi, 2013; Saxenian, 2002, 2005; Saxenian & Hsu, 2001; Zaheer et al., 2009). Diaspora denotes a worldwide dispersion of highly qualified members of a group who are affiliated to multiple geographical localities by birth but associated by some common tie or occupation (Bauböck & Faist, 2010; Kuznetsov & Sabel, 2008). Diaspora members leverage their cultural similarities and shared national background when establishing personal relationships across clusters (Lorenzen & Mudambi, 2013). This global connectivity is a critical asset for stimulating the circulation of individual professionals and entrepreneurs across these locations (Daugeliene & Marcinkeviciene, 2009; Saxenian, 2005).

In this regard, the notion of BC has particularly gained prominence (Saxenian, 2005). BC is involved with knowledge, technology and practice diffusion and translation through diaspora network ties between emerging and typically more established clusters, e.g., the connection between Silicon Valley and Hsinchu (Bresnahan et al., 2001; Saxenian, 2005; Saxenian & Hsu, 2001). BC includes the permanent move of 'returnees' back to their home countries after gaining educational and professional experience abroad (Kenney, Breznitz, & Murphree, 2013), but it also relates to continuous workforce mobility between globally dispersed locations. Importantly, the focus of this study is on BC through the movement of people between particular emerging and/or established clusters – in short, IBC.

Many scholars (see, e.g., Daugeliene & Marcinkeviciene, 2009; Biao, 2005; Kuznetsov and Sabel, 2006; Le, 2008; Saxenian, 2002, 2005; Tung, 2008; Yun-Chung, 2008; Teffera, 2005) argue that BC replaces the traditional concepts of brain drain and brain gain in the globalized and knowledge-based world. Brain drain was seen in the 1960s as a process in which advanced economies (mainly the US) attracted the most talented people away from already poor developing nations (Adams, 1968; Bhagwati & Hamada, 1974). The US, in particular, was extremely attractive to foreign students in the period after World War II (Kenney et al., 2012; Saxenian & Hsu, 2001). This attraction was reinforced by the 1965 Immigration Act, which removed national quotas and generated a rapid increase in emigrating scientists and engineers from tertiary nations such as India and Taiwan (Saxenian & Hsu, 2001; Kenney et al., 2013). Developing nations particularly feared this loss as they tried to catch up to the global knowledge and technology frontier in the hope of boosting their economies (Taeube & Sonderegger, 2010). In fact, these educated immigrants commonly remained in the US in high-tech-based regions such as Silicon Valley and Boston (Kenney et al., 2013). They received higher salaries than they could expect in their homelands, could undertake more challenging work, and lived in a developed country environment (Kenney et al., 2013). Those immigrant scientists and engineers in the US represented a substantial, highly skilled work force.

In contrast, starting in the 1990s, these immigrant scientists and engineers began returning to their homelands to establish new businesses and become returnee entrepreneurs (Kapur, 2001; Kenny et al., 2012; Saxenian, 2006). This phenomenon was seen as a positive effect; this effect was called brain gain by scholars (see, e.g., in Tung et al., 2006; Yun-Chung, 2007; Le, 2008; Zweig, Fung, & Han, 2008), and these returnees were typically called transnationals by sociologists (see, e.g., in Guarnizo and Smith, 1998; Ong, 1999; Pries, 1999; Sassen, 1988). This phenomenon has suggested that scientist and engineer immigrants could absorb technical expertise and managerial and entrepreneurial skills when they are embedded in knowledge-based regions (such as Silicon Valley). Brain gain reflects the migration of highly skilled people who studied and had a work career abroad (particularly in advanced economies such as the US) and then return to their motherland after these experiences Kenney et al., 2012; Saxenian, 2005). This two-way flow of highly skilled people helped the development of high-tech clusters in countries such as Taiwan, China, Israel, India (Saxenian, 2002, 2005, 2006; Saxenian & Hsu, 2001) and Korea (Yoon, 1992), in particular stimulating the process of knowledge transfer, innovation, and upgrading (Bathelt et al., 2004; Humphrey & Schmitz, 2002; Owen-Smith & Powell, 2004).

The earlier pattern of one-way flows of highly skilled people from advanced economies to the periphery (the brain drain process) has been replaced since the 2000s by a far more complex and decentralized two-way flow of highly skilled people between differently specialized regional economies (Saxenian, 2005). Immigrant scientists and engineers have been moving across national boundaries from their homes typically to more advanced economies, and they rarely cut all ties when they leave (Taube & Sonderegger, 2010). This BC (Saxenian, 2005) has benefitted both sending and receiving countries by creating cross-border entrepreneurial and technological networks. These highly skilled people usually travel back and forth, bringing with them knowledge of markets and new technologies, and they promote relationships between people and organizations in both countries (Taube & Sonderegger, 2010). Saxenian (2006) coined the name 'new Argonauts' for these particular high-skilled people, alluding to the heroes in Greek mythology with the same name.

The circulation of the 'new Argonauts' has increased in recent decades (Saxenian, 2006). For example, the Chinese and Indian diasporas represent the largest groups of scientist and engineer immigrants in the US, and they have heavily concentrated in high-tech-based regions such as Silicon Valley (Saxenian, 2002, 2005, 2006). Since the 1990s, the ratio of foreign-born scientists and engineers in Silicon Valley, primarily from Asia, has been one-third (Saxenian & Hsu, 2001). By 2000, for example, there were approximately 9,000 US-educated Taiwanese scientists and engineers working in Silicon Valley, the majority of who arrived prior to 1990 (Saxenian & Hsu, 2001). These representatives of the Taiwanese diaspora started to return to their homeland in the 1990s because of the promise of economic opportunity and the desire to return to their families and contribute to their home country (Saxenian & Hsu, 2001). In the early 1980s, approximately 200 scientists and engineers returned to Taiwan annually and a decade later, more than 1,000 were returning annually (Saxenian & Hsu, 2001).

Based on these phenomena, IBC captures a critical process in the growth and upgrading of high-tech clusters in the current knowledge-based economy (Daugeliene & Marcinkeviciene, 2009; Kenney et al., 2012; Saxenian, 2005, 2006). IBC is assumed to include knowledge, technology and practice diffusion and translation through individual networks between emergent and typically more established clusters that are globally interconnected by network ties (see mainly Bresnahan et al., 2001; Saxenian & Hsu, 2001; Saxenian, 2005; Daugeliene & Marcinkeviciene, 2009; Kenney et al., 2012; Lorenzen & Mudambi, 2013).

All of these IBC processes and practices through individual networks differ over the developmental process of clusters. Whereas global connectivity is typically characterized by weak organizational and individual ties, brain-drain, and the one-way flow of talent during the emergent developmental stage of clusters, in the subsequent developmental stage, global connectivity is strengthened by the promotion of organizational and individual ties, reversed brain drain and initial IBC process (see, e.g., Saxenian & Hsu, 2001; Saxenian, 2005; Kenney et al., 2012). In addition, the prior dynamic of brain-drain and a one-way talent flow (see these dynamics in the cases of, e.g., Bangalore and Hsinchu) helps to create diaspora communities and a shortage of talent that further sparks IBC and the global circulation of returnees due to enabling and facilitating conditions (Saxenian & Hsu, 2001; Saxenian, 2005). Figure 9 illustrates the combination of these dynamics by the emerging and growing stages of cluster development (in which the arrows represent the dynamics of cluster development including the local and global dimensions).

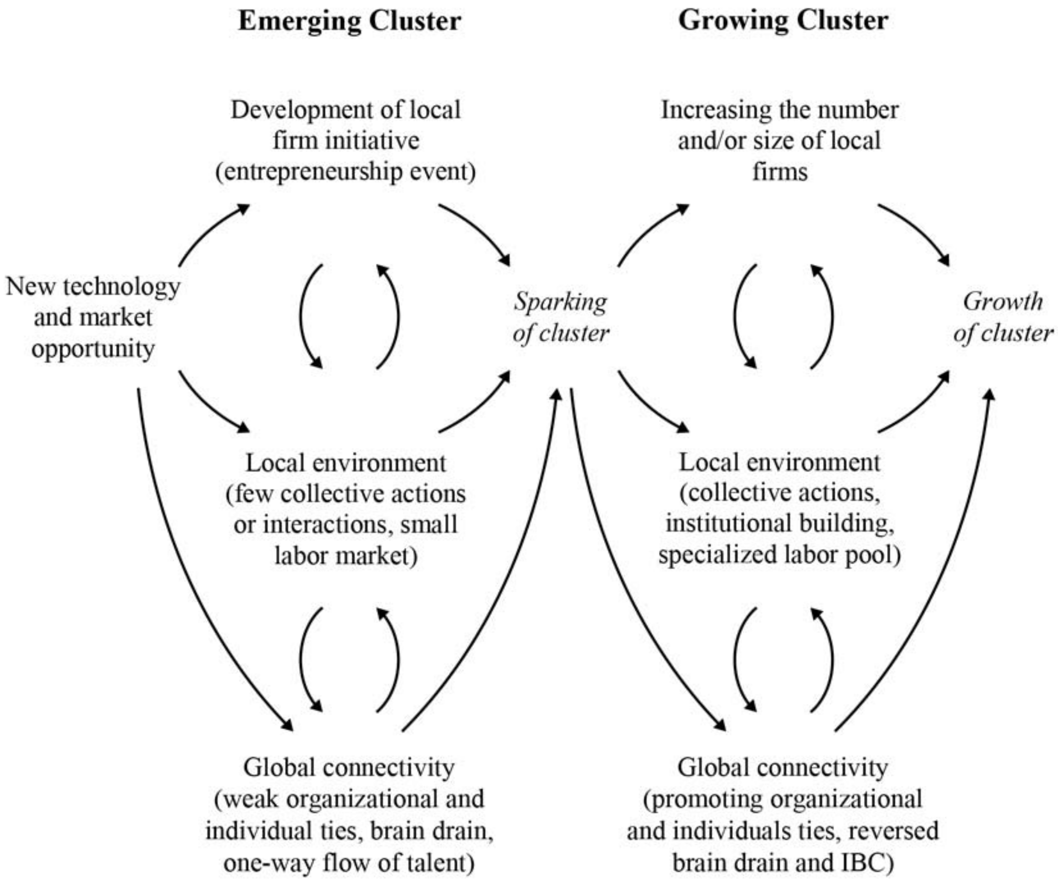

Figure 9. Dynamics of local cluster development and global connectivity

Based on these dynamics (se figure 9), arguably, IBC also plays a critical role in the growth and upgrading of clusters. On the one hand, some scholars argue that the dynamics of IBC were particularly important for the formation of high-tech industries in Taiwan, China, Israel, Korea and India (Saxenian, 2002, 2005, 2006; Saxenian & Hsu, 2001; Yoon, 1992). From this point of view, the key actors in this process are neither policymakers nor MNCs acting in isolation, although both certainly play a role, but rather the returnees (Saxenian, 2006). On the other hand, Kenney et al. (2012) argue that returnees were not determinative of the seminal emergence and early development of the high-tech ICT industry in the cases of India, China and Taiwan. These authors (Kenney, Breznitz, & Murphree, 2013) collected evidence that these highly skilled scientists and engineers only returned after the domestic industry had already achieved international success; at this point, these returnees rejoined their home country and contributed to the subsequent rapid expansion phase of domestic industry in a BC model. The authors note that in all of the three cases studied, public policy and the effort of local entrepreneurs through investment and technology transfer/learning from MNCs played key roles in the emergence and early success of these high-tech industries through self-reinforcing development prior to the arrival of the returnees. Additionally, they argue that the returnee entrepreneurs started to play a key role only after the growth phase of the industry sparked.

This argument from Kenney et al. (2012) could indicate tendencies toward circular causality as seen in the 'chicken-and-egg problem' in cluster formation (for more detail, see item 2.2). While attracting MNCs to latecomer regions often requires skilled labor markets (Pouder & St John, 1996), the returnees typically rely on employment opportunities (Bresnahan et al., 2001). To address this circular causality, globally dispersed clusters could co-develop certain talent pools and expertise along the value chain through BC (Manning et al., 2010; Saxenian, 2005). Furthermore, the IBC concept offers a strategy applied by many policy makers in latecomer regions who are trying to start the development of their high-tech industries (Mahroum, 2005; Yun-Chung, 2008). Particularly, regions such as Korea faced the exodus of highly talented people in the 1960s and successfully overcame the brain drain phenomenon through government policy interventions (Yoon, 1992). The diaspora of highly skilled scientists and engineers to the US was seen by Korean policy makers as labor market storage. The Korean government stimulated IBC first by investing in infrastructure (e.g., the scientific and technological park model) and particular policies (e.g., fringe benefits and improving living conditions) to attract those people back to their motherland and second by creating beneficial legislation and taxation systems for them (Daugeliene & Marcinkeviciene, 2009). Generally, the returners (Kenny et al., 2012) also helped to build up local capabilities (such as science and technology (S&T) capabilities) in the early developmental stages through their overseas experience (of, e.g., technological, managerial, and bureaucratic systems). These scientist diaspora communities have been seen as an essential asset for latecomer nations because they stimulate IBC as well as economic growth (Daugeliene & Marcinkeviciene, 2009; Saxenian, 2005; Teferra, 2005; Tung, 2008). Additionally, Shin and Nak Choi (2015) argued that IBC could be seen as a new model to compensate for the future lack of global talent, in particular, for future workforce change in countries in which the age of the population is shifting dramatically[11].

2.3.3 Governance of inter-cluster brain circulation

To determine the role of IBC in stimulating cluster growth and upgrading, its impact on knowledge, technology and practice diffusion depends on the role of governance. It is assumed that the effectiveness of these processes thus depends on network governance. Scholars have been discussing network governance over the last two decades (see, e.g., Powell, 1990 and Provan & Kenis, 2008, in general; and, e.g., in Schüßler et al., 2013 in particular from the cluster perspective). Network governance denotes network coordination

11 Shin and Nak Choi (2015) are in favor of the argument that the BC model contributed to Korea's sustainable growth. This is mainly because they argue that the competition for skilled foreigners will increase due to economic globalization and the demographic transition in many parts of the world. They empirically demonstrated that Korea will face demographic crisis, and BC could be a model to overcome this crisis (with certain limitations). They argued that BC is a positive-sum game in which countries and businesses benefit from building ties across geographic space rather than the zero-sum game implied by the global war for talent metaphor. Some evidence collected from their work is explored in chapter 4 (case study of Daedeok Innopolis - Silicon Valley connection) as a secondary source of evidence.

and functioning using a wide range of mechanisms and actors, from various forms of contracts to social relationships (Lin, Huang, Lin, & Hsu, 2012; Provan & Kenis, 2008). Some scholars (e.g., Kenis & Provan, 2006) argue that there appears to be some reluctance to study the control mechanisms of networks because they (networks) are collaborative arrangements and are not about hierarchy and control. In this respect, networks cannot be seen as legal entities that act collectively without any single entity representing the network as a whole (Provan & Kenis, 2008). Because a network comprises a range of interactions among participants, however, governance is critical for coordinating actions and practices across the network to achieve goal-directed consensus and conflict resolution (Kilduff & Tsai, 2003; Provan & Kenis, 2008; Schüßler et al., 2013). In this view, the network is seen as a 'form of governance'[12] (Provan & Kenis, 2008). Although "serendipitous interactions can also occur" (Schüßler et al., 2013), network governance can support the processes of cluster upgrading and transformation under resource constraints through the various network archetypes of cluster connectivity (Lorenzen & Mudambi, 2013; Schler et al., 2013; Altenburg et al., 1999). Network governance thus allows the elucidation, in particular, of the governance of IBC by considering different coordination levels of IBC for achieving goal-directed consensus and conflict resolution.

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[12] The organizational literature broadly characterizes networks through two basic approaches: 'network analytical' and 'network as a form of governance' (Provan and Kenis, 2008). The network analytical approach has been used mainly by sociologists focusing on the network's structural characteristics and the configuration of individuals using concepts such as density, centrality and structural holes (see more detail in Wassserman and Faust, 1994; and Provan and Kenis, 2008). In contrast, the network as a form of governance approach considers the network as a mechanism of coordination (Provan and Kenis, 2008). Provan and Kenis (2008) explored this approach (network as a form of governance) by means of mainstream research on markets and hierarchies that challenges the conventional wisdom that the market is the only efficient system of nonhierarchical coordination (economic perspective) and by taking an organizational and administrative science perspective that network coordination can achieve outcomes equal to those of the market. It is assumed that this approach (network as a form of governance) is more appropriate to the scope of this research, treating networks as discrete forms of governance (based mainly on the studies of Provan and Kenis, 2008).

The coordination levels of network governance can be adopted from a range between a bottom-up process led by the market, at a decentralized level, to top-down strategic decisions made by organizations, at a centralized level (Powell, 1990; Provan & Kenis, 2008; Schüßler et al., 2013). Processes depend on the local and external actors and institutions that comprise the inter-cluster interactions as well as on the cluster's evolution (Sydow et al., 2010). Successful clusters are effective at building and managing a variety of channels to access relevant knowledge and technology through connectivity (Bathelt et al., 2004; Lorenzen & Mudambi, 2013). The central element of governance is to monitor and control the behavior of the coordination levels (or management interventions) in these channels. In this respect, Provan and Kenis (2008) note that network governance can be categorized along two different dimensions: 'brokered' or 'not brokered'. Networks that are not-brokered can be governed by the organizations that comprise the network in a dense and decentralized form. In this dimension, network governance adopts a bottom-up process lead by the market through shared governance. For the scope of this research, it is assumed that the not-brokered dimension has *organic* network governance. In contrast, networks that are brokered can be governed by a single organization, a centralized network broker or a lead organization acting in a centralized manner. In this dimension, network governance adopts strategic decisions made by organizations in a top-down process. Brokered networks can be network-participant governed or externally governed (see, e.g., Schüßler et al., 2013). It is assumed that the brokered dimension is characterized by *coordinated* network governance for the scope of this research. Table 2 summarizes both dimensions of network governance according to Provan and Kenis (2008).

Table 2. Dimensions of network governance (based on Provan & Kenis, 2008)

	Organic **network governance**	***Coordinated*** **network governance**
Forms of governance	Governed by the organizations that comprise the network	Governed by a single organization, a centralized network broker, or a lead organization
Governance system	Not brokered	Brokered
Level of coordination	Dense and decentralized form	Centralized form
Leadership	Shared governance	Participant-governed or externally governed
Processes adopted	Bottom-up process led by the market	Strategic decisions made by organization in top-down process

Based on these distinctions, conditions can be formulated under which each dimension of network governance (organic vs. coordinated) is more likely to be effective. There appears to be no single universally superior or effective dimension; each has its own strengths and weaknesses, leading to different outcomes (Provan & Kenis, 2008). Provan and Kenis (2008) note that between the two dimensions, network members can lead certain activities and responsibilities while leaving others to an organic process. Additionally, a network can generate social controls that are superior to and substitute for governance mechanisms (Powell, 1990). Although there appear to be potential alternatives, the two proposed dimensions can be assumed to address the complexity of governance in cluster connectivity in general (see, e.g., Schüßler et al., 2013) and IBC in particular (see, e.g., Saxenian & Hsu, 2001; Saxenian, 2005; Kuznetsov, 2006; Kenney, Breznitz, & Murphree, 2013). Additionally, one dimension can benefit particular clusters of larger size that are already growing and attracting both local and foreign firm investment. In contrast, another dimension can be effective in particular for small, nascent clusters with limited resource conditions that lack the branding power and the market conditions to attract highly skilled people.

2.4 The case of the Bangalore (IN) - Silicon Valley (US) connection

Bangalore is regarded today as one of the major clusters of IT-enabled services for global business clients across industries (Global Services, 2008; Lorenzen & Mudambi, 2013; Manning, 2013). In fact, approximately 50% of all business services projects of US-based firms and approximately 30% of projects from European clients are sourced from major Indian services hubs, including Bangalore, Chennai and Hyderabad (Hejmen et al., 2011). Services include not only IT and software services but also payroll transactions, insurance and mortgage processing, tax preparation, legal services, medical services, contact centers and analytical services (see, e.g., Zaheer et al., 2009). Despite the growing importance of other service hubs in India, 35% of India's pool of IT service professionals are located in Bangalore. In addition, most major US, European and Indian business service providers, e.g., Infosys, Accenture, and IBM Global Services, are either headquartered or at least located in Bangalore, as are many major IT companies today, including Google, Microsoft and Cisco. Figure 10 illustrates the development timeline of Bangalore.

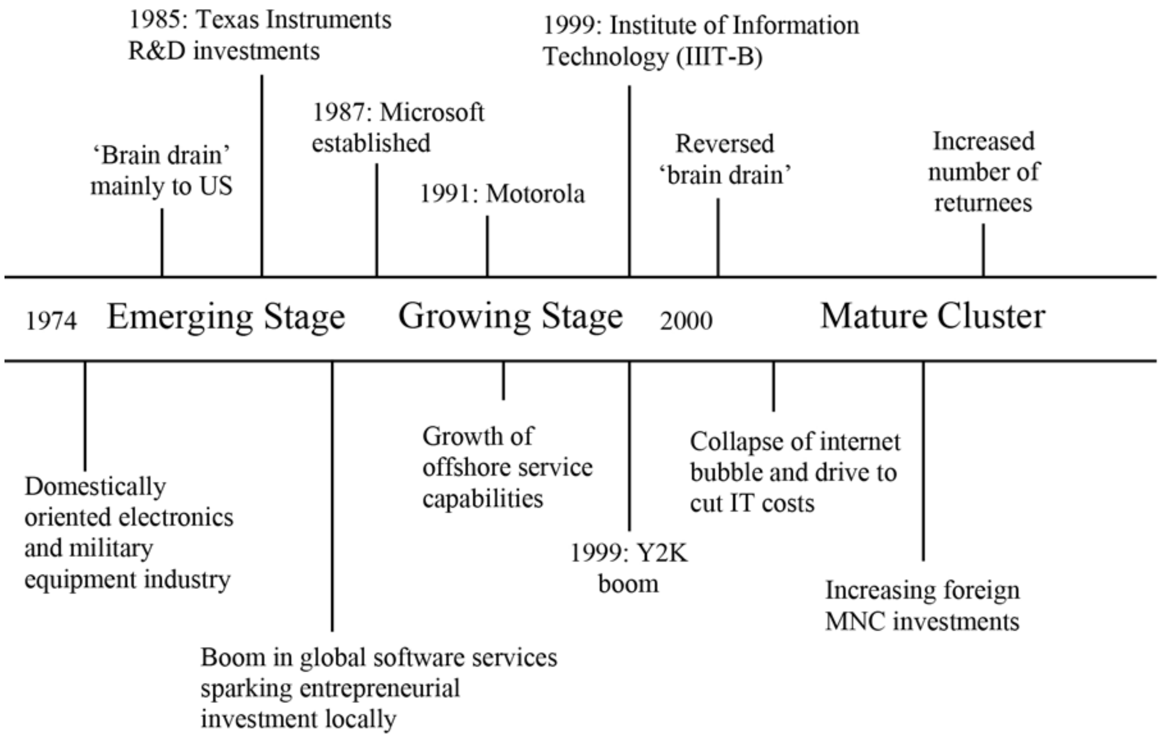

Figure 10. Bangalore development timeline

The growth of Bangalore as a software and IT services cluster is rooted in the combination of a favorable shift in industrial policies and supportive economic conditions during the mid-1980s. Before that time, Bangalore was home to a largely domestically oriented electronics and military equipment industry, and the boom in global software services only started in approximately 1985 (Athreye, 2005). After a failed attempt to substitute imports of hardware and software in the early 1980s, the deregulation of import licensing, a de-coupling of hardware and software policies, falling global hardware prices, and a resulting growing demand for software sparked entrepreneurial investment in software services using a growing local pool of qualified, lower-cost software engineers. Initially, in the early 1990s, programmers were mainly hired onsite by US and UK firms, but subsequently growing service capabilities; an improved local infrastructure, including software development parks;

and reduced global communication and coordination costs, along with the institutionalization of process standards, led to the growth of offshore service capabilities in Bangalore, especially since the mid-1990s (Athreye, 2005; Dossani & Kenney, 2007; Ethiraj, Kale, Krishnan, & Singh, 2005). The so-called Y2K bug generated a further boost of demand for labor-intensive offshore IT services from India (Arora et al., 2001). Since 2000, the service industry in Bangalore has diversified into a range of IT-enabled services, beyond software and IT infrastructure, in response to the growing commoditization of and demand for services across business functions (Athreye, 2005; Sako, 2006).

Throughout this process, MNC linkages to other clusters, in particular Silicon Valley, have been of critical importance (Lorenzen & Mudambi, 2013). Many scholars regard the decision of Texas Instruments in 1985 to invest in research and development (R&D) operations in Bangalore to be the starting point of cluster growth. Driven by the increasing demand for high-skilled, yet lower-cost engineers, many firms, including Microsoft (1987), HP (1989) and Motorola (1991), followed by establishing IT, software and engineering centers. Arguably, these MNCs not only promoted the transfer of technological and process knowledge but also helped improve the local IT infrastructure (Texas Instruments), established collaborative ties with local universities (e.g., Texas Instruments and Motorola), established the Indian Institute of Information Technology, and trained local suppliers to deliver services in line with high-level process standards (e.g., HP). Later, sparked by these early experiments, various other firms, including US and European service providers and high-tech start-ups, established operations in Bangalore and thereby strengthened organizational pipelines to other clusters.

At the same time, research suggests that diaspora networks with Silicon Valley were critical in promoting IBC and cluster development in Bangalore (see Taeube & Sonderegger, 2010; Saxenian, 2005; Arora et al., 2001). Typical patterns of IBC included either the return of India-born, but Silicon Valley-based, entrepreneurs to Bangalore and their investment in firms serving US clients (e.g., Rakesh Mathur, the founder of Armedia, Junglee and Stratify) or the expansion of India-based entrepreneurs into Silicon Valley (e.g., A.V. Sridhar, former senior manager of Wipro). In both cases, entrepreneurs used their Silicon Valley contacts or operations to improve access to markets and capital while expanding their Bangalore operations to access lower-cost skills (Bresnahan et al., 2001; Saxenian, 2005). As a result, these movements not only promoted knowledge exchange between clusters but also the co-specialization of operations in Bangalore and Silicon Valley, thus shaping the way both clusters position themselves in GVCs (Saxenian, 2005).

One very early facilitating factor for Bangalore's diaspora-based IBC was government investments in engineering education starting in the 1950s (Altenburg et al., 2008). The abundance of qualified engineers attracted early foreign investment and continues to drive today's cluster dynamic. However, the lack of domestic demand and production capacity for hardware and software products in the 1980s, as well as the lack of linkages between universities and local firms (Saxenian, 2005), led to an oversupply of engineers in the 1980s (Taeube & Sonderegger, 2010). This, combined with the attractiveness of lower-cost engineers accompanied by a growing demand for software services in the US, stimulated significant 'brain drain', in particular to Silicon Valley, at that time. In the late 1990s, the quota for temporary H1B visas further increased (in response to growing demand and a stagnating number of US engineering graduates), which further accelerated emigration (see also Lewin et al. 2009). In 2000, 124,697 Indian nationals received H1B visa approvals – which amounts to almost 50% of the total quota (Saxenian, 2005). However, Indian migrants maintained close contacts with their home country, facilitated by IT, which helped establish transnational communication channels.

> *"The professional and personal networks linking Indians in Silicon Valley to family members, friends, and colleagues at home combined with access to e-mail and low-cost travel and phones to generate an unprecedented rate of information exchange between the United States and India." (Saxenian, 2005, p. 53)*

Until the late 1990s, most Indians who migrated to the US – either for further education or for job opportunities – did not return to India. Despite cultural 'pull effects', such as the expectation to marry in India, the career advantage of staying abroad prevailed. By the turn of the millennium, however, opportunity structures began to change. First, the demand for lower-cost IT and software services exceeded the availability of visas and jobs in the US, not least based on the rather sudden Y2K bug problem (Arora et al. 2001). The aftermath of 9/11 further limited the availability of H1B visas, including a significant cut in 2003 (Lewin et al., 2009). At the same time, foreign MNC investment in India in general and Bangalore in particular had increased, promoting an improved IT and education infrastructure and increasing career and entrepreneurial opportunities. In addition, venture capital firms emerged that specialized in promoting cross-regional business models – especially linking operations in Bangalore and Silicon Valley (Saxenian, 2005). Over time, the number of Indians returning to Bangalore and other Indian cities increased quite rapidly. Rakesh Matur is an example:

> *"The key constraint to starting a business in Silicon Valley in the late 1990s was the shortage of software developers. I realized that I could go to India. All three of my start-ups had design centers in Bangalore but were registered as American technology companies" (Mathur, 2002, cited in Saxenian, 2005, p. 52).*

Today, we find a situation where, in fact, most entrepreneurs and senior managers at IT services firms with operations in Silicon Valley and Bangalore have an education and professional background in both locations. Talented people have been moving in a two-way flow across the two high-tech clusters. Several businesses have dual headquarters, and continuous communication, travel and movement between these locations has become common practice and an integral part of sustained cluster growth for both Silicon Valley and Bangalore. Lorenzen and Mudambi (2013) argue that these interactions across the clusters have allowed the upgrading of Bangalore over recent decades. In this sense, Bangalore started based on the domestically oriented electronics and military industries in the 1970s in its initial development period, sparked as a high-tech cluster by the 1990s, and saw a rapid expansion period with an increasing number of MNCs and IBC by the 2000s.

2.5 The case of the Hsinchu (TW) - Silicon Valley (US) connection

The Hsinchu-Taipei region of Taiwan (henceforth, Hsinchu) is seen as one of the major high-tech clusters in semiconductors (pure-play foundries and fabless IC design), personal computers (PC), networking hardware and software, biotechnology, multimedia software, and internet-related infrastructure and services (Kenney et al., 2012; Manning, 2013; Saxenian, 1999, 2005; Saxenian & Hsu, 2001; TSIA, 2015). Hsinchu Science-Based Industrial Park (HSP) is located in this region and houses almost all of Taiwan's semiconductor firms, which are integrated in local and global production systems (Chang, 2003; Hung et al., 2004; TSIA, 2015). The Taiwanese semiconductor industry, for example, accounted for 60% of global foundry revenues in 2014, leading the dedicated IC foundry segment of the semiconductor industry (TSIA, 2015). HSP also accounted for 20% of the global IC industry in 2014 (including design, manufacturing, packaging and testing) and was ranked number two worldwide, following the US, as a provider of outsourced global services for IC packaging and testing (TSIA, 2015). HSP firms have continued to aggressively expand production and develop new technologies through an export-driven economy based on high-end technology-based products and services. Since the 1990s, as a large and mature high-tech cluster, many MNCs have established subsidiaries at HSP including, e.g., Philips, D-Link, Foxconn, Acer, Kingston, Applied Materials and Qualcomm. In additional, a number of HSP based-technology firms have expanded their reach to competitive high-end markets and global production systems.

The region started as an agricultural valley in the 1950s, without advanced industries (Han, 2007), and became a high-tech-based cluster by the 1990s (Saxenian, 1999; Saxenian & Hsu, 2001). Following Saxenian and Hsu (2001), three main determinants appear to account for Hsinchu's success. First, the national economic free market allowed high levels of human capital formation, domestic entrepreneurship and market competition in both Taiwan and the US. Second, the activist state acted as a determinant through the intervention of agencies such as Taiwan's Industrial Technology Research Institute (ITRI). Third, arguably, the local geography of production offered the cluster a competitive advantage. Most of Taiwan's high-tech-based industries are geographically concentrated in the 50-mile industrial area linking Taipei to the HSP. This region welcomes many high-tech companies, R&D centers, industry associations and world-class research universities. These are network interconnected, 'generating cost reduction for individuals and increasing returns to the region as a whole' (Saxenian & Hsu, 2001). Moreover, in particular, Saxenian's work (Saxenian, 1999, 2001, 2006; Saxenian & Hsu, 2001) argues that the transnational technical community has bridged Taiwan and the US and that this connection has been key to Hsinchu's success. Transnational technical communities have stimulated the upgrading of Hsinchu by transferring technical know-how and organizational models through close ties to the US (Saxenian, 1999; Saxenian & Hsu, 2001). Policymakers and MNCs rely on these diaspora networks to keep them updated on state-of-art technologies and leading-edge markets in the US (Saxenian & Hsu, 2001). Figure 11 illustrates the development timeline of Hsinchu.

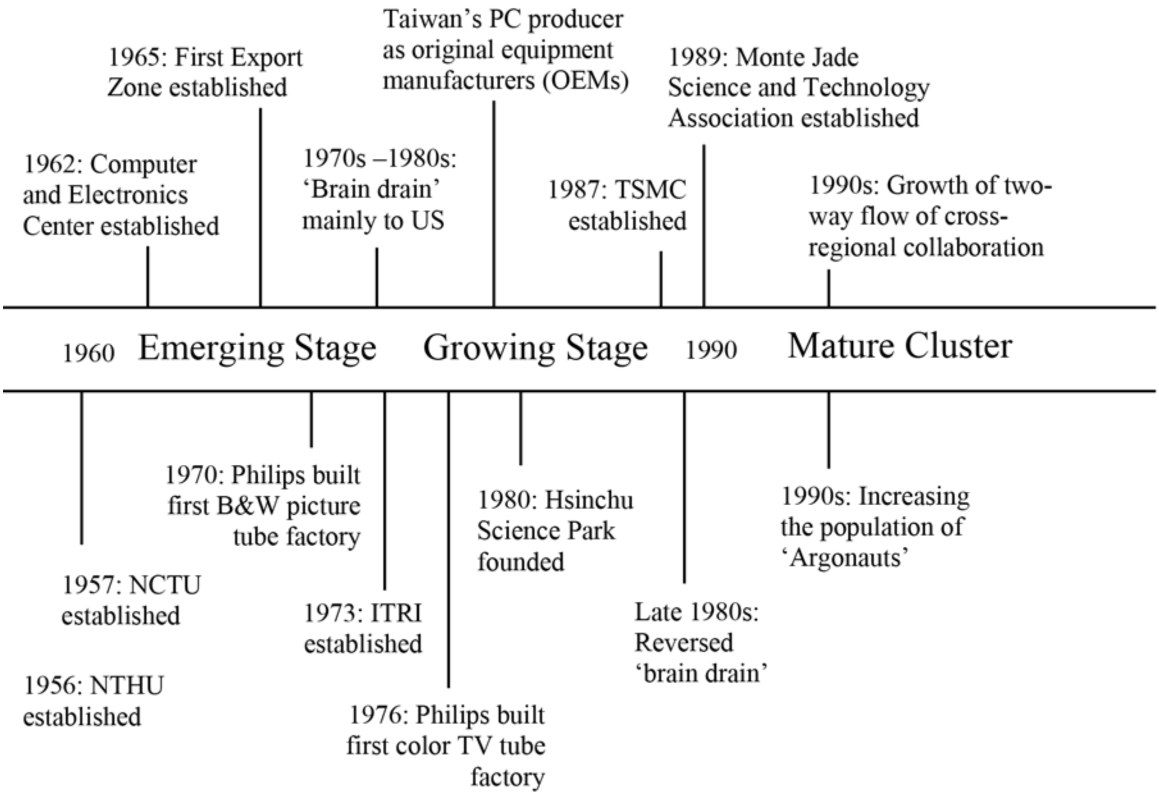

Figure 11. Hsinchu development timeline

The development of Hsinchu started in the 1960s and 1970s as a source of low-cost skills for labor-intensive calculator and later personal computer production (Saxenian, 2005). The campus of National Tsing Hua University (NTHU) and National Chiao Tung University (NCTU) were established in Hsinchu City in 1956 and 1957, respectively. NCTU, in particular, was established to focus on developing the electronics industry for the national economy and defense. This focus created, for example, the Computer and Electronics Center in 1962 by special funding from the United Nations, introducing computer technology, initiating television broadcasting, and manufacturing the first transistors and solid-state lasers at Hsinchu. During the 1960s and 1970s, some high-tech institutes and centers at NCTU were created by public funds (e.g., semiconductor and electronics technology institutes). The education, research and infrastructure commitment was important to improving local capabilities and skills for industrial upgrading (Saxenian, 2005, 2006). Meanwhile, Saxenian (2005) notes that policymakers created local institutions that could promote 'entrepreneurship events' (Shapero, 1984). These entrepreneurship events eventually allowed an industrial shift from local family-based firms to higher-value-added activities in market technology niches in cooperation with industry leaders (Saxenian, 2005; Saxenian & Hsu, 2001). The leading US and Japanese PC companies established Taiwan's PC producers as original equipment manufacturers (OEMs) in their global production system initially by seeking cheap labor (Saxenian & Hsu, 2001). The integration of Taiwanese OEMs into the US and Japanese electronics supply chains later upgraded the cluster through 'organizational pipelines' (Bathelt et al., 2004) by stimulating knowledge and technology creation and diffusion (Saxenian & Hsu, 2001). Local firms expanded their locally produced content from 10% in 1972 to over 30% by 1979, illustrating the improvement of their local capabilities (Breznitz, 2007).

In addition to the OEMs' role facilitating the inflow of updated knowledge and technology for catching-up, US-educated Taiwanese scientists and engineers played an important role in cluster growth. From the early 1960s to the late 1980s, top Taiwanese students in science and engineering completed their undergraduate degrees in Taiwan before continuing their studies in the US and ending up mainly in Silicon Valley (Han, 2007; Kenney et al., 2013; Saxenian, 1999). Many of them chose to remain in the US for better facilities, higher salaries and the intellectual atmosphere (Kenny et al., 2012). This situation created a 'brain-drain' phenomenon because they chose to leave Taiwan to study and work abroad and to not return to their homeland (Han, 2007; Saxenian, 1999). Saxenian and Hsu (2001) note that the number of Taiwanese scientists and engineers who immigrated to the US during this period was impressive and, in particular, expanded dramatically after the Immigration Act of 1965.

> *"Taiwan, like most other Asian countries, was historically limited to a maximum of 100 immigrant visas per year. As a result, only 47 scientists and engineers immigrated to the US from Taiwan in 1965. Two years later, in 1967, the number had increased to 1321. In the 1970s and 1980s, the Taiwanese students in the US accounted for thousands yearly." (Saxenian & Hsu, 2001, p. 901)*

The Taiwanese government made an effort to attract US-educated Taiwanese scientists and engineers to return home during the 1970s and 1980s. Taiwanese policymakers recognized the brain-drain phenomenon and the potential asset represented by these highly skilled people. The government sponsored technical meetings and conferences and recruited engineers either temporarily or permanently to reverse the 'brain drain' (Saxenian, 1999). Saxenian and Hsu (2001) observed that government agencies transferred state-of-art technologies from the US and created a venture capital industry in Taiwan through these interactions. They also developed the HSP[13] based on policy advice from overseas Chinese (Saxenian & Hsu, 2001).

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[13] Hsinchu Science-Based Industrial Park (HSP) was established in 1980 inspired by the Silicon Valley model. The idea was first proposed in 1976 by the former President of NTHU and Prime Minister of S&T, Mr. Shu Shien-Siu. He travelled to the US, Europe, and Japan to learn about National S&T development. The government decided to place the Science Park next to NTHU (the Stanford model from Silicon Valley). Mr. Kwoh-Ting Li, former Finance Minister, made an effort to convince US-educated Taiwanese scientists and engineers to start up companies in Hsinchu. Among those who returned was Mr. Morris Chang, who later led the Industrial Technology Research Institute (ITRI) and founded the TSMC (present Chairman). Mr. Li also introduced the concept of venture capital to the country to attract funds to finance high-tech startups in Taiwan. At present, Hsinchu Science Park (HSP) covers six locations: Hsinchu, Zhunan, Tongluo, Longtan and Yilan parks as well as the Hsinchu Biomedical Science Park, which are located in the northern, central and southern parts of the island. In 2014, all of them combined span a total area of nearly 1,400 hectares, welcome

All of these efforts, combined with the promise of economic opportunity and the desire to return to families and contribute to their home country, resulted in growing numbers of US-educated Taiwanese scientists and engineers returning home.

> *"Approximately 200 scientists and engineers returned to Taiwan annually in the early 1980s. A decade later, more than 1,000 were returning annually. According to the National Youth Commission, by 1998 more than 30% of the engineers who studied in the US returned to Taiwan, compared to only 10% in the 1970s." (Saxenian & Hsu, 2001, p.905)*

Saxenian and Hsu (2001) argue that MNCs alone could not have achieved the combination of local capability building and global integration and that these transnational technical communities helped in this process. Saxenian (Saxenian, 1999, 2005, 2006; Saxenian & Hsu, 2001) argues that transnational technical communities played a central role in cluster growth; however, others (Kenney, Breznitz, & Murphree, 2013) are skeptical about exaggerating their central role in this process during the initial developmental stage during the 1970s and 1980s. Arguably, Kenny et al. (2013) note that even though the returnees played an important role in policy formulation, the central role was played by 'indigenous entrepreneurship and MNC investment, not returnees'. For example, Philips' investments in the Hsinchu manufacturing factories for the first picture tube and the first TV tube in the 1970s allowed the Taiwanese ICT industry to upgrade. Engineers and managers from Philips trained Taiwanese employees in a powerful learning dynamic (Kenny et al., 2012). Philips later provided the initial capital for TSMC[14] (Taiwan Semiconductor Manufacturing Company), becoming an integral part of

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approximately 500 high-tech companies, generate USD 34 billion in total sales, have 2,000 patents approved, and have 152 thousand employees (100 thousand with a higher educational degree including bachelor's, master's and doctoral). (Data accessed on December, 2015 from http://www.sipa.gov.tw/ and https://en.wikipedia.org/wiki/Hsinchu_Science_and_Industrial_Park)

[14] TSMC (Taiwan Semiconductor Manufacturing Company), founded in 1987 by Mr. Morris Chang, is the world's largest dedicated independent (pure-play) semiconductor foundry. Its headquarters and main operations

the Taiwanese high-tech industry (Kenney, Breznitz, & Murphree, 2013). This is one of the examples that illustrate the central role of MNCs in stimulating cluster upgrading by mobilizing technology, skills and capital.

By the late 1970s and in the 1980s, the state played a more activist role in the rapid expansion of Hsinchu. After the OEMs built network ties with foreign firms in the 1970s, supplying components for consumer electronics MNCs, local companies were prepared to make parts for and assemble personal computers. The Taiwanese government opened the consumer electronics industry to global competition, forcing Taiwanese firms to search for new business opportunities (Kenny et al., 2012). This rapid and deep expansion helped Hsinchu take off as a high-tech cluster by the 1990s. The transnational community of US-educated Taiwanese scientists and engineers shifted from a one-way flow to a growing two-way flow of cross-regional collaboration during the 1990s (Kenney et al., 2013; Saxenian, 2006). These talents were attracted to return home to seek new opportunities available through rapid economic development. For example, HSP became a destination for hundreds of returnees annually, who started new companies and ventures (Saxenian & Hsu, 2001). Because the HSP was located next to world-class research universities and technology institutes (such as NCTU and ITRI, respectively), the returnees were attracted to the western-style innovation ecosystem. Taiwan's government also offered a 'range of fiscal incentives for qualified technology investments, provided returnees with preferential access to scarce, high-quality housing and to the only Chinese-American school in Taiwan' (Saxenian & Hsu, 2001).

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are located in the Hsinchu Science and Industrial Park in Hsinchu. The total revenue of the company was approximately USD 20 billion in 2013, with approximately 28 thousand employees. (Data accessed on December, 2015 from http://www.tsmc.com/)

In addition, the new dynamic and the rapid expansion of Hsinchu by the 1990s resulted in a IBC process, growing the population of ‘new Argonauts’ (Saxenian, 2006) who worked in both Hsinchu and Silicon Valley and travelled between the regions once or even twice a month (Saxenian, 1999). These new Argonauts bridged a cross-regional economy and generated social collaboration between the two regions in a relationship supported by close communication, joint problem-solving, and trust interactions (Saxenian & Hsu, 2001). The Argonauts worked closely with the Taiwanese returnees and US-based scientists and engineers, allowing distant producers to upgrade their local capabilities and to become integrated in global production systems. These social ties were institutionalized in 1989 by establishing the Monte Jade Science and Technology Association (Saxenian, 1999). This private association has close network ties to the government and aims to promote business cooperation, investment, and knowledge and technology transfer between Silicon Valley and Taiwan. By 2000, for example, there were approximately 9,000 US-educated Taiwanese scientists and engineers working in Silicon Valley, the majority of whom arrived prior to 1990 (Saxenian & Hsu, 2001). These IBC dynamics are illustrated by survey data from Saxenian and Hsu (2001).

> *“Silicon Valley’s Taiwanese engineers and scientists continue to travel to Taiwan regularly (7.3% travel to Taiwan more than five times a year for business purpose, 22% travel between two and four times a year). The great majority (85.3%) have friends and colleagues who have returned to Taiwan to work or start a company, with 15.8% reporting more than 10. They regularly exchange information with friends and colleagues in Taiwan about technology and about job opportunities in both locations. More than one-third (38.9%) have helped to arrange business contracts in Taiwan, one-quarter of them (24%) have served as advisors and consultants for Taiwanese companies, and one-fifth (19.2%) have invested their own money in start-ups of ventures funds in Taiwan. Many have caught the Silicon Valley bug as well, with 58.8% reporting that they plan to start their own business in the future, and 50% that say they would consider locating their business in Taiwan.” (Saxenian & Hsu. 2001, p. 916)*

The reciprocal connection between Hsinchu and Silicon Valley is seen as a complementary and mutually beneficial relationship (Kenney et al., 2013; Saxenian, 1999, 2006; Saxenian & Hsu, 2001). The decentralized industrial system of Hsinchu allows flexibility and supports the innovative capacity of the cluster members, protecting them in the volatile high-tech market environment (Saxenian, 2006). IBC has contributed in these markets through a complex mix of interactions between Argonauts, US-educated Taiwanese scientists and engineers and US-based scientists and engineers. Their formal and informal collaboration has contributed to individuals (such as entrepreneurs, SMEs and MNCs) and to the cluster as a whole on both sides of the Pacific (Saxenian, 2006).

3 EXPLORATORY STUDY: SINOS VALLEY – KOREA CONNECTION

The main goal of this empirical exploration is analytical generalization from the case findings (Yin, 2009), including the development of propositions for further validation. The first section of this chapter defines the data and research method of this exploratory study. The findings of this study are illustrated in the second section. Based on the theoretical framework (including both prior case studies) and on this exploratory study, the third section develops propositions for validation in the subsequent case study.

3.1 Data and research method

The prior cases of Bangalore and Hsinchu and their connection with Silicon Valley have been utilized numerous times to better understand the preconditions and dynamics of cluster growth (Bresnahan et al., 2001; Kenney et al., 2012; Lorenzen & Mudambi, 2013; Reddy, 1997; Saxenian, 1999; Saxenian & Hsu, 2001). Both cases aimed to analyze the role that returnees and 'brain circulation', especially connections with Silicon Valley, have played in cluster development and the role that governance played in this process. An opposing case was then selected (Eisenhardt, 1989) – a rather small and nascent cluster –to stimulate theorizing around the similarities and differences in IBC across these cases. More concretely, based on access to empirical data, 'Sinos Valley' in Brazil, with its connections with Korea, was selected as an example of a small and nascent cluster for an exploratory case study. Unlike the prior cases, most data used for this case were based on original data collection, including interviews with local representatives in both countries (as a primary data source), a database of students in exchange programs, government policies and other documentation (as secondary data sources).

The study was divided into three steps aiming to explore (i) the evolution of the semiconductor industry in Brazil, (ii) the development of Sinos Valley, and (iii) IBC between Sinos Valley and Korea. The first step mapped the evolution of the semiconductor industry in Brazil, finding that even without a policy strategy supporting cluster formation, semiconductor initiatives have been agglomerating geographically through a bottom-up process in Brazil. One of these agglomerations is in Southern Brazil, in particular in the Sinos Valley region. Having identified this region, its history was explored in the second step to better understand its trajectory. Based on this work, the third step identified the atypical connection between Sinos Valley and Korea.

3.1.1 Data sources

Initially, to explore the empirical field of this research, an open and in-depth interview strategy was employed. The primary sources came from in-depth interviews. The interview questions were basically related to the three steps of this exploratory study: (a) the evolution of the semiconductor industry in Brazil, (b) the development of Sinos Valley, and (c) IBC between Sinos Valley and Korea. The respondents were selected based on their involvement and leadership in cluster formation and in IBC between the two countries. Local representatives of the government, universities and companies in both countries were interviewed, as presented in table 3.

Table 3. Respondent's profiles from the exploratory study

Number	Job position	Age	Education level	Place of degree	Unit of context
1	President of UNISINOS	67	PhD	Pontifical Gregorian University; Italy	University
2	CEO of HT Micron, Executive Member of BOD of PARIT Group	60	MS	Federal University of RS, Brazil	Company
3	CEO of Hana Micron, Chairman of BOD of HT Micron	66	PhD	Korea Polytechnic University; Korea	Company
4	CFO of HT Micron, Former CFO of HANA Micron	45	MS	Dankook University; Korea	Company
5	CTO of HT Micro, Former Director of Strategic Planning of HANA Micron	49	BS	Han Yang University; Korea	Company
6	CIR of HT Micron	50	MBA	UNISINOS University; Brazil	Company
7	Manager of Technology of HT Micron	42	BS	Rensselaer Polytechnic Institute, US	Company
8	Former head of S&T division of Brazilian embassy in Korea	38	PhD	KAIST, Korea	Government
9	Dean of Engineering School of UNISINOS	51	PhD	University of Manchester; UK	University
10	Former CEO of Development Bank of RS State	45	MS	University of Caxias do Sul; Brazil	Government
11	Former President of Gsell at Brazil	56	BS	Chung-Ang University; Korea	Company
12	Exchange Student	25	Student	UNISINOS University; Brazil	University
13	Exchange Student	27	Student	UNISINOS University; Brazil	University
14	Exchange Student	23	Student	UNISINOS University; Brazil	University

The interviews were conducted personally, and the data were collected through personal notes, and later quotes were collected through email exchanges. This study took one and a half years (from early 2013 to the middle of 2014). Contributions must be highlighted from members of the Brazilian Embassy in Korea, the Korean Embassy in Brazil, the State Development Secretary of Rio Grande do Sul, the universities' international affairs offices (mainly UNISINOS), faculty members who participated at the Brazil & Korea International Forum at UNISINOS, members of the International Presidential Forum at KAIST, and a semiconductor industry specialist; these resources also provided important information through informal conversations[15] and archival data. All of the archival data such as reports on the output of the exchange programs, videos, news and reports were used as secondary sources of evidence. In addition, it is important to note that the main author of this study had the opportunity to actively observe[16] the relationship between Sinos Valley and Korea (since its launch in 2010), and I was also able to visit other high-tech clusters[17], giving him a broad understanding of the research subject.

3.1.2 Data analysis

In terms of data analysis, the main focus was on the preconditions and effects from the movement of entrepreneurs and professionals as clusters developed over time as well as the way in which these movements were stimulated by policies and governance attempts. It is further paid attention to the interplay of individual and organizational, local and global ties as well as potential linkages across sectors, for example, private sector, government and universities. This analysis allows an arrival at the two potentially generic forms of IBC governance – *organic* process and *coordinated* effort – which differ not only in terms of their

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[15] The many people with whom I had informal conversations are not included in table 3.

[16] The main author of this research was able to observe the relationship between Sinos Valley and Korea during this period (2010 – 2014) through three main activities: (a) business trips to Korea to strengthen and promote collaboration between Brazil and Korea in the ST&I fields. Starting in 2010, He made fifteen trips to Korea, helping to develop a broad understanding of cluster and IBC dynamics in Korea; (b) his job positions at UNISINOS, which allowed him to better understand the IBC dynamics between both countries; and (c) participation in the bi-lateral ST&I meetings between Korea and Brazil.

[17] In addition, during the same period (from 2010 to 2015), the main author of this research made several business trips internationally. In particular, he had the chance to visit high-tech clusters such as Silicon Valley (US), Haifa (Israel), Hsinchu (Taiwan), Bangalore (India), Medical Valley (Germany), Route 128 (US), Manchester (UK), and (of course) Daedeok Innopolis (Korea). All of these activities and trips supported his own broad understanding of cluster development and the role and dynamics of IBC.

own dynamics and the role of governance but also in how/the extent to which they apply to our main cases. Next, these forms of IBC governance are discussed in detail. Following this analysis, theoretical propositions are developed for further validation in the case study of Daedeok.

3.2 Findings from the exploratory study

Sinos Valley in Southern Brazil marks an ambitious attempt to establish the rather knowledge-intensive semiconductor industry in this region without prior industry experience, with a limited labor pool, with no prior related foreign MNC investment and non-existent branding power. This case needs to be considered in the context of a recent industrial policy push at the national level toward the development of the semiconductor industry in Brazil. The semiconductor industry (design and production) is geographically concentrated in a few regions of the world (Byun, 1994; TSIA, 2015). Countries such as Korea, the US, Taiwan, China and Japan hold more than 90% of the global market share of semiconductors. Asia currently leads with approximately 60% of the market share (TSIA, 2015), becoming the leader after the 1980s. In this global scenario, the Brazilian industry's market share is barely noticeable. The global semiconductor market has shown high levels of growth (more than 15% on average annually, considering data from 1976 to 2014), and the total global revenue of the industry in 2013 was 303.3 billion USD (SIA, 2015).

Although the Brazilian semiconductor industry has an insignificant global market share, Brazil has one of the largest end markets for electronics and semiconductors. Brazil is among the world’s top four markets for computers, cell phones and technological applications, such as in the automotive and medical areas (Ministry of Science, Technology and Innovation - MCTI, 2013). Semiconductors, mainly integrated circuit (IC) components, are in nearly all of these electronic products. Because there are few enterprise initiatives in the Brazilian semiconductor industry, there is no national production to cover the Brazilian market. This situation reflects a large trade deficit in semiconductor products (approximately 20 billion USD in 2013, according to ABINE).

Brazil has taken different approaches over time to develop its semiconductor sector. First, between the 1930s and the 1980s, Brazil adopted a protectionist policy with market barriers that resulted in low productivity and a large technological gap in the semiconductor industry (Campanario, Muniz, & Costa, 2009). These market barriers were lifted suddenly in the 1990s. At that time, the government believed that a liberal market (e.g., no restrictions on imported IC components) could attract foreign investment and consequently transfer technology to national industry development. However, the weakness of the Brazilian national innovation system was that it did not support the national industry, which was faced with the entrance of competitive foreign products with updated technologies. As a result, most of the enterprise initiatives in Brazil broke down (Campanario et al., 2009). At the same time, the import barriers (created in the 1960s) were reduced for the entrance of foreign technology in the 'free economic zone' in Manaus. Based on this incentive, the free economic zone attracted a large number of electronic enterprises (e.g., computer assembly plants) by offering them the opportunity to import updated semiconductor components at competitive costs (by reducing import taxes). Brazilian companies essentially stopped purchasing national technology (see IC components) and started purchasing foreign technology. Most of the domestic semiconductor business vanished at that time.

After that period, in early 2004, the Brazilian government launched the 'Industrial, Technological and Foreign Trade Policy' (PITCE) along with a number of other programs, all of which reflected the government's renewed interest in promoting the semiconductor industry (along with other selected sectors) through interventionist policies. These policies aimed to promote R&D investments locally by providing tax incentives to companies. These initiatives focused mainly on four areas: the Porto Alegre metropolitan area, São Paulo, the Belo Horizonte metropolitan area and Recife. Arguably, some of these regions, particularly São Paulo, benefited from these policies mainly as an 'add-on' to prior related clustering and size effects and the resulting competitive advantages. For example, even prior to these policies, São Paulo benefitted from the availability of highly skilled human resources, R&D investments, infrastructure, and specific policies on the state level. By contrast, other regions, such as the Porto Alegre and São Leopoldo areas, were rather disadvantaged due to a relatively smaller talent pool and a lack of prior related foreign investment. A certain combination of federal and state policies, along with the strong presence of related university training programs, would eventually make up for these disadvantages and help the region become what local actors would call 'Sinos Valley'.

3.2.1 The co-evolution and development of Sinos Valley

Sinos Valley is located in the state of Rio Grande do Sul (RS) in Southern Brazil. It started in the late 1960s as a shoe manufacturing cluster (Schmitz, 1999). Mostly small and midsize local firms produced initially for the domestic market and later on a larger scale for US buyers. The integration into the US footwear value chain facilitated the upgrading of Sinos Valley in this sector (Humphrey & Schmitz, 2002) and led to the growth of the cluster until the late 1980s, generating more than 500 jobs. In the early 1990s, Chinese producers undercut Brazilian products in the US market, which led to a sharp decline in the price of Brazilian products. This move affected more than 80% of the output of Brazilian producers and stopped 40% of their exports (Humphrey & Schmitz, 2002). However, Sinos Valley continues to be an important national production hub for shoes with an export-oriented strategy.

Since the early 1990s, the IT industry has become an important sector in Sinos Valley. This industry has grown by more than 10% per year over the last decade in the region (Fochezatto & Grando, 2008). More than 1,500 enterprise initiatives have generated approximately 35,000 jobs in RS (AGDI, 2014). Sinos Valley, including Porto Alegre and its metropolitan area, hosts more than 70% of all initiatives (Fochezatto & Grando, 2008). Most of them are located in regional technical parks, such as TECNOPUC, TECNOSINOS and VALETC. These parks have become important local innovation hubs within global value chains because they host several foreign MNCs, such as SAP in TECNOSINOS and Dell and HP in TECNOPUC. In addition, universities associated with these technology parks (PUCRS, UNISINOS and FEEVALE) and others in the state (such as the Federal University of RS - UFRGS) have graduated approximately 700 new students per year at all levels of IT knowledge (both undergraduate and graduate). However, despite the high number of graduates, the state of RS and Sinos Valley in particular have suffered from a limited availability of talent. The main reason is brain drain: graduates seek new opportunities in more metropolitan Brazilian states and abroad. State initiatives have not been able to retain talent or to attract it back.

Unrelated to developments in the shoe and IT clusters of Sinos Valley, policy efforts have been made by both the federal government and regional players to establish the semiconductor industry in the region. Although this cluster initiative could build on existing capabilities, resources and initiatives to a degree, one objective was to avoid prior mistakes. First, efforts were needed to make local employment less dependent on a volatile global competitive market (such as shoe manufacturing). Second, measures needed to be put in place to prevent harmful brain drain (such as in IT).

One starting point was the national ‘Semiconductor Industry Development Support Program’ (PADIS), which started as part of the Industrial, Technological and Foreign Trade Policy (PITCE) in 2004. Part of this program has involved a zero tax policy for local enterprise initiatives with a mandatory and minimum local R&D investment of 5% of total revenue (a minimum of 1% must be invested outside of the company). Based on this, in 2008, the federal government decided to place CEITEC (a public semiconductor company linked to the Ministry of Science, Technology and Innovation - MCTI) in Porto Alegre. CEITEC develops integrated circuit design and wafer fabrication for RFID (radio frequency identification), sensors and digital TV technologies. It is a network linked to the Federal University of RS, UFRGS. Additionally, PUCRS and UNISINOS, both local private universities, launched semiconductor initiatives. For example, UNISINOS hosts the Semiconductor Technological Institute (ITT Chip) and the research program in electrical engineering with an emphasis on the packaging and testing of semiconductors. The former IT technology park (presently TECNOSINOS) has also become an important platform for new corporate and research initiatives. Of particular importance is HT Micron, a joint venture located at TECNOSINOS between the Korean firm HANA Micron (a spinoff of Samsung) and the Brazilian group PARIT, which focuses on industrial-scale production of the packaging and testing of semiconductors to supply the domestic market. When HT Micron started in 2010 (in São Leopoldo city), UNISINOS and the state government launched a strategic alliance with Korea to foster ST&I collaboration. This alliance formed important infrastructure for brain circulation between Sinos Valley and Korea.

3.2.2 Coordinating Inter-Cluster Brain Circulation between Sinos Valley and Korea

The alliance between Sinos Valley and Korea has evolved on multiple levels. Even before the alliance between HT Micron, UNISINOS and Korean partner universities, the Brazilian and Korean governments had a joint interest in developing the science and technology (S&T) capabilities of their countries. In fact, in 1991, a national S&T cooperative agreement was signed that became the foundation for several high-level meetings, institutional-level agreements, research partnerships, and projects (see Fink, Hameed, So, Kwon, & Rho, 2012; Fink, 2013). Both countries were seen as equal in terms of economic development in the 1980s. However, Korea has progressed much more rapidly, from a mostly agriculture-based country in the 1950s to an international high-tech competitor in the 2000s. As a result, the bilateral relationship between Brazil and Korea has been inversely specialized. Whereas Korea is now on the edge of nanoscience and technology as well as engineering, computer and material sciences, Brazil's attractiveness to Korea has involved its market potential for Korean manufacturers (see also Fink et al., 2012; Fink, 2013).

The collaboration between Sinos Valley and Korean partners began in 2010 when the HT Micron Joint Venture was launched at TECNOSINOS between the Korean firm HANA Micron and the Brazilian group PARIT. Today, this collaboration involves activities at multiple levels, including firms, universities and governments. These activities include institutional missions and business matchmaking (promoted by governments); business development, transfer technology, and joint projects (promoted by firms); and institutional missions, business development, exchange programs (both undergraduate and graduate), and scientific forums (promoted by universities). All of these activities attempt to build a strategic alliance between these three sectors at the local and global levels in an effort to overcome prior mistakes in the development of local capabilities and including local industry in the global production system as the president of UNISINOS points.

> *Firstly, we need to become aware of our local incompetence in terms of technological innovation and thus develop the competences needed to promote a high tech cluster in Sinos Valley. Secondly, try to understand how South Korea has inserted itself in major global production arrangements in order to understand the strategic mistakes made by Brazil that have excluded it from these arrangements and consequently take positive action to overcome those mistakes. Thirdly, to be known and to know leaders who can build good partnerships with us. [Brazilian, President of UNISINOS]*

The first meetings began in 2009 when the CEOs of PARIT and HANA Micron collaborated to start a business project to realize market opportunities in the semiconductor industry in Brazil. Based on the technological experience of the Korean CEO (first generation of the semiconductor industry in Korea with a Samsung background) and the market and business experiences of the Brazilian CEO (senior businessman in the IT and automation industries), they decided to start a 'fifty-fifty' joint venture. At that time, each visited the home country of the other to start the business development plan for the Brazilian joint venture. This beginning led to several personal interactions that planted the seeds of a trust relationship, as the CEO of HT Micron notes:

> *The great decision to go further in developing an integrated circuits business was taken during my first trip to South Korea, when I met a person who was new in my network. His company was a source of knowledge, and he was willing to be a partner in the Brazilian project. From then, several business trips increased the range of relations and created a network which allowed the development of the project. [Brazilian, CEO of HT Micron]*

After a national bidding process, in early 2010, a memorandum of understanding (MoU) was signed between the company (HT Micron), TECNOSINOS (technology park), UNISINOS (university), and the municipality (government). The scope of this MoU was to place a semiconductor manufacturing plant in TECNOSINOS that was supported by special incentives from the municipality and the state (such as local tax incentives) and a differentiating business model with UNISINOS. This model was based on the PADIS policy (federal level), in which UNISINOS would build clean room facilities to host the company´s manufacturing line (through a rental contract) and would support the company's R&D investment in the long term (through an R&D contract). R&D investment would be made through a training program, applied research, and technology service and development. The CEO of Hana Micron shared his enthusiasm about this win-win partnership:

> *The most valuable asset of a business is its employees. For that, HT Micron´s partnership with UNISINOS is priceless for both of us. We have outstanding students from UNISINOS to work at HT, and HT can help UNISINOS with R&D projects. It is a win-win strategy, and, very fortunately, UNISINOS´ President and I share the same vision. [Korean, CEO of Hana Micron and Chairman of BOD of HT Micron]*

Later in 2010, UNISINOS decided to further promote collaboration through an S&T plan with Korean universities. The idea was to foster the university´s internationalization plans through student and faculty exchange programs, joint research and business projects. To promote this concept, the university president and board members met with several representatives of Korean universities, such as KAIST (Korean Advanced Institute of Technology), SKKU (Sungkyunkwan University), SOGANG University, KIST (Korean Institute of Science and Technology), and Hongik University. Furthermore, also in 2010, it was decided to transfer clean room technology from Korea to Brazil to build the HT Micron manufacturing plant. The Brazilian and Korean embassies played an important facilitating role in this process, not least by helping the partners understand each other's language, cultural norms and institutional protocols.

In 2011, a group of six of UNISINOS' leading faculty members spent one semester at SKKU and SOGANG universities. Based on that experience and another project led by the university´s president, they decided to host an international scientific forum and to develop a dual master's degree program in electrical engineering in semiconductors (packaging and testing) and a technological institute of semiconductors (ITT Chip). The master's degree has a dual degree program in partnership with SKKU in Korea, and ITT Chip has strong federal support (investment of approximately 8 million USD by a non-refundable fund from the Ministry of Science, Technology and Innovation). The dean of Engineering School of UNISINOS offered his perception of the challenges to the university and the region in this particular high-tech knowledge area. He stated that it was possible to develop a minimum level of trust during these interactions to further develop the region:

> *… It is important to note that being a new knowledge field for UNISINOS and extremely developed in countries like Korea and the US, our efforts to create this area of knowledge have been very big … there is a local lack of human resources at the master's and doctoral levels … a lack of infrastructure, which is extremely expensive to be sustained ... but, after 5 years, we have two masters who graduated in this area already acting as researchers in ITT Chip, maintaining partnership with Korea, opportunities to send master's students, faculty and graduate students to top universities there, and even participation in events of the semiconductor packaging area as speakers. Thus, winning the trust of the international partners also involves a slow conquest, and let's say this trust relationship has advanced enough until this moment. There is a long way to go; it requires a lot of effort, focus, and patience from the university to the maturation of human resources in this area. [Brazilian, Dean of Engineering School of UNISINOS]*

In late 2011, the state´s governor led a parallel mission to promote new investments, establish institutional contacts, and learn about Korean industrial and technological policies. A record number of 74 representatives spent ten days in Korea, which was an important stepping stone in the further development of the semiconductor industry. Some of the key policy makers of the RS state were part of this mission and later exchanged information with Korean policy makers regarding the creation of semiconductor policy. In addition to these activities, HT Micron started a transfer technology process from HANA Micron to a pre-operation plant at UNISINOS. This pre-operation plant was housed in a building located in the technological institute area at UNISINOS and aimed to start the operation of smart chip products (low technology). The CFO of HANA Micron was expatriated to Brazil, and a Korean management company was hired to manage the clean room construction. The CFO of HT Micron shared his perception of this stepping stone in developing the business:

> *HT Micron started as a start-up company, and in 2012, UNISINOS provided the building of our first small factory, as we called 'BASECAMP', which was remodeled from an old traditional building to a clean room facility plant. In parallel, UNISINOS provided financial and construction support to our main building with world-class clean room technology. I believe that only with this kind of win-win enterprise partnership we can be successful. This partnership could be a good model for innovation. [Korean, CFO of HT Micron and Former CFO of HANA Micron]*

In 2012, the Brazilian federal government launched the Science without Borders program (SwB). This program aims to strengthen the national innovation system by promoting the international exchange and mobility of talented students (at both the undergraduate and graduate levels). Since the program was launched, it has supported more than 75,000 students (SwB website, 2014). Although most of these students went to US and UK universities, 450 went to Korean universities (2012 - 2014). Most of the students who went to Korea combined both academic and work experiences. HANA Micron, for instance, opened its doors to the Brazilian students for an internship experience, including the packaging and testing of semiconductors. Other Korean companies followed suit, such as Hyundai Motors, Samsung Electronics, POSCO Steel and Hyundai Elevators. The association between academic and internship experiences has been referred to by the students as 'added value' in their careers.

Both of these opportunities involved tremendous engagement with the Brazilian Embassy in Seoul, as the former head of S&T division of Brazilian embassy in Korea noted:

> *The connection between the business and the academic environment seems to be a motivating factor in the mobility of students (still very absent in Brazil). Undoubtedly, it favors the company with more access to well-skilled professionals. …. A relevant point was the partnerships with the Brazilian Embassy in South Korea, which has been very engaged in the organization of the internships in South Korean companies for all the students during the periods of academic summer and winter vacations. [Brazilian, former head of S&T division of Brazilian embassy in Korea]*

This model was adopted by HT Micron and UNISINOS and combined academic and internship experience locally and internationally. Hence, a student from UNISINOS could apply for a scholarship (through an internal call) to have an academic experience in Korea followed by an internship experience in Korea (for a total of one semester) and could have an internship or advanced career opportunity when he/she returned to Brazil at HT Micron. The student could replace his/her curriculum grades with academic and internship activities. This program (called the 'HT scholarship') is supported by private R&D funds at both the undergraduate and graduate (master's) levels. Two students shared their international experiences in this program:

> *I could go through the challenges of being part of a big global company, of a worldwide research center and of an academic population of a top university in the global scenario. These three experiences brought me a different perspective from what I had ever imagined before. Actually, I never thought I would be here at only 22 years old, given the opportunity to prepare myself better for the challenges yet to come. It is still difficult to measure the direct effect, but the self-confidence of wanting to go further and higher definitely came together with this experience in Asia. [Brazilian, exchange Student]*

> *The experiences I have gained in Korea contributed directly to my career because during the period in that country, I had the opportunity to have an internship at Hana Micron … They showed me the entire semiconductor packaging process, the technologies employed in a hands-on experience. In addition, the Samsung company also contributed to show the exchange students its semiconductor manufacturing plant. After this international experience, I became an employee in*

the new products and semiconductor packaging technologies division at the local company. [Brazilian, exchange Student]

Based on these initiatives, Sinos Valley has been able to attract more Korean firms and professionals. The construction of HT Micron´s manufacturing plant was completed in late 2013. The Korean managing firm, along with a local partner, transferred the clean room technology with an international quality standard at competitive costs. HT Micron also started technology transfer for other products, such as DRAM memory and NAND flash memory with SiP (System in Package) high technology. A large team of highly qualified engineers was involved. Korean engineers came to Brazil to set up equipment, transfer tacit knowledge, and train local engineers, and Brazilian engineers went to Korea to gain hands-on experience. These exchange activities facilitated the transfer of knowledge, not least because language barriers would have constrained formal transfer. Engineers, CEOs and companies were embedded in a learning process and began to build pipelines between both countries through regular meetings and through the exchange of both codified and tacit knowledge. Although this first stage of the business and partnerships were successful, there were some local constraints to attracting senior professionals to further develop the business as well as the cluster. An American shared his positive and negative perceptions since his arrival from the US to work at HT Micron as a senior technological professional, and an Korean shared his perception of the local infrastructure since his arrival from Korea to Sinos Valley as a permanent senior technological executive (CTO position).

Regarding the attractiveness of the cluster, like any place, there are positive and negative perceptions. As positive points: (a) multiple companies in the semiconductor / IT technology sector are here (HT, SAP, CEITEC, Dell & HP at PUC, Dell in Eldorado do Sul). For example, I am working at HT Micron, and my wife is working at CEITEC in the lithography process area. (b) UNISINOS and UFRGS both have programs related to semiconductors and are offering both fresh talent and continuing education opportunities. My wife is working on her PhD at UFRGS, HT Micron has 4 engineers completing the master's program *right now, and we are sending students and trainees to Korea to learn the industry using the strong ties developed by HT Micron and UNISINOS. As negative points: (a) quality of life (safety, traffic, etc.) does not compare to a cluster in the US, such as Austin or upstate NY, or in Germany, such as Silicon Saxony. (b) While it is getting better, we are still very isolated here professionally (to participate in a JEDEC conference or semiconductor event, you must travel to a different continent or state. This November will be the second semiconductor event in South America in Rio, but there has never been one here in the Rio Grande do Sul. (c) Dependence on the protected market drives the industry here much more than global technological trends. [American, Manager of Technology of HT Micron]*

Not much experience in Sinos Valley because I stay in the office every day and go back to my house in Porto Alegre city … Frankly speaking, Sinos Valley is not prepared for foreigners. There are so many things to improve. (a) Safety: this is the first factor for foreigners to decide the location of housing ...; (b) Education: even though there is an international school for my kids, the tuition fee is too high; (c) Health care (hospital): it would be attractive if a hospital in São Leopoldo could support foreigners, for example, through language support, at least English; (d) Entertainment: the capital city of Porto Alegre is a much better place for going to shopping malls. I think São Leopoldo needs to differentiate from shopping in Porto Alegre. Like Korea, big cities have many good shopping malls downtown but not good entertainment places because of the high price of the land. So small cities near big cities like São Leopoldo that have a lot of land at a low price need to invest in specialized entertainment items such as resorts, activity parks, amusements, festivals … to attract people and foreigners. [Korean, CTO of HT Micron and former Director of Strategic Planning of HANA Micron]

Interactions at the university and government level also increased during these years. For example, there have been other faculty and student exchanges. Students received support from the SwB program, the HT scholarship program, and summer programs. Additional international scientific forums occurred at which several Koreans met their Brazilian counterparts to exchange knowledge and develop joint research projects. At these forums, Korean and Brazilian government representatives also became involved in interactions. The UNISINOS president led yearly institutional missions to Korea, and the SKKU president, in return, launched the first institutional mission to Sinos Valley in 2014. UNISINOS opened a Korean language course in 2012 led by a native teacher supported by the Korean government, and more than two hundred students applied for the first course. UFRGS also offered a language course to teach Portuguese to Koreans. Government activities included institutional meetings in both countries (mainly to promote new S&T opportunities) and matchmaking between Korean and Brazilian entrepreneurs, some of which resulted in the start-up of new companies. A local senior policy maker summarized the main outcomes of all of these interactions over this period (2010 – 2014):

> *The fact that HT Micron enhances the interaction with South Korea - one of the most important countries in the high-tech industries – stimulates this cluster in technological upgrading, both from a personal and an organizational point of view—in technological transfer, mainly due to UNISINOS' prominent role, the flow in both directions of executives and academics who participate in several activities, and including the region in the minds of Korean entrepreneurs as a natural candidate for new Korean investments in Brazil. [Brazilian, Former CEO of Development Bank of RS State]*

The success of the still rather young IBC initiative in Sinos Valley is also reflected in numbers. Over the last five years (2010 – 2014), 393 highly qualified people benefited from various exchange programs between Sinos Valley and Korea. Of these, 57% traveled from Brazil to Korea, and 43% traveled from Korea to Brazil. Most of them came from the university (56%), followed by company staff (22%) and government representatives (21%). Initially, in 2010, HT Micron and the first UNISINOS mission supported the exchange of only 17 high administrative members between both countries. In 2011, this number rose to 123 thanks to the development of the RS mission in Korea. Most exchanges occurred in 2012 (156) and 2013 (137), including student and faculty programs, forums, business activities, cleanroom construction, the establishment of line production equipment, and institutional meetings. Table 4 shows the total number, frequency and length of stay of the exchange participants at all levels.

Table 4. Talent mobility between Sinos Valley (SV) and Korea (KR) per year

IBC in numbers		1st year (2010)	2nd year (2011)	3rd year (2012)	4th year (2013)	5th year (2014)
Company	SV to KR	1 (3) (28)	12 (15) (176)	10 (13) (219)	7 (10) (161)	1 (2) (35)
	KR to SV	8 (11) (1,668)	25 (30) (3,225)	16 (20) (3,688)	28 (33) (3,985)	6 (7) (1,555)
University	SV to KR	6 (7) (44)	15 (18) (1,274)	60 (73) (9,628)	66 (68) (8,252)	39 (47) (4,377)
	KR to SV	2 (2) (2)	7 (7) (14)	44 (44) (451)	27 (31) (409)	18 (18) (382)
Government	SV to KR	0 (0) (0)	64 (65) (674)	2 (2) (20)	3 (3) (25)	5 (5) (25)
	KR to SV	0 (0) (0)	0 (0) (0)	24 (24) (24)	6 (6) (7)	5 (5) (5)

Table notes:

(i) The cell values express the total number of people involved in mobility, followed by (total frequency in time) and (duration in total number of days). For example, one person from the company traveled from Sinos Valley (Brazil) to Korea 3 times in 2010 and stayed there a total of 28 days (approximately 10 days each time).

(ii) The activities involved with the company refer to the mobility of high-level administrators (such as the president or director), line production engineers and clean room construction engineers. University activities refer to the mobility of high-level administrators (such as the president or director), faculty and students (both undergraduate and graduate levels). Government activities refer to the mobility of high-level administrators (such as the governor, Secretary of State, Development Bank and agency presidents) and special guests of institutional missions (such as entrepreneurs).

All of these exchanges stimulated technology transfer, knowledge creation, and the development of domestic capabilities in the semiconductor cluster. Along with other local semiconductor initiatives, such as CEITEC and UFRGS research and teaching, these programs have stimulated cluster upgrading. It should also be noted that the emergent relationships between Brazilian and Korean CEOs (corporate level) as well as university presidents have provided important seeds for this process. HT Micron has already hired approximately 200 employees, 25% of whom came from the UNISINOS partnership (HT Micron data, 2014). Eight of these employees had internship experience at HANA Micron combined with academic experience at SKKU or Hongik universities. Many of these people are now employed in the R&D department of the Brazilian company. In the near future, approximately 500 more hires are expected. From the Korean perspective, this partnership represents the internationalization of HANA Micron by means of potential new market opportunities and the transfer of high technology. From the university perspective, this partnership has upgraded UNISINOS' internationalization process and strengthened its science, technology and innovation system by means of international exchange and mobility programs, joint research projects, international scientific and institutional forums, and business collaboration. Ten agreements were established with Korean universities to support these activities, and an S&T agreement was established with Georgia Institute of Technology in Atlanta through which a full professor from that university joined UNISINOS' master's program and the technology institute. The state government has supported this emergent cluster by means of special policies and funds and the promotion of new business initiatives (mainly SME). The federal government has promoted the international exchange and mobility of faculty and students through the SwB program and has supported innovation projects through its S&T agencies (see FINEP, CAPES, and CNPQ) and special funds from its development bank (see BNDES).

In sum, these activities have stimulated an IBC process that is much more coordinated at multiple levels than 'organic' IBC as experienced between established clusters such as Bangalore and Silicon Valley. As part of the coordination effort, various otherwise unconnected cluster resources, such as internship and employment opportunities at local firms, training and research programs at universities, and exchange programs at the government level, can be combined and leveraged as a package that compensates for the perhaps limited market attractiveness of each individual resource. Arguably, local as well as international linkages *across sectors* (firm, university, government) are unlikely to have been established organically and could only be formed through the deliberate, collective coordination of participating parties. Figure 2 illustrates the operation of linkages across levels.

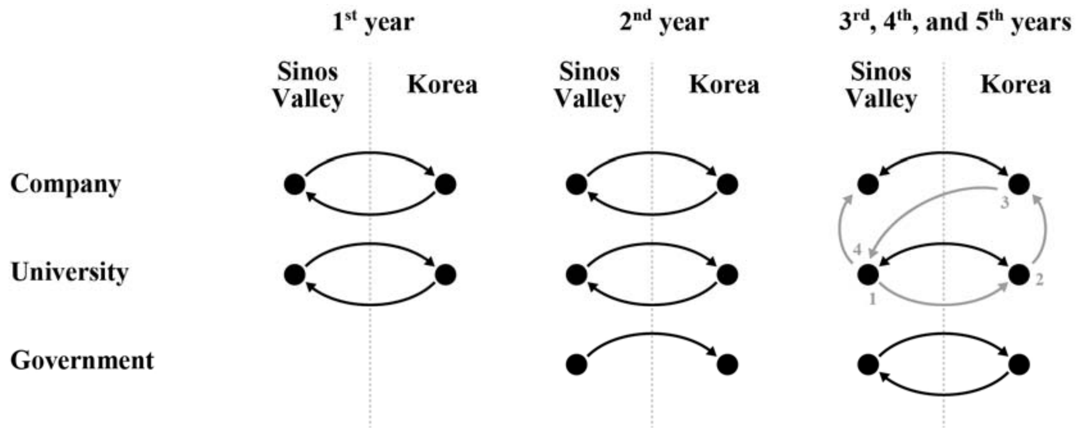

Figure notes:

(i) Circles indicate talented people who have moved from one country to another.

(ii) Arrows indicate the direction of talented people across national across national boundaries and over different levels.

(iii) The ties in black indicate network interactions at the same level (company, university or government), and the ties in grey indicate network interactions at differentlevels (in this case, company and university).

(iv) The numbers in the grey ties indicate the sequence of movement for talented people across national boundaries and over different levels.

(v) There is no relationship between the circle´s size and the ties´ thickness with the number of talented people's mobility. These data are explored below by means of the impact of the BC between Sinos Valley and Korea.

Figure 12. IBC architecture and its relational effects

Through this effort, the 'mistakes' of prior clustering processes in the region could be prevented. On the one hand, multi-level strategic coordination has established a rather idiosyncratic bond between cluster participants in Sinos Valley and Korea, which makes cluster growth less contingent on global competitive dynamics. In the case of the shoe industry, for example, switching costs for multinationals are relatively low due to limited location-specific investments; this is clearly not the case for semiconductors. Both Brazilian and Korean partners have a joint interest in continuing and even extending this collaboration over the long term. In contrast, the cross-sector approach helps to manage the risk of brain drain to other locations. As illustrated above, both local and global linkages between universities and firms are in line with the potential career paths of professionals, from basic and advanced education to internships and full employment. Unlike the case of the IT industry, where many graduates seek career opportunities abroad or in larger cities, the rather elaborate system of cross-sector linkages in semiconductors provides longer-term career incentives in the region.

3.3 Research propositions

Based on the theoretical framework and on this exploratory study, generic propositions were then formulated for further validation. First, with attention to the prior research on IBC and its effects on cluster development, in particular in emerging economies (Bresnahan, Gambardella, & Saxenian, 2001; Saxenian, 2005; Saxenian & Hsu, 2001), the empirical cases suggest that the dynamics of IBC and cluster growth are mutually reinforcing. It is thus important not to treat diaspora effects merely as an antecedent of cluster attractiveness or as a consequence of cluster growth (for this discussion, see also Zaheer et al., 2009; Lorenzen & Mudambi, 2013). By contrast, it is suggested that a dynamic, co-evolutionary perspective needs to be taken to understand the interdependent effects of global IBC and local cluster development. The following is thus posited:

Proposition 1: Global IBC and local cluster growth are mutually reinforcing. IBC can promote cluster growth, and cluster growth can promote IBC.

Focusing on IBC governance and using the lens of the network governance literature (following Provan & Kenis, 2008), two generic forms of IBC governance are differentiated: an organic process and a coordinated effort. Organic IBC describes a rather market-driven process by which ‘reverse brain drain’ is stimulated by increasing the attractiveness of particular clusters, e.g., through foreign direct investment, improved infrastructure, and employment and career opportunities. Governance plays only a minor role in this type of IBC. Both organizational and individual, local and inter-cluster ties driving IBC thus develop rather sporadically by means of positive feedback loops. The examples of the emerging connection between Silicon Valley and Bangalore and Hsinchu, in terms of talent movement, knowledge exchange, and professional development, illustrate this dynamic process (see also Saxenian, 1999, 2005; Saxenian & Hsu, 2001; Bresnahan et al., 2001; Lorenzen & Mudambi, 2013). By contrast, coordinated IBC describes a process of individual movement and exchange and the resulting knowledge transfer between clusters that is deliberately designed and governed through cluster policies and a strategic alliance of organizational actors, e.g., firms, universities, and governments. The case of Sinos Valley illustrates this process. Tie formation – both within and between clusters – in the case of coordinated IBC is stimulated through strategic agreements. They become part of an interdependent ‘IBC architecture’. Table 5 summarizes the key differences between these two forms of IBC governance.

Table 5. Comparison of IBC governance as an organic process versus a coordinated effort

	IBC as Organic Process	**IBC as Coordinated Process**
Cluster attractiveness	Market driven: Size and branding effects	Governance driven: Resource bundling across sectors
Interplay of individual and organizational ties	Sporadic, entrepreneurial	Part of governance architecture
Interplay of local and global ties	Sporadic, independent, e.g., transnational VCs	Part of governance architecture
Facilitating conditions	Many (e.g., prior MNCs, infrastructure, talent pool)	Strategic consensus of multiple stakeholders
Cross-sector linkages	Sporadic	Intentionally promoted
Stage when approach is effective	Growth stage	Emergent stage
Facilitating cluster size	Medium to large	Small
Magnitude of effect	Unlimited (limited only by agglomeration diseconomies)	Limited (cohorts of students, limitations of coordination)
Role of governance	Limited to tax incentives; Venture Capital (VC) firms; associations spanning clusters;	Multi-level governance: building linkages, setting up exchange programs

Based on this distinction, conditions are formulated under which each mode is more likely to be effective. First, organic IBC appears to be most effective when clusters are already growing and thus becoming more attractive for investment, entrepreneurship and employment. This is because one major driver of organic IBC is the competitive advantage of one location over another – a mechanism that network scholars refer to as 'preferential attachment' (Powell et al., 2012). The cases of Bangalore and Hsinchu exemplify this. Only after certain enabling conditions (such as an ecosystem of local technological capabilities, MNC investments and the international success of domestic industry) in Bangalore and Hsinchu were recognized by a significant number of potential returnees from overseas as being better than in other locations would the dynamic of reverse brain drain set in (Kenny et al., 2012). By contrast, clusters at a nascent stage have neither the branding power nor the market conditions to attract talent. Under these conditions, as in the case of Sinos Valley, coordinated IBC is a more effective way to leverage local resources. Also, unlike organic IBC, coordinated IBC does not require that talent already exist outside of the cluster. Instead, it may stimulate exchange and movement based on locally anchored programs and incentive systems. However, arguably, the effectiveness of coordinated IBC may fade as clusters grow and attract both investments and talent more organically. The following is thus posited:

Proposition 2: Organic IBC particularly benefits cluster development when the cluster is already growing, whereas coordinated IBC particularly benefits clusters at a nascent stage.

Similarly, the cases studied suggest that size matters. One important driver of location attractiveness – and of organic IBC – is the size of the relevant local labor pool as well as the community of both local and foreign firms (Altenburg & Meyer-Stamer, 1999; Bresnahan et al., 2001; Patibandla & Petersen, 2002). As Saxenian (2005) noted, smaller locations are much less likely to stimulate IBC dynamics. However, it is showed that coordinated IBC approaches can partly make up for size disadvantages. They do so in particular by combining otherwise unconnected local resources – labor pool, education system, employment opportunities – through cross-sector ties between firms and universities – both locally and between clusters. As noted by others, coordinated cluster approaches may help manage more complex transactions and interchanges (see also Schüßler et al., 2013; Sydow et al., 2010). Also, they help develop a certain level of idiosyncrasy that prevents either individuals or firms from easily switching locations (e.g., in favor of larger locations). However, prior research also suggests that any more advanced coordination effect within clusters is constrained by the number of participants. The more people, firms and institutions need to be coordinated, the more difficult it becomes to align incentive systems, prevent free-riding, and administer processes. The study by Manning, Sydow and Windeler (2012) illustrates that problem by comparing the effectiveness of non-poaching agreements between foreign multinational enterprises in a small location in Romania (effective) versus in Shanghai, China (ineffective). The following is thus posited:

Proposition 3: Organic IBC particularly benefits cluster development when clusters have a large labor pool and a significant number of firms, whereas coordinated IBC particularly benefits the development of clusters with a small labor pool and a limited number of firms.

Along with prior research, this study also shows how important both local and global linkages are for clusters to emerge and grow (see, e.g., Bathelt, Malmberg, & Maskell, 2004; Lorenzen & Mudambi, 2013). In the particular context of IBC, ties between universities and firms are of specific importance (Feldman, 2001). In the empirical cases, such ties have emerged, in particular local ties. However, only in the Sinos Valley case have such cross-sector ties been developed to an equal extent both locally and between clusters. As a result, Sinos Valley has established multi-level linkages with Korean partner firms and universities. It is argued that the complex undertaking of developing and interconnecting those linkages has been facilitated through coordinated rather than organic IBC approaches. This observation can be further supported by research on different types of market economies – coordinated (e.g., Germany) versus liberal (e.g., US). In particular, coordinated market economies, such as Germany and Japan, often show rather complex alliances between firms and universities at both the research and educational levels. The following is thus posited:

Proposition 4: At an early emergent stage of clusters, IBC can be promoted through both local and global linkages between firms and universities. Coordinated IBC can facilitate these linkages better than organic IBC

Finally, our study also addresses the ambiguous role of employee turnover and talent migration for cluster growth. Whereas in already established clusters, talent movement between firms is 'internalized' within cluster boundaries, thus promoting learning and innovation among firms (see, e.g., Song, Almeida, & Wu; Almeida & Kogut, 1999), in less developed clusters, brain drain (to more established locations) can be a serious threat to cluster growth. In particular, the Sinos Valley case indicates that this problem can be in part mitigated when both local and transnational cluster linkages are in line with individual career progression paths. Having the opportunity to obtain a basic degree, take advanced courses in a foreign country, engage in an internship and obtain follow-up employment locally offers a longer-term career perspective that may prevent talent from leaving the emerging cluster (in favor of more established ones). Arguably, this high level of alignment between organizational ties and individual career progression can be achieved more affectively through coordinated rather than organic IBC. The following is thus posited:

Proposition 5: At an early emergent stage of clusters, IBC can be promoted when organizational linkages are in line with individual career paths. Coordinated IBC can facilitate building these linkages better than organic IBC.

4 CASE STUDY: DAEDEOK INNOPOLIS – US CONNECTION

The case study of Daedeok was selected to test the research propositions of this study and to propose forms of IBC governance in promoting the growth and upgrading of clusters in emerging economies. Because it was possible to access data for Daedeok's evolution from the early to the mature developmental, an analytical comparison over the cluster's development allows the objectives of this study to be achieved. The first section of this chapter defines the research method, data collection method and the single-case analysis. The findings of this case study are illustrated in the second section. The discussion regarding the cases studied and testing of the research propositions are illustrated in the next chapter.

4.1 Data and research method

Case study designs that include both quantitative and qualitative data are a means to study multi-faceted and complex development processes (Yin, 2009). Descriptive-exploratory research was employed for this case study, combining the analysis of both qualitative and quantitative data. The primary approach was qualitative, which is considered to be a more appropriate method for studying early emergent clusters. Scholars (see, e.g., in Stoerring, 2007) agree that it is possible to identify the seeds of an emergent cluster (such as the number of firms, the presence of universities, linkages between them, and existing dynamics), but it is not possible to definitively claim that a particular phenomenon will lead to a cluster developing during the growth stage. In this respect, a qualitatively oriented method allows better exploration into the dynamics of a potential cluster in the early developmental stage.

Moreover, a qualitative approach also allows deeper exploration of the external linkage dynamics (global networks) of a cluster, in particular, as related to IBC dynamics, control mechanisms, cross-sector links and alignment between individual career paths and IBC. For these reasons, the use of primarily qualitative research techniques is favored, in particular, in-depth interviews with cluster actors. These techniques allow the network dimension of the cluster to be investigated based on the assumptions of this study. As there is no standard methodology for studying emerging clusters, this study explored the cases based on a mixture of (primarily) qualitative and quantitative data.

To facilitate the correlation between the case study and the research question and propositions, six dimensions of analysis were established. It is important to note that the dimensions of analysis do not exactly follow a logical deduction of the propositions; they were the *means* to answering the research question and testing the propositions. Maxwell (2013) argues that the research propositions and the research method are two separate parts of the research design: there is no way to mechanically convert the research question and propositions into a research method (Maxwell, 2013). The research method depends not only on the research question and propositions but also on what technique will most effectively capture the needed data (Maxwell, 2013). For these reasons, six dimensions were established aligned to the research question and propositions as illustrated in Figure 13.

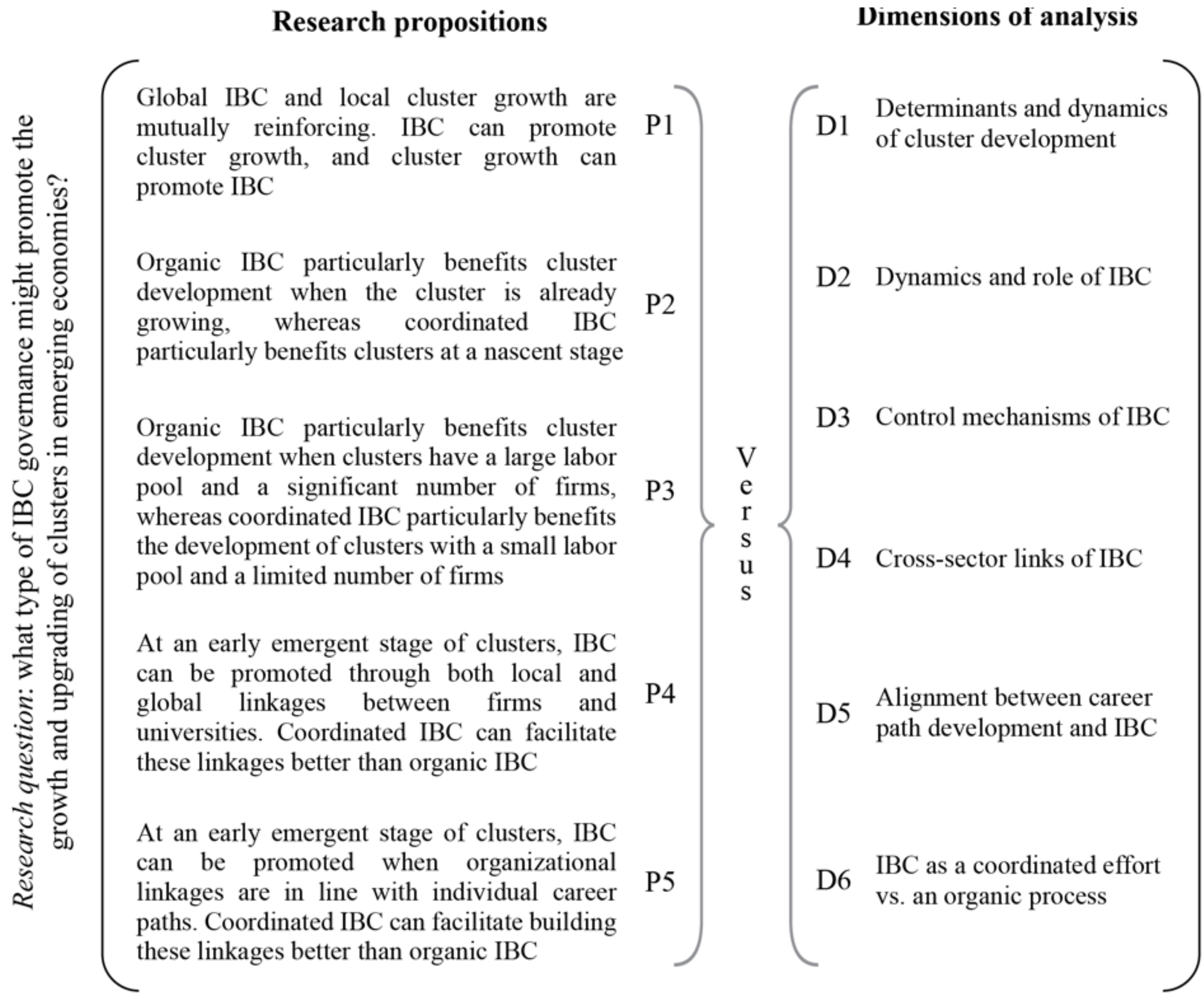

Figure 13. Relationship between the research propositions and the case dimensions of analysis

The dimensions of analysis have facilitated the relationship between the research propositions and the subsequent analysis of this research. They helped to define the categories of analysis and operationalize this case study. Table 6 gives a description of each dimension of analysis.

Table 6. Descriptions of the dimensions of analysis

Dimension of Analysis	Description
D1: Determinants and dynamics of cluster development	General information about the development process of Daedeok Innopolis, such as its dynamics, starting point, evolution, initiators, members, expectations and goals.
D2: Dynamics and role of IBC	The dynamics of international talent mobility and its role in transfer technology, knowledge diffusion, and local cluster upgrading.
D3: Control mechanisms of IBC	Governance systems of IBC, such as formal and informal control mechanisms, the coordination of IBC for achieving goal consensus and conflict resolution, local policies and programs (including public funding) and regulatory and legislative pressures.
D4: Cross-sector links of IBC	Links, for example, between companies and universities, to facilitate the interplay of global and local ties, communication and cooperation between actors, and types of knowledge to be transferred across levels.
D5: Alignment between career path development and IBC	Career paths such as alignment between organizational and individual ties, opportunities for communication and cooperation on and across organizational and individual ties, rules, guidelines and practices for developing a career path.
D6: IBC as a coordinated effort versus an organic process	The role of, and limitations to, deliberate intervention and coordination in the IBC process.

4.1.1 Data sources

Data were collected from primary and secondary sources. Primary sources include semi-structured interviews; secondary sources include document analyses of different document sources among journal papers (Mason, Kim, Perkins, Kim, & Cole, 1980; Oh & Yeom, 2012; Yoon, 1992), published books (Kim, 1997; OECD, 2008; Shin & Nak Choi, 2015), a policy report from Jin, Lee, Yoon, Kim, and Oh (2006), class materials from the STP Program[18] (INNOPOLIS Foundation, 2015), the INNOPOLIS Foundation website

[18] The Science & Technology Park (STP) training program was launched in 2008 to share the success experience of Daedeok Innopolis. It is a two-week program through which an international audience can learn theories in high-tech cluster development and operational know-how based on the Innopolis model. The program is hosted by both the Ministry of Science, ICT and Future Planning and the INNOPOLIS Foundation. The classes are located at the INNOPOLIS Foundation's building in Daejeon, Korea. The materials referred to here are the presentations, papers and reports from these courses.

(https://www.innopolis.or.kr/), the Korean Statistical Information Service - KOSIS (http://kosis.kr/), OECD data (http://www.oecd.org/statistics/), and an open exhibition from the National Museum of Korean Contemporary History. All of these secondary sources were used to develop a broad understanding of cluster development (e.g., the history of Daedeok accessed in Oh & Yeom, 2012), of a particular IBC dynamic (e.g., numbers of PhD holders circulating through IBC accessed in Jin et al., 2006), and of a specific IBC governance type during a particular period of cluster development (e.g., Yoon, 1992). These secondary sources were important for creating a broad overview of Daedeok's development, supporting the drafting of interview protocols, and bringing additional evidence to the empirical case.

The primary source of evidence was semi-structured interviews. The respondents were selected based on a background related to the context and were from academia, government and industry. An equal number of the respondents were selected for each sector. The respondents also had to meet one of the following two requirements. The first was to be in a strategic position and directly involved with the development of Daedeok. The second was to have prior international exchange experience (e.g., obtained his/her PhD in the US or an established international program for highly skilled scientists and engineers). These experiences were also important for gaining testimony regarding IBC. The interviews were conducted with four senior respondents from each sector (12 in total). All had prior international exchange experience. Nine respondents were directly involved in the development of Daedeok, and five obtained their PhD in an advanced economy (US and UK). Two respondents are in strategic positions at the INNOPOLIS Foundation, the other two are CEOs of spin-off companies from the government research institutes (GRIs), and one of these was directly involved in recruiting Korean-American scientists and engineers to the private sector. Two respondents were senior policy makers. One is a former executive member of the Ministry of Science and Technology in the central government and the current President of the Daejeon Institute for Regional Program Evaluation. The other is a senior research fellow at the Daejeon Development Institute. Both of these have been directly involved in Daedeok's cluster policy. The respondent profiles are presented in Table 7.

Table 7. Respondents' profiles

Number	Job position	Age	Education level	Place of degree	Unit of context
1	Professor at KAIST, Director of the Future Management Research Institute	54	PhD	US	University
2	Professor at KAIST, Director of the Post Catch-up Research Center	52	PhD	UK (Sussex)	University
3	Director of Global Cooperation at INNOPOLIS Foundation	-	PhD	California State University, US	Government
4	Executive Director of INNOPOLIS Foundation	-	PhD	Korea (Chungnan)	Government
5	Senior Research Fellow at Daejeon Development Institute	50	PhD	UK (Sussex)	Government
6	Professor at Solbridge, Chair of the Management Science Department	42	PhD	Korea (KAIST)	University
7	CEO of COXEM	45	PhD	Korea (KAIST)	Company
8	Professor at KAIST, Chair of the Business and Technology Management Department	52	PhD	US (Syracuse)	University
9	President of Daedejon Institute for Regional Program Evaluation	57	PhD	US (Stanford)	Government
10	CEO of FLEXSCON	51	PhD	Korea (KAIST)	Company
11	President of KFAS	64	MA	Korea (SNU)	Company
12	CEO of Hana Micron, Chairman of BOD of HT Micron	65	PhD	Korea (KPU)	Company

The interview guide was organized by categories and sub-categories of analysis. The categories (represented in the first line of figure 14) were the three phases of cluster evolution as identified in the secondary sources. These sources also defined the period, name, strategy and main activities of the cluster over the three phases. All of these categories were tested during the interviews. The phases of the cluster between the early and mature developmental stages were selected for further comparative analysis. In this sense, the sub-categories (represented in the first column of figure 14) were established by the dimensions of analysis, which were interrelated with the research question and propositions as described below (figure 13). The categories and sub-categories were established to facilitate the subsequent analysis. Figure 14 illustrates the interview guide.

Phase	Phase 1	Phase 2	Phase 3
Period	1973 - 1989	1990 - 2004	2005 - present
Name	Daedeok Science Park	Daedeok Valley	Daedeok Innopolis
Strategy	R&D	Innovation	Innovation Cluster
Activities	Groundbreaking R&D Public R&D	Private R&D High-tech start-ups	Technology commercialization Business hub
D1. Determinants and dynamics of cluster development			
D2. Dynamics and role of IBC			
D3. Control mechanism of IBC			
D4. Cross-sector links of IBC			
D5. Alignment between career path development and IBC			
D6. IBC as a coordinated effort vs. an organic process			

Figure 14. Interview guide

All of the interviews were conducted during July of 2015. They were scheduled at Daedeok Innopolis in the workplace of each respondent. The interviews were scheduled through email interactions, which were followed by a phone confirmation. Two confirmations were made before each interview appointment. In the first interaction, a summary of the study was sent in advance to the respondents (approximately one month before the interview) to give them an overview of the research, the study aims, an illustration of IBC between Daedeok Innopolis and the US, the outcome expectations of the study (e.g., academic publications), the PhD supervision and my resume. This summary helped to clarify the research scope and prevent cancelation of the interview due to any confusion.

When conducting the interview, the respondents had a printed copy in A4 format of the interview guide (figure 14), and the aim was to discuss each cell of the guide (e.g., the control mechanisms of IBC in the first phase of cluster evolution – D3 vs. Phase 1). There were questions related to the dimensions that supported the interviews. These questions were printed (and not shown to the respondents) and also used to guide the interview (see appendix A). The interview guide facilitated interactions, conducting the interview, and an understanding of the research scope. This method was tested in a prior interview at a closed seminar of the graduate program of the Business and Technology Management Department at KAIST. The pilot-test interview was important for developing a training section for the interviews. Although the interviews were conducted in English, they were supported by a Korean native speaker who was a Master's student at KAIST[19] with advanced English skills. He supported the interviews primarily through translation (e.g., some technical names) and logistics. This support was critical to conducting productive interviews.

The duration of the interviews was, on average, one hour and eighteen minutes. The interview data were collected through full audio records and personal notes. After the interviews were

[19] His research subject is also cluster development.

concluded, they were fully transcribed for later analysis. The interviews were transcribed in separate Microsoft Excel spreadsheets. The lines of each spreadsheet were numbered to track the quotes and other material from the respondents. All of the twelve interviews represented an accumulated 69,228 words in total.

4.1.2 Single-case analysis

Based on the designs of the conceptual framework and the research method, a *categorizing* strategy was used for this single-case analysis (Maxwell, 2013). This decision was made primarily to obtain similar and different relationships that could be used to compare data based on the categories and sub-categories of analysis. Thus, *coding* was used as a categorizing strategy. The goal of the coding was to fracture the data and rearrange them into categories and sub-categories that would facilitate comparison between them. Thus, codes were used to describe and summarize this comparison by collecting parts of the interviews (Myers, 2009). These were organized into the same matrix used for the interview guide (see figure 14) to organize the collected data to address the propositions and the research question. After coding the primary sources (interviews), triangulation was used for validity testing (Fielding and Fielding, 1986). Although triangulation does not automatically increase validity, it allows better assessment of the general application of the codes to the explanations and it reduces the risk of systematic biases due to a single interview method. The triangulation compared the primary sources (interviews) to the secondary ones.

The case study data were analyzed through three steps. The first step was organizing the interview transcripts: all were read again and the notes and secondary source documents were reviewed. Additionally, in this step, the interview transcriptions were copy edited (mainly to correct grammar errors because the respondents were not native English speakers). During this process (copy editing), the text of the transcriptions was numbered based on the line of the Excel spreadsheet (per interview).

Then, in the second step, interview codes were selected and copied into an analysis matrix. This matrix was based on the interview guide (figure 14) based on the categories and sub-categories of analysis. The categories were the phases of cluster evolution (columns of the matrix), and the sub-categories were the dimensions of analysis (lines of the matrix). Thus, each cell of the matrix contained codes from the interviews as a cross-analysis between categories and sub-categories. To track the codes, each was numbered by the respondent's identification plus the number of the respective line of the code (only the first line). For example, respondent 9 provided testimony about his career path based on his experience as a PhD student at Stanford (US) and later as a scientist at ETRI (Korea) in the first phase of cluster evolution. This code started at line 542 of his interview. Thus, this evidence was identified as 9:542. In similar manner, all of the evidence was collected and identified on the analysis matrix (see the matrix with all codes in appendix B). After completing the matrix, a triangulation analysis was conducted between the interviews (primary sources) and the secondary sources; the goal of this triangulation was to confirm the evidence of each cell using the secondary sources and to bring additional evidence (such as context, specific program, numbers of IBC) to complement the codes.

Based on this matrix, the third step was to define how to describe the findings of this case study. This definition was based on (i) analyzing the determinants and process of cluster development over its three phases, (ii) analyzing the IBC, in particular, its dynamics, role, control mechanisms, cross-sector links, and career path alignment (dimensions 2, 3, 4 and 5) by each phase of cluster evolution, and (iii) analyzing the IBC governance over the three phases of cluster evolution. Figure 15 illustrates how the findings were described and provides the respective section.

Dimensions of analysis	Cluster evolution		
	Phase 1	Phase 2	Phase 3
D1: Determinants and process of cluster development	(4.2.2) →		
D2: Dynamics and role of IBC	(4.2.3.1) ↓	(4.2.3.2) ↓	(4.2.3.3) ↓
D3: Control mechanism of IBC			
D4: Cross-sector links of IBC			
D5: Alignment between career path development and IBC			
D6: IBC as a coordinated effort vs. an organic process	(4.2.4) →		

* Arrows indicate the description and analysis directions, and the number in parentheses indicates the respective item in the findings chapter containing the description of the analysis.

Figure 15. Definition of the case study's description

4.2 Findings from the case study

Based on the definition of the case study's description (see figure 15), this section presents the findings of the case study regarding the connection between Daedeok Innopolis and the US. The first sub-section gives an introduction of IBC in Korea followed by the development process of the cluster in the second sub-section. The third section presents the dynamics, role and governance of IBC over time, followed by a comparison between the types of IBC governance found over the development process of Daedeok Innopolis in the fourth sub-section.

4.2.1 *Introduction to inter-cluster brain circulation in Korea*

In the context of cold war geopolitics, Korea was one of the biggest recipients of US economic and military aid[20] in the 1950s (Mason et al., 1980). Such assistance helped promote radical economic growth in Korea to a controversial degree (see Mason et al., 1980); furthermore, in the process of implementing aid programs during that period, US tutors provided Koreans with ample opportunities to accumulate invaluable exposure to modern technology and management systems in the government, military, and industry (Kim, 1997). Most young Korean men engaged in compulsory military service for two or three years, obtaining various technical skills and experience in military bureaucracy with US assistance (Kim, 1997). There were economic assistance programs that exposed a high proportion of senior personnel in government, business and academia to foreign training, primarily in the US. This particular period of US assistance ended in the mid-1960s; nevertheless, the tradition of overseas training continued from that period to the present.

After the US ended economic and military assistance in the mid-1960s, overseas talent became a prominent asset in Korea's radical growth. In all of these communities from the diaspora[21], Korean immigrants who became scientists and engineers in advanced economies (such as the US), in particular, represented a strong talent pool, as they were among the most highly educated and skilled group (Shin & Nak Choi, 2015). On the one hand, these particular

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[20] Korea received approximately $6 billion in economic aid and another $7 billion in military assistance from the US in early 1945 (according to Mason et al., 1980).

[21] There are over 7 million ethnic Koreans currently living overseas; these left the country starting in the 1960s for a wide variety of reasons. China (2.7 million), the US (2.0 million), and Japan (0.9 million) host the largest number of Koreans living overseas (Shin & Nak Choi, 2015).

diaspora communities could be seen as representing a shortage of Korean talent that could strengthen Korea's S&T system when they were repatriated. But, on the other hand, the large amount of talent overseas resulted in serious brain drain for Korea throughout the 1960s (Kim, 1997). This phenomenon was characterized by overseas graduates refusing to return home (Kim, 1997; Yoon, 1992) due primarily to poor R&D and management systems, a lack of autonomy and responsibility within R&D institutes, low technological capacity in the private sector, no secure funding for R&D activities, and a lack of social infra-structure (INNOPOLIS, 2015). As of 1967, for instance, 96.7 percent of Korean scientists and 87.7 percent of Korean engineers educated abroad remained there, primarily in the US, compared with corresponding figures of 35 and 30.2 percent for all countries at that time (Yoon, 1992).

The brain drain was successfully overcome by a state-led model implemented throughout the 1960s-1980s (Kim, 1997; Yoon, 1992). In the context of the five economic development plans[22] led by President Park, the state government led a reverse brain-drain policy in an attempt to repatriate scientists and engineers (Yoon, 1992). In 1968, for instance, 2,000 Korean scientists and engineers lived abroad (OECD, 2008). Yoon (1992) argued that Korea's reverse brain drain was an organized government effort, rather than a spontaneous phenomenon, and that various policies and the political support of President Park were instrumental[23] to its success. An industrial research complex was created as a facilitating

[22] Korea's rapid economic development was led by President Park's dictatorship regime. The Economic Planning Board was established in 1961. A program of rapid industrialization based on exports was launched. The shift in orientation was reflected in the First Five-Year Economic Development Plan (1962-66) and the subsequent second (1967-71), third (1972-76), and fourth (1977-81) five-year economic development plans.

[23] It is important to note a series of laws that served as instruments that directly and indirectly affected returning talent such as the "Science and Technology Advancement Law" (1967), which the national government enacted to express its explicit support for the promotion of S&T, the "Technical Development Promotion Law" (1972), with a revision in 1989, which encouraged R&D in the industrial sector and protected public sector R&D, and

condition to bring expatriates back to contribute to the development of Korea´s knowledge base (OECD, 2008); for example, the Korean Institute of Science and Technology (KIST) was developed in the late 1960s. KIST started by recruiting a group of eighteen highly skilled scientists/engineers who received their PhD degrees from the US and West Germany in 1966 in the first attempt at the systematic repatriation of highly skilled S&T workers to Korea (Yoon, 1992). Other particular features of Korea's reverse brain drain policies were also created then, such as the empowerment of returning PhDs by means, for instance, of exceptionally good material benefits, guarantees of research autonomy, and high salaries (Yoon, 1992). They were empowered through the offer of strategic decision-making positions in key policy-making posts in the government (e.g., cabinet posts) or the private sector (e.g., corporate executives, directors). This was an unusual situation in the context of that time because the returnees had been among the "managerial task elite" in other countries (Lee, 1968) and not "tactical and strategic decision makers" (Straussman, 1978), as they became in Korea (Yoon, 1992). All of these state-led policies had enormous implications for S&T (and economic) development in Korea throughout the 1960s – 1980s. After the success of Korea's model for reverse brain drain, this phenomenon ceased to be considered a social problem by policy-makers. To the contrary, preventing the exodus of US-trained Korean "brains" became a serious policy concern in the US, which was the major educator of Korean professionals (Yoon, 1992).

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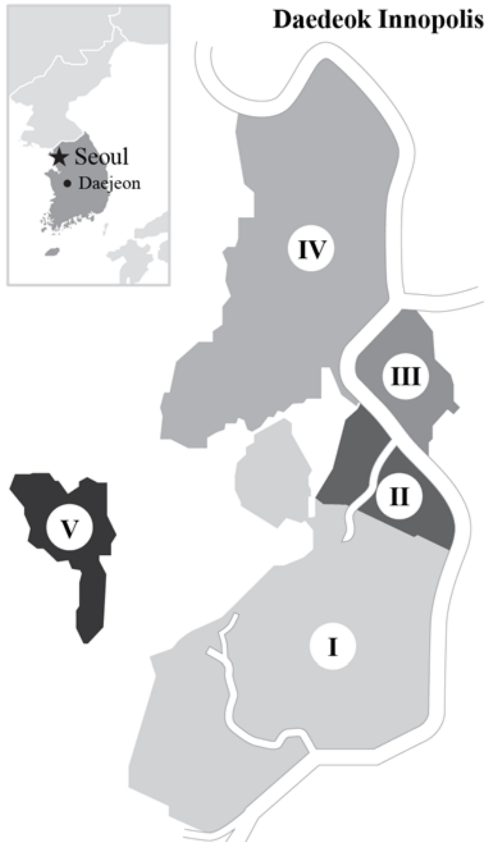
the "Engineering Services Promotion Law" (1973), which was enacted to promote/protect local engineering services and also benefited returning scientific personnel (see more detail in Yoon, 1992).

The state-led repatriation program then served as a model to overcome brain drain for the private sector (Kim, 1997). As the industry developed throughout the 1980s and 1990s, this model drew upon global networks of Korean scientists and engineers still overseas. There was aggressive recruitment that allowed these people to leapfrog into state-of-the-art technologies in the 1980s and 1990s (Kim, 1997). In 1983, for instance, a Samsung investment in designing and producing chips involved two parallel groups: one group in Silicon Valley (US) that employed 300 US engineers led by five Korean-Americans with PhDs and design experience at major US chip companies and another group in Korea led by two Korean-American scientists and Korean engineers. Samsung´s Silicon Valley unit also trained the Korean engineers from the company as part of a strategy to transfer technology from the US (Kim, 1997; OECD, 2008). In general, 427 scientists and engineers were recruited by corporate R&D centers from abroad in 1992 alone (Kim, 1997). Some of these scientists returned for short-term assignments, indicating that many Korean scientists and engineers abroad maintained close technical ties with Korean companies (Kim, 1997). In addition, another government-led program called "Brain Pool" offered subsidies to GRIs and universities to recruit scientists and engineers from abroad for particular R&D projects lasting between six months and two years (Kim, 1997). All of these Koreans worked extremely hard with strong energy and commitment, enabling Korea's radical economic growth throughout the 1980s and 1990s (Kim, 1997).

Since the early 2000s, domestic investment by businesses and government has driven the development of indigenous high-tech capabilities in Korea. Lazonick (2007) argued that Korea has achieved the research capability to serve the high end of the high-tech market. The brain drain has not only been reversed, with MNCs choosing to locate in Korea and subsidiaries of Korean companies locating overseas, both gaining access to highly skilled labor pools, but it can also no longer be taken for granted that the centers for high-end work are in the US and Japan (Lazonick, 2007). The global networks maintained by Korean scientists and engineers with their former host countries (particularly with the US) have been vital for the knowledge transfer and diffusion processes associated with the IBC model. Furthermore, in recent years, global networks have been also seen by Koreans as a way to commercialize high-end technologies.

4.2.2 The development of Daedeok Innopolis: from public R&D strategy to high-tech cluster

Daedeok Innopolis is the oldest and largest high-tech cluster in Korea. This agglomeration of firms, universities and other interconnected institutions is located in Daejeon, Korea (approximately 160 km from South Seoul). Daedeok is an important global innovation hub for knowledge economies such as information communication technologies (ICT), semiconductors, biotechnologies, materials science, chemical engineering, and energy resources (INNOPOLIS Foundation, 2015). It currently hosts, in total, 91 tenant institutions and more than 1,300 high-tech companies (SMEs), which generate approximately 64,300 jobs (of these employees, 10,300 hold PhDs); all of these initiatives are located within its five zones as illustrated in figure 16. Recently, Daedeok Innopolis has moved beyond S&T, emerging as a global innovation hub in a RD&B model (Oh & Yeom, 2012).



Establishment	**November 1973** Korean National Government Initiated
Location	**Daejeon Metropolitan City**, Korea
Employment	**64,321 People** (10,333 PhDs) * approximately 11% of PhDs in Korea
Tenants	**91 Tenant institutions** 30 Government research institutes (GRIs) 11 Public research institutes (PRIs) 14 National and public agencies 29 Non-profit organizations 7 Universities (HEIs) **1,312 High-tech companies (SMEs)** Spin-offs from GRIs and PRIs, high-tech venture-based businesses
Major Fields of Science and Technology	**Knowledge economy fields** ICT Semiconductors Nanotechnologies Biotechnologies Materials Science Chemical Engineering Energy Resources
Zones	**Sector I** (27.8 km2): Daedeok Research Complex A cluster of research entities, including government research and private sector institutions; an R&D cluster of research-focused universities, including KAIST; and venture start-up collaboration zones **Sector II** (4.3 km2): Daedeok Techno Valley The research and production base of support for advanced businesses in the Daedeok Research Complex **Sector III** (3.2 km2): Daedeok Industry Complex The industrial base of Daedeok Innopolis **Sector IV** (31.2 km2): Northern Green Belt Area The northern area near the Daedeok Research Complex, which includes the core science belt areas of Shindong and Dungok **Sector V** (3.9 km2): Area of the Agency for Defense Development Area for military defense, which includes ADD and Hanhwa (defense contractors)

Figure 16. Overview of Daedeok Innopolis cluster (adopted by Oh & Yeom, 2012; data refreshed by the INNOPOLIS Foundation, 2015)

The evolution of Daedeok can be divided into three phases according its growth over its 40 years of history (see Oh & Yeom, 2012). The development timeline of Daedeok is illustrated in figure 17, which indicates the primary determinants of cluster evolution through its three phases: the changing name, strategy, primary activities and dynamics of the cluster as explained in the section below.

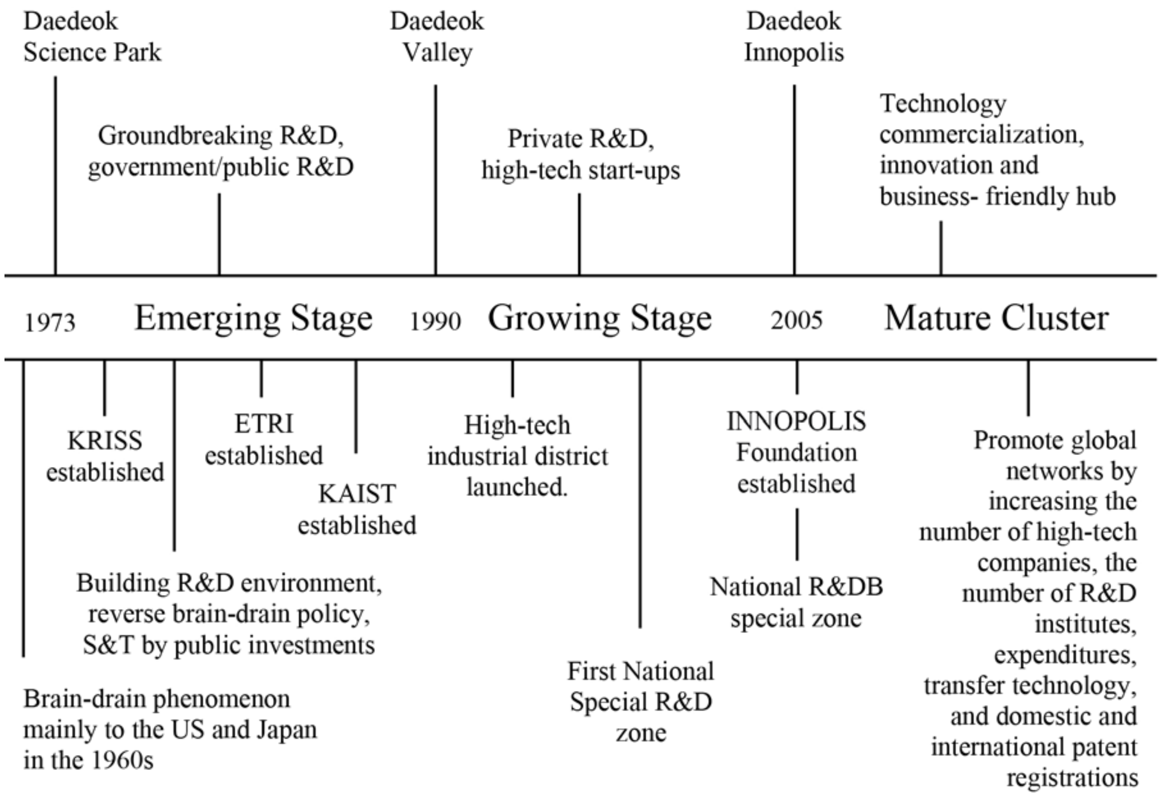


Figure 17. Daedeok Innopolis development timeline

The first phase was from 1973 to 1989, and it was based on building groundbreaking R&D supported by public investments. In 1973, the Korean government decided to place Daedeok Science Town[24] at Daejeon. The cluster was intentionally created by the government[25] as an

[24] The name of the cluster has been changed twice as it has grown: from Daedeok Science Town (1973 – 1999) to Daedeok Valley (1999 – 2004) to Daedeok Innopolis (2005 – present).

[25] Daedeok Science Town was built with a government investment of USD 3.16 billion over the past three decades to better respond to the economic demands of Korea (Oh & Yeom, 2012).

engine for enhancing national competitiveness in high technology and for generating economic prosperity (Oh & Yeom, 2012). The master plan of the cluster was concluded in 1973, and construction of the infrastructure began immediately after (in 1974). The cluster was first launched as the Korean Research Institute of Standards and Science (KRISS), which was a spin-off of the Korean Institute of Science and Technology (KIST) established in 1966 by the central government. It was clearly a government-driven initiative involving senior levels in the central government, and local authorities were excluded from this initial period, as both the president of Daedejon Institute for Regional Program Evaluation and the senior research fellow at Daejeon Development Institute point out.

> *President Park ordered his Minister of Science to build a cluster. That was on November 30th, 1973, the first order from the President to Mr. Choi, who was the minister at that time. Although President Park asked his minister, the Ministry of Science was not strong in the cabinet. It took three years because that ministry could not provide funds at the beginning. President Park came to know that it was not going as he wanted, so he was angry. He asked his secretary in the Blue House, his name is Mr. Oh, to take over this project, not the Minister of Science anymore. So, at this stage, the main determinant was the strong policy from the highest level of the government. This is all the period of only investments, no outcomes. [Korean; president of Daedejon Institute for Regional Program Evaluation]*

> *The main determinant in this period was driven by the central government. There was basically no involvement of the local government, only of the central government. It was mainly central government centered, but in the process of cluster development, local government had their own path. [Korean; senior research fellow at Daejeon Development Institute]*

The Korean government invested over 80% of government national R&D investment during this early period to establish Daedeok Science Town (INNOPOLIS Foundation, 2015), mainly by creating an R&D environment for industry, attracting overseas scientists and professionals (reverse brain drain), and promoting S&T as the economic development orientation (Park, 2015). The cluster was intentionally created by the government to play a key role as an S&T center in Korea (Oh & Yeom, 2012). Later, in 1979, the Ministry of Science & Technology's

Daedeok Administration Office was established in the town to expand the R&D foundation. The Electronic and Telecommunication Research Institute (ETRI) was launched in 1985, and the Korean Advanced Institute of Science and Technology (KAIST) was moved there in 1989. Both of these GRIs were also spin-offs of KIST, and they played an important role by providing S&T capabilities, as the professor at Solbridge and the president of Daedejon Institute for Regional Program Evaluation note.

> *Daedeok Science Park was formulated through basically a government intervention; it was coordinated with government support to build up science and technology capability. Korea was improving its R&D investments, building up its science and mainly technological capabilities. In particular, ETRI brought a lot of value in terms of the system development [Pakistani; professor at Solbridge]*

> *The cluster took several tens of years before coming up with something handy such as companies, revenues, hiring. So, how long did it take? Forty years. It was a time for investing in infrastructures, people, and all the resources supported by the government. I can clearly state, at the early stage, that the main determinant of Daedeok development was the policy of the government. This was a policy (plan) for a long time. [Korean; president of Daedejon Institute for Regional Program Evaluation]*

The second phase of the cluster was from 1990 to 2004, and its name was changed to Daedeok Valley. Although the cluster was initially planned by the central government as a satellite city of the Daejeon metropolitan region, in 1983, Daedeok Valley was incorporated administratively into Daejeon city. The cluster was considered to be a secondary urban center by the municipality, and the location was only important in terms of national goals (Oh & Yeom, 2012). Therefore, the cluster and the regional economy in Daejeon did not have a positive relationship (Oh & Yeom, 2012). The local government had partial involvement in cluster development, such as urban infrastructure, as the senior research fellow at Daejeon Development Institute notes.

> *Cluster development was still driven by the central government, but the local government was involved with a very slight portion, such as land development*

(like transportation infrastructure). [Korean; senior research fellow at Daejeon Development Institute]

After establishing S&T research capability, in the second phase, the cluster shifted to an innovation strategy by means of promoting private R&D and high-tech start-ups and of building the university-industry-GRI network (INNOPOLIS Foundation, 2015). The focus of the cluster during this phase was innovation creation and no longer just scientific research, as it had been in the previous phase. Some new products were launched and commercialized by the GRIs, such as memory semiconductor products and CDMA technology, which were both designed by ETRI (INNOPOLIS Foundation, 2015). These disruptive innovations are examples of a new cluster dynamic appearing in this phase. The innovation was supported by various mechanisms, such as establishing high-tech venture firms and creating technology business incubators, post technology business incubators, and a venture park (Oh & Yeom, 2012). The local government (Daejeon metropolitan city administration) mapped out a scheme to develop a high-tech industrial district to promote technology commercialization and mass production. They called this industrial district Daedeok Techno-Valley. All of these areas (Daedeok Valley and Daedeok Techno-Valley) were linked to the first National Special R&D Zone as a pilot project in regional innovation and technology-led economic development with strong support from the central government. This phase was important for developing the cluster as an innovation hub that led regional industry through the efficient development of advanced science and technologies (Oh & Yeom, 2012).

The third phase of the cluster started in 2005, when it changed its name to Daedeok Innopolis and consolidated as a high-tech cluster with a technology commercialization strategy. This phase is characterized by its growth performance, in particular, increasing the number of high-tech companies, the number of R&D institutes, expenditures, transfer technologies, and domestic and international patent registrations. There are currently 1,412 companies located at Daedeok Innopolis, an increase of 2.2 times the number existing in 2004. There are 41 foreign R&D institutes[26], and total R&D investments grew from USD 163 million in 2005 to USD 625 million in 2015. Technology transfer increased from 611 cases in 2005 to 1,054 cases in 2015, and the total associated fees increased from USD 4.7 million to USD 6.2 million, respectively. Domestic patent registration grew from 22,625 cases in 2005 to 49,156 in 2015, and international patent registration from 5,935 to 16,256, respectively. Employment was 23,558 in 2005 and 67,054 in 2015, increasing 2.8 times, and 10,333 of these employees in 2015 held a PhD degree (representing approximately 11% of all PhDs in Korea). These numbers[27] illustrate a different dynamic within Daedeok Innopolis than in the previous phases. The cluster is seen currently as a global innovation hub for technology commercialization, combining R&D, business, and production (Oh & Yeom, 2012). Since 2005, the central government has designated the cluster as an R&DB special zone. The government created the INNOPOLIS Foundation in 2005 as an organization that specializes in technology commercialization by promoting the transfer of technologies to private companies and by realizing innovation through practical start-ups for entrepreneurs. The Foundation has promoted a complete technology innovation cycle starting with basic research, application and R&D, commercialization, and entrance into global networks. They have primarily supported these activities through technology search, matching commercialization, and growth support. Although the central government still has its role in

[26] These foreign R&D institutes include 30 GRIs and 11 PRIs.

[27] All numbers here are based on information from the INNOPOLIS Foundation (2015).

cluster development, local support has also been important, as the senior research fellow at Daejeon Development Institute points out.

> *From this stage, local government was partly involved in the design process of Innopolis. Also, the local government has supported local high-tech-based firms with central government funds. From 2005, the Korean central government designated here, at Daedeok, as an international research, development and business hub. They have a quite strong program through its Foundation for supporting international networks, commercialization, and renowned scientists and engineers. [Korean; senior research fellow at Daejeon Development Institute]*

According to Oh & Yeom (2012), Daedeok Innopolis has played a critical role through the years in raising Korea´s scientific global competitiveness as a world-class innovation cluster and a hub for global technology commercialization. On its solid foundation, some R&D achievements such as CDMA systems (which have become the global standard for mobile communication) and memory semiconductors (e.g., 4M DRAM developed through a joint effort between ETRI and private companies) have contributed significantly to Korea´s economic growth. From its S&T foundation to a business-friendly environment supported by the industry-academia-research network, the cluster is now seen as a stronghold for state-of-the-art technology enterprises that compete on the global scale (Oh & Yeom, 2012).

4.2.3 IBC at Daedeok Innopolis: from a coordinated effort to an organic process

The dynamics, role and governance of IBC at Daedeok Innopolis changed throughout its trajectory. The IBC governance moved, in particular, from a coordinated effort by a state-led model (early developmental phase), followed by combining public and private coordinated models (middle phase) to the current diversified IBC model driven by the market as it is explored next.

4.2.3.1 Daedeok Science Park (1973 – 1989): Coordinated IBC by a state-led model

Highly skilled people such as scientists and engineers (primarily PhD holders) were the major concern of policy makers during the early period of Daedeok Science Park in their efforts to build S&T research capability. Although a reverse brain-drain effort existed before the launching of Daedeok (in the 1960s), they did not have this type of resource at that time, as both professors at KAIST state.

> *At that time (the early stage of Daedeok), our talented people were very much scarce resources. [Korean; professor at KAIST and director of the Post Catch-up Research Center]*

> *In 1973, the Korean government built the Daedeok Science Park. At that time, I think the most important thing was just to bring the human capital, highly skilled engineers and scientists. [Korean; professor at KAIST and director of the Future Management Research Institute]*

In the early stage of Daedeok (1970s), the Korean government decided to attract overseas scientists and engineers (reverse brain drain) and integrate them into local society. Most of them had received PhD degrees from universities in advanced economies; in particular, 60% had received a PhD degree from the US and 25% from Japan in ST&E fields (Jin et al., 2006), as the professor at KAIST points out.

> *… They studied mostly in the USA. Usually they were there to study at a PhD degree level. [Korean; professor at KAIST and director of the Future Management Research Institute]*

These talented people had an enormous impact, narrowly on cluster development and more broadly on economic development in Korea, in particular, on the transfer of S&T skills and managerial systems from other economies. They played a fundamental role in the knowledge diffusion and technology catch-up strategy. Both professors of KAIST support the importance of this role.

The Koreans who got their PhD abroad (mainly in the US) led economic development in Korea by means of developing innovation policies and modern education and management systems. They played the key role in it. [Korean; professor at KAIST and chair of the Business and Technology Management Department]

They have caught-up technologies, and they understood techniques such as project management. [Korean; professor at KAIST and director of the Post Catch-up Research Center]

Korea did not have the necessary skills, such as in S&T research capabilities and in managerial systems. Countries such as the US held leadership in these types of expertise. These returning PhDs transferred new models for research, technological institutes and science parks, as stated by the senior research fellow at Daejeon Development Institute. These types of skills were helpful to the design process of Daedeok in the early developmental stage of the cluster.

In the first stage, oversea specialists were involved with the design of Daedeok Science Park. In the process of designing the cluster, the central government benchmarked some institutes, mainly Battelle in the US. The central government was inspired by them. Also they benchmarked Tsukuba Science Park in Japan, Novosibirsk in Russia, Rehovot in Israel … They wanted to establish the basic line of science and technology infrastructure in this place. Science and technology specialists from Korea and the US exchanged information in the design process of Daedeok Innopolis. [Korean; senior research fellow at Daejeon Development Institute]

Some of the Koreans who obtained PhDs overseas, primarily in the US, became partners (and in some cases friends) and maintained their network ties among themselves. These personal ties were also important for sharing technological skills and new business models to promote growth opportunities for companies such as Samsung and SK (which did not have these skills locally at that time). They became, for instance, the first generation of semiconductor experts in Korea, as the CEO of FLEXSCON points out.

The first group of semiconductor [professionals] in Korea studied in the USA, and the Korean government got (companies like Samsung) experts from the USA to Korea, and they became the first generation of semiconductor [professionals] in

Korea. It was around the 1980s. Both former CEOs of Samsung and SK studied at the US, for example, and they were good friends … They implanted the high technology in the company in Korea. [Korean; CEO of FLEXSCON]

Although Korea was in the process of implementing S&T capabilities at that time and lacked a good infrastructure (e.g., attractive conditions and an intellectual atmosphere), the returnees were attracted to the fact that they were empowered and were not just another employee as they had been in the US. A professor at KAIST gives this example.

Korean people usually go back to Korea after studying in the US rather than staying there. It was maybe because some cultural situation. Since Korea is a small country, the returners could have a big voice in academics, politics and other areas. If they stayed in the US, they would be just another one of many citizens. Also, Koreans could not be a major ethnic group in the US, just a small group. So, if they come back to Korea, they could become big guys in the academics, politics and industry. [Korean; professor at KAIST and chair of the Business and Technology Management Department]

The Korean government supported the largest portion of the PhD exchange programs by giving scholarships during that time, in particular, under the Ministry of Education. According to Jin et al. (2006), the number of those who received PhD degrees overseas increased from only a few per year (e.g., 29 PhDs in 1965 and 101 PhDs in 1973) early in this period to reach one thousand per year (e.g., 1,016 PhDs in 1989) toward the end of it. On average, each year, 262 foreign PhD holders were produced in all academic fields from the past (in 1965) to 1989, in particular, 55% of them were related to S&T fields such as science and engineering (Jin et al., 2006). The competition to gain government scholarships was very high. The government offered scholarships to send a select group of talented people to top universities worldwide, most of them in the US. The president of Daedejon Institute for Regional Program Evaluation took advantage of this opportunity, as is shown below.

There was significant support from the US government at that time. There had been a government scholarship program for several years. To tell the truth, I am one of the recipients of the government scholarships. We applied for a call to get the government scholarship in order to study abroad under evaluation of the

Korean Ministry of Education. The competition ratio at that time for this scholarship, at my time, was like forty-four to one vacancy. In my time, probably there were only four men selected. I was lucky because, for example, the tuition of Stanford University (where I have been) was high. The government covered this tuition, and also they gave us all cost of living. So we were very happy, it was very sufficient so that we could study without any worries about money problems. [Korean; president of Daedejon Institute for Regional Program Evaluation]

The government also established some control mechanisms that aimed to attract those highly skilled scientists and engineers back to Korea. In addition to the strategy to enhance the attractiveness of the cluster for these people by building an R&D environment, the control mechanisms included an obligation to return to Korea after obtaining a PhD degree for those people who received government scholarships. The president of Daedejon Institute for Regional Program Evaluation and two professors of KAIST discuss this obligation.

The only obligation that we had to get this scholarship was to come back to Korea permanently. [Korean; president of Daedejon Institute for Regional Program Evaluation]

There was an obligation to return back to Korea after getting your PhD degree abroad in the early stages of development. [Korean; professor at KAIST and director of the Post Catch-up Research Center]

The government gave them high incentives to bring them back to Korea. Why don´t they contribute for their country developing science and technology capabilities? So, the government built some research institutes here supported by the government to host those experts. [Korean; professor at KAIST and director of the Future Management Research Institute]

The PhD holders were also encouraged to return to Korea through package incentives. These benefits were quite similar to the packages of fringe benefits provided to returning scientists and engineers in the state-led repatriation model in the 1960s and 1970s (for more details of this particular package, see Yoon, 1992: p.14). The benefits included relocation expenses (e.g., airfare for them and immediate family members and door-to-door moving expenses), free housing, overseas travel, subsidized education for their children, subsidies for local transportation, and salary advantages. Because the spin-off effect was being generated at that time (in the 1970s), the private sector also offered a package of fringe benefits to attract overseas talent. Although fewer in number than public institutions, private institutions tended to offer more benefits to these repatriates than the public sector (such as higher relocation coverage, educational subsidies for children, housing, and automobiles). Some private companies, for instance, also offered long-term no-interest loans to subsidize housing. Therefore, the majority of scientists and engineers who received PhD degrees overseas were hosted by GRI (such as ETRI and KAIST) during the early developmental stage of Daedeok. In these cases, the government tried to match the salary and other conditions to the pattern in the West (mainly the US) to increase the attractiveness to the returning PhDs, as two professors of KAIST and two members of regional government share.

> *The government provided some benefits for returning Korean PhDs from the US. Those who came from the US received double their salary. For example, at that time, the Korean government tried to meet (set) the US level of salary … probably avoiding brain drain in Korea. [Korean; professor at KAIST and chair of the Business and Technology Management Department]*
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> *ETRI was my first job after returning from the US, and they provided a house to my family. [Korean; president of Daedejon Institute for Regional Program Evaluation]*
>
> *The United States' living conditions was really high comparing to here at that time, so people had a kind of penalty if they did not go back to Korea after the scholarship period ... The salary was high and the fringe benefits were also high, attracting them back. So, if they stayed here, they got more favorable conditions than others, including leaving conditions (such as receiving apartment or housing). [Korean; professor at KAIST and director of the Future Management Research Institute]*
>
> *… The Korean government gave them houses and a very high level of salary [Korean; senior research fellow at Daejeon Development Institute].*

These types of efforts from the Korean government were the foundation of the S&T research capability at Daedeok. Because they offered the returning PhDs better salaries and good fringe benefits, they encouraged highly skilled scientists and engineers to return to Korea. An executive member of the INNOPOLIS Foundation gives an example of a senior professional of the first generation of semiconductor experts in Korea.

> *There is a man called Dr. Bon Lee, who was studying in the United States, and the Korean government offered him to come back to Korea. They gave him some incentives such as a house. He was researching semiconductor chips, DRAM mems chips. It was around 1970s and 80s, when it had been building the foundation of the National R&D capacity. [Korean; director of Global Cooperation at INNOPOLIS Foundation]*

The CEO of Hana Micron was also from the first semiconductor generation in Korea. Although there were those types of benefits (salary and leaving conditions), he shares how hard was to recruit PhD holders from the US at that time to the private sector. He also points out the importance of the roles these people played in the development of high-tech businesses (such as in the semiconductor industry).

> *I was the senior manager at Samsung, and then I was promoted to vice president in 1987. I started to recruit some Korean PhDs in the US to work at Samsung in Korea at that time. It was 'very very' difficult to persuade them because they knew about Samsung semiconductor, the technology was 'very very' poor … The Korean government and a lot of Korean professors were 'very very' worried about Samsung's ideas and risk. The former chairman made that decision, and after that, I had to invite some Korean engineers who worked at American semiconductor companies. Firstly, I could hire only one PhD because they didn't want to work in a very poor and risky place. Because it was not attractive. Even though we offered enough salary, scholarships for their children, housing, and everything we could. The first year, I could recruit only one PhD. His name is Dr. Gyn, and later he became a minister in the Korean government at the telecommunication department. A very famous guy. And he was the first PhD. After that, he gave me a lot of information about the Korean PhDs working in the United States semiconductor companies. With that material, I visited some places. I've been to many places such as in New York State, California and Phoenix. I visited those places, and I tried to persuade them, saying, 'please, let's go, let's develop the Korean semiconductor industry. We can be heroes at this semiconductor business in Korea.' Every year, the number was increasing, but even though ... business is business, that's why Samsung didn't have enough competitiveness, and some of them escaped from Samsung and they went to university as professors … Some years I supported more than 50 high engineers from the United States. That's why Samsung is the semiconductor number one in the world. Samsung semiconductor business has more than 500 PhDs already. That's why Samsung semiconductor is doing memory business, and they are also challenging some systems, smartphone application processes, they are doing*

'very very' well. It is because they have 'very very' good human resources who studied in United States universities. [Korean; CEO of Hana Micron]

Through the testimony from the CEO of Hana Micron, it is possible to see that cross-sector links were unlikely at that time. Moreover, even though there were a few companies, there was internal competition for highly skilled scientists and engineers between the GRIs and the private sector. That period was characterized by the S&T foundation, and the relationship between the GRIs, universities and industry was not developed. There is no evidence that these network ties were intentionally promoted, as two professors and a regional government member note.

The university and industry linkages were not very well developed at Daedeok in this early period. [Pakistani; professor at Solbridge and chair of the Management Science Department]

Even KAIST was moved to Daejeon in this period; at the early stage, only weak ties existed between research institute and industry. [Korean; president of Daedejon Institute for Regional Program Evaluation]

The cross-sector links at that time were highly unlikely. It is mainly because most of them got their individual fund to complete his or her studies in the US. After returning, for example, they got a job in a government research institute (GRI). [Korean; professor at KAIST and director of the Post Catch-up Research Center]

Even though these network cross-sector ties were unlikely, the majority of the returning PhDs made enormous contributions to the future of the industry. The contributions were, for instance, the transfer of high technology and knowledge from advanced economies such as the US to Korea. A former PhD student at Stanford offers testimony on the technology transfer process through the translation of technical manuals for equipment that Koreans purchased from a specialized US company.

I was almost finished with my thesis, after four years studying at Stanford (US), and I got a temporary job at Applied Materials. This company was a big name for semiconductor equipment. I did translation for Korean engineers who were coming to Applied Materials to get educated on the machines that they buy. There were manuals to operate their machines, which were written only in English.

That's not very convenient for the Korean engineers, who are not very familiar with foreign languages. So I translated them. That must be the first time that the manuals from Applied Materials came out in the Korean language. So Korean engineers could easily understand how to operate the machine from Applied Materials. [Korean; president of Daedejon Institute for Regional Program Evaluation]

Based on the evidence above, it is possible to see that the likely final destinations of the returning PhDs were GRIs, research institutes, and universities (and not companies). Moreover, cultural aspects strengthen this point because Korean society has long respected the position of professors. The returning PhDs wanted to achieve a professor position for cultural reasons, as a professor at KAIST notes.

… after they got their PhD degree, they come back to join a public research institute or the private institute, right? They continue their research or job (in that place), and finally they wanted to join the university. It was because here in Korea, as a traditional society, we respect our professors. The final destination was to become professors. [Korean; professor at KAIST and director of the Future Management Research Institute]

It is highlighted here that the early stage of Daedeok was embryonic and under development. There were only basic conditions, for instance, for the infrastructure and research facilities (such as labs and teaching facilities). The returning PhDs were the first highly skilled people to arrive there to develop S&T research capabilities (according to the cluster strategy of this period). In this sense, the returning PhDs did not have a clear alignment with their career path development. On the one hand, they received their PhD degree overseas after writing a PhD dissertation focused on certain specific knowledge. On the other hand, they were also usually involved with a research atmosphere that emphasized accumulating broader knowledge. They took both types of knowledge to their hometown (knowledge learning – diffusion process). That was the starting point. The interviews indicate that the majority of the returning PhDs did not have clear alignment between their local career path and their overseas experience. Basically, the majority of returning PhDs lacked this alignment. Most of them moved from their PhD subjects to other fields. However, a few of them had the opportunity to develop their career path according their PhD subject. A senior executive who was a PhD student at Stanford and returned to Korea to take a job position at ETRI and also an executive position at the Ministry of Science and Technology of Korea followed by his present job position as a regional government member gives examples of both situations from his own job career experience, which was an exception.

> *I have been working on compound semiconductors for all my job career, including my graduate studies, maybe more than thirty years. The best place for my research at that time (and still now) was ETRI because we have a private clean room for compound semiconductors. I was very lucky to run it, develop, and hire people, everything only for compound semiconductors. Actually Mr. Kwon (who was the CEO of Samsung electronics at that time) and I used to play tennis and had dinner all together. He got his PhD also from Stanford a couple of years earlier than me. I did not get a job at Samsung because my major was on compound semiconductors, not silicon semiconductors. I am one of the luckiest people. All my career path has been in line with my studies abroad and local work activities. That's not the usual case with many people. One of my best friends, who went to Stanford with me, is a mechanical engineer, and he is running a venture capital company now. [Korean; president of Daedejon Institute for Regional Program Evaluation]*

4.2.3.2 Daedeok Valley (1990 – 2004): coordinated IBC by combining public and private models

The cluster’s dynamics during this period were clearly different from those of the previous period. The scientists and engineers who obtained high educational degrees overseas made an enormous effort to establish S&T research capabilities in the previous phase of Daedeok. During this second phase, Daedeok’s policy was focused on innovation strategy. The returning PhDs had made an enormous contribution here, for instance, because they were in decision making positions. A professor at KAIST provides an example of this:

> *After the early period, if you analyze the public research institutions, a high majority of its presidents came from the United States, they were educated in the*

> *United States. [Korean; professor at KAIST and director of the Post Catch-up Research Center]*

The returning PhDs were also in key positions at local universities. They transferred new models of innovation systems from institutions in advanced economies (mainly in the US) to GRI and local universities. Both of these (GRI and local universities) actively supported innovation by means of, for instance, creating business incubation centers with administrative, marketing, and legal services (Oh & Yeom, 2012). They were building their own R&D capabilities and leapfrogging into state-of-the-art technologies. On the one hand, this new model for an innovation system created the seed for future technology commercialization. On the other hand, the returning PhDs maintained close ties with their previous experience overseas. These two forces (a new model of innovation systems and global personal networks) leveraged innovation initiatives resulting, for example, in international joint patents, as told by a professor at KAIST:

> *We built our own individual technological capabilities in the 1990s. Based on that, there was a balance in the international cooperation of Korea. We started to develop join patents with the United States. [Korean; professor at KAIST and director of the Post Catch-up Research Center]*

Not only did the returning PhDs working at Daedeok institutions during that period play an important role in the new innovation environment, but they were joined by Korean-American scientists and engineers who were leaving the US (or other advanced economies such as Japan) at that time. In the 1990s and early 2000s, the number of foreign PhD holders had dramatically increased. On average each year during that period (1990 – 2004), 1,500 foreign PhD holders were produced in all academic fields compared to fewer than 300 hundred, on average per year, during the previous period (1965 – 1989). Among those receiving PhDs during this phase (1990 – 2004), approximately 700 PhD holders were in the ST&E fields (Jin et al., 2006). Approximately 20% of them stayed in the US when they began their study in the

US (Jin et al., 2006). These PhDs basically left Korea more than a decade ago (in the 1980s and 1990s), earned their PhD degrees at top US universities, and did not return to Korea, instead, rising to the ranks of such leading US companies as IBM, Fairchild, Intel, and National Semiconductor (KIM, 1997). Additionally, a higher percentage of those who stayed overseas chose a post-doctoral research position as their immediate career path. Jin et al. (2006) show that more than 75% of PhD holders completed a post-doctoral course after completing their PhD. Although these numbers represent all of Korea, Daedeok attracted the majority of the PhDs (in particular, those with degrees related to ST&E) because the cluster was considered to be the first nationwide S&T zone at that time. Both the Korean government and the private sector (such as companies´ R&D subsidiaries) recruited these Korean-American scientists and engineers for short- and middle-term assignments for particular R&D projects. These new IBC dynamics also had enormous implications for the cluster´s growth.

These new IBC dynamics were promoted not only by the public sector, as during the previous phase, but also by the private sector. Korea´s private R&D sector also offered challenging jobs and attractive compensation packages with considerable independence in an attempt to recruit Korean-American scientists and engineers to Korea. Some did return[28] for short- and middle-term assignments, maintaining close technical ties with Korea´s private sector. The new IBC dynamics were also instituted by the government by creating programs[29] to recruit Korean-American scientists and engineers for particular R&D projects lasting between six

[28] Government statistics show that the number of scientists and engineers recruited from abroad by Korea´s private R&D centers was 427 in 1992 alone (Kim, 1997).

[29] See item 4.2.1 of this chapter for more details of the "Brain Pool" program.

months and two years. All of these programs changed the Daedeok environment, attracting overseas talent. A professor at KAIST shares his experience.

> *I was a master's student at Seoul National University in Science Promotion Policy in 1989, and we had a field trip to Daedeok cluster in order to see what was happening there. So, when I was visiting there, it was a kind of a culture shock. I had never seen that kind of housing. It was, actually, a US style of living environment. And there was a kind of flat land, a green lawn field, well maintained with a house in the middle. But that house was totally different from a Korean traditional house. It was a kind of two-story cottage. But in Korea, at that time, as I grew up in Korea, I had never seen that kind of two-story cottage. Totally modern style housing unit. Daejeon units were built for those who were returning to Korea. [Korean; professor at KAIST and chair of the Business and Technology Management Department]*

Additionally, because the Korean military culture was strong at that time, Korean men usually served in the army for three years. For those who received a PhD degree locally, the Korean government gave them high incentives to attract them to work at the GRIs and to avoid the loss of those highly skilled people, as the same professor says.

> *There was a king of an incentive to attract talented Korean people to KAIST at this time. All Korean males must serve in the army for three years at that time (nowadays it is two years). But, if they got a PhD here at KAIST, then they simply were trained just for four months at military training camp. This was an incentive to attract talented people and avoid brain drain in a sense. [Korean; professor at KAIST and chair of the Business and Technology Management Department]*

Based on the previous government effort to build up S&T research capabilities, given that there was basically no cross-sector links, in this phase, the private sector started to establish R&D subsidiaries at Daedeok. They intentionally established subsidiaries there to be embedded in an innovation environment and to promote their relationship with the GRIs and universities. Companies such as LG and Samsung are two examples of this, as another professor at KAIST indicates.

> *After installing the technology park here and after establishing some public institutes here, other companies (to say something) such as LG and Samsung established their R&D subsidiaries here … We promoted the relationship between companies and universities during the 1990s differently than in the beginning,*

where there were no ties between them. [Korean; professor at KAIST and director of the Future Management Research Institute]

The government made some special policies to promote the relationship between companies, GRIs and universities. They promoted their relationship by offering them particular grants and funds through local and international joint project programs. An executive member of INNOPOLIS Foundation offers evidence of this.

The Korean government made a special program in the 1990s, in which universities, industries and government organizations had to make a consortium for getting funds. That was the case in which the Korean government made policies for promoting cross-sector links through joint research projects. [Korean; director of Global Cooperation at INNOPOLIS Foundation]

The CDMA system[30] is one example of a joint project between ETRI and Qualcomm Inc. (an US based company). In 1991, a joint development agreement was signed by Qualcomm and ETRI to develop and commercialize the CDMA system in Korea along with other manufacturers, operators, and research actors (see details in West, 2001; and Tahir, 2012). Qualcomm essentially developed the technology design (as a chipmaker), and ETRI adopted it in the communication system in Korea. After testing the technology, it was transferred to Korean manufacturers, who completed commercial testing by 1995. A professor in a Korean university who studied the case of ICT systems in Korea in depth explains this process.

Early in this period (around 1990), there was a search for wireless technologies to replace the broadband technologies. ETRI brought these domestic capabilities for system development … The wireless system projects had been funded by the government, and they were coordinated and developed by ETRI. Their technology and systems were also commercialized by ETRI for the private sector. After developing wireless technology, ETRI also led the development of the CDMA technology in partnership with Qualcomm (from the US) ... Korea could

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[30] Code Division Multiple Access (CDMA) technology is a channel access method used by various communication technologies worldwide that was developed after the GSM (Global System for Mobiles) system. These (CDMA and GSM) were the two major radio systems used in cell phones in the 1990s before communication systems moved to other technologies such as 4G technology, which is used currently.

contribute with Qualcomm by building their technology into a system and providing a market where it could be launched, tested and diffused. [Pakistani; professor at Solbridge and chair of the Management Science Department]

The Korean government rejected GSM and declared CDMA to be the national standard as the most efficient mobile communication solution. The technology was rapidly diffused in Korea, which became the leading CDMA market[31] after the US (Tahir, 2012). This example illustrates how global networks between cross-sector links drove high-tech development and its commercialization in Korea at that time. A senior researcher comments on this.

In this period, ETRI developed the CDMA system. They got the IP license for the basic core technology from Qualcomm (a US company). Qualcomm had its own concept of CDMA technology, but ETRI developed it for commercialization. So, in that period, they succeeded through this international cooperation … There were also other institutes in which they had this kind of cooperation in fields like biotechnology, semiconductors, and nuclear power. They mainly adopted the first stage of technology from overseas and then they developed it to the commercialization stage. [Korean; senior research fellow at Daejeon Development Institute]

The international mobility of talent was promoted through the CDMA project. The dynamic of those people played an important role in the technology and system development process. Returning PhDs who were working at Daedeok institutions and Korean-American scientists and engineers who were leaving the US helped this process. These talented people moved from the US to Korea and vice-versa, transferring tacit knowledge and technology. The professor specialized in ICT systems comments on this pattern.

Qualcomm was an active partner in which there was a very frequent movement of talented people from Korea to the US and vice-versa. There was a significant number of those people who were well educated in the US, trained in the US, and working on this project at Daedeok cluster. [Pakistani; professor at Solbridge and chair of the Management Science Department]

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[31] There were approximately 9 million total subscriptions for cellular service based on CDMA systems by 1998 (Tahir, 2012).

The Koreans caught up with the CDMA technology, transferred it, and commercialized it to their system faster than anyone. This system was rapidly diffused and commercialized worldwide. Because of their rapid co-development skills, Koreans were recognized as fast-followers. There is no evidence that this type of dynamic was in line with the IBC career path. Although the PhD holders who were working at Daedeok and those in the diaspora who were leaving the US (after obtaining their PhD degree, for example) were generically consistent with the S&T fields developed at Daedeok's institutions, they had no direct and specific alignment through their career path; a professor at KAIST shares his experience.

> *In my case, for example, I got a PhD at the UK in the 1990s. After returning to Korea, I got a job position at ETRI, and then I moved to KAIST as a Professor. But it was not intentionally in line with my career path. [Korean; professor at KAIST and director of the Post Catch-up Research Center]*

4.2.3.3 Daedeok Innopolis (2005 – present): Diversified IBC model driven by the market

The rapid development of Daedeok resulted in growth in the number of high-tech companies, R&D institutes, expenditures, transfer technologies, and domestic and international patent registrations (see all related numbers for these new cluster activities in section 4.2.2 above); since 2005, Daedeok has been a source of more diverse and heterogeneous value. The cluster has been moving rapidly to become a global innovation hub for technology commercialization, combining R&D, business, and production. Based on these new values, Daedeok has been competing globally in high-end volatile markets. A professor at KAIST differentiates this new dynamic from the previous phase:

> *The dynamic is more diverse today. Market driven gets more value, more diverse, more competition. There was a very narrow value at the beginning of the cluster. [Korean; professor at KAIST and director of the Future Management Research Institute]*

Even though the government is still contributing to cluster growth, the private sector has been the central element for current cluster development, as the same professor points out.

> *Based on economic growth, society becomes even more complex, and the power shifted from the public sector to the private sector … Now the government budget is smaller than the private sector. So, the companies are financing themselves because their income has been increasing based on their strong network (such as branches in the US and other countries). [Korean; professor at KAIST and director of the Future Management Research Institute]*

Based on these new cluster activities (and values), the knowledge network flows have been diversifying. In the early developmental stage, the cluster was catching-up in technologies, primarily through a knowledge learning process from advanced economies such as the US, and diffusing them locally. The returning PhDs played a major role in these processes. Since 2005, the cluster has been targeting global markets through a commercialization strategy. The knowledge networks have become much more globalized not only through knowledge learning-diffusion processes but also by targeting large markets such as China. Both personal and organizational ties are important paths to strengthen this type of global network, as a regional government member notes.

> *From this period, we already have substantial resources like manpower, funding, and other research facilities. So, many Korean scientists and engineers established their own network with overseas scientists and engineers. They have their own path for international cooperation. And each research institute in Daedeok also has their own organizational path for international cooperation. Both of them are very important nowadays. [Korean; senior research fellow at Daejeon Development Institute]*

After more than thirty years of development, the investments in human resources and global networks are generally well recognized. The returning PhDs guided government investments in building science and R&D capabilities at Daedeok. The government (and more recently the companies) alone could not have achieved the combination of local capabilities and global integration. The success of the cluster is primarily ascribed to investment in those human resources linking local knowledge and global connections, as a CEO of a local high-tech company (spillover from ETRI) states.

> *Definitely, we are very successful by focusing on human resource development, especially by having international connections through them. [Korean; CEO of FLEXSCON]*

The IBC dynamic has shifted from being government-driven during the early developmental phase of Daedeok to its current market-driven orientation. These new dynamics are much more diversified than those in the two previous phases. Although the government still supports the IBC, for example, by giving grants and funds to joint research projects, companies and individuals have also been supporting projects and programs broadly and strongly. A professor at KAIST discusses this diversification.

> *The intervention of the government in the global brain circulation in the beginning was much stronger than today; that is driven by the individual and/or company (market) and not driven by only the government anymore. [Korean; professor at KAIST and director of the Future Management Research Institute]*

The current innovation environment of Daedeok has been encouraged by promoting venture capital, start-up companies, and technology based companies, and by support from previously established institutions such as GRIs, universities and private R&D centers. A professor at KAIST shares his perception about this new diversified innovation environment and the Daedeok trajectory.

> *We were looking at the manpower development in the early period (1970s and 1980s) and promoting technological innovations and improving information networks in the 1990s onwards. Later, in the year 2000 onwards, we have been encouraging new technology based firms, venture capital, preferred investment environment, and those kind of things ... policies have been clearly changing. [Korean; professor at KAIST and director of the Post Catch-up Research Center]*

Because the government established Daedeok as a national R&DB special zone in 2005, the current outcome expectation is technology commercialization. The cluster's actors have been focusing on creating new business opportunities locally and globally by means of technology innovations supported by their R&D activities. An executive member of the INNOPOLIS foundation mentions this focus.

> *This is a special law by the Korean government designating Daedeok as the area where the research results must be commercialized and must foster startups or starting businesses. [Korean; director of Global Cooperation at INNOPOLIS Foundation]*

All of these new activities and values for the cluster have changed the governance system of the IBC from a centralized (driven by the government) to a decentralized (driven by the market) control system. The control mechanisms of the IBC are conducted by each actor independently and are no longer coordinated by the government. The companies, universities, GRI, and R&D centers of Daedeok have been establishing their own strategy and control mechanisms for IBC. The local universities, for instance, have their own international strategy and activities. They established their international offices as a control mechanism for supporting, monitoring, and managing (for example) the international exchange of faculty, researchers and students. The companies have also been coordinating their own activities in global value chains by, for example, establishing their subsidiaries in major markets (such as China) and embedding themselves in high-tech regions (such as Silicon Valley). These are just two examples of a more diversified IBC under the supervision of these different actors. They are currently independently targeting technology development and its commercialization locally and globally. A professor at KAIST discusses this change.

> *… in the 2000 onwards, private sectors and universities are building up their own R&D capabilities. Universities are now making their own international collaborations by themselves … We have been funding public research institutes for a long period, but your commercialization rate was so small. So now we are not aiming at the policy architecture, it must have their own exact target for the commercialization. So these are the big architectural changes for innovation policies. That's the change for the commercialization driven. [Korean; professor at KAIST and director of the Post Catch-up Research Center]*

Because the number of Daedeok's institutions (companies, GRI, R&D centers, and universities) has increased over recent decades, the interaction between them has also increased. The INNOPOLIS Foundation, for instance, was created in 2005 to contribute and facilitate those interactions. The Foundation is committed to revitalizing mutual cooperation and supporting the commercialization of R&D performance by turning innovation into practical start-ups for entrepreneurs. A professor and a regional government member discuss this role.

> *The management of this innovation cluster has changed over the previous phases, especially from the second phase when it became a research, technology and business development hub. The INNOPOLIS Foundation was created in this last phase as an organization which takes an interest in more commercialization and innovation than just R&D. Since then, the university and industry linkages have become better. [Pakistani; professor at Solbridge and chair of the Management Science Department]*
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> *Since there are many universities and GRIs in the cluster, the ties became significant between academia and industry. And now, the main targets of the cluster activities are technology transfer or commercialization or ventures. [Korean; president of Daedejon Institute for Regional Program Evaluation]*

Evidence of the increment in these interactions is the growth of small and medium high-tech companies through the spillover process. Universities and GRIs have been developing new technologies, sparking new start-ups and entrepreneurial companies. A professor notes this trend.

> *One evidence is the growth of small and medium high-tech companies. I have seen examples of spillover companies from research institutes such as KAIST and Chungnam University. There were a few hundred spillover companies in 2008, and now we have more than twelve hundred companies locally. That's very sizeable growth. [Pakistani; professor at Solbridge and chair of the Management Science Department]*

Coxem is one of these spillover companies from KISS. This high-tech company is now located in the industrial district of Daedeok (surrounded by more than thirteen thousand similar high-tech-based companies), and it has been targeting local and global markets for its microscope technology, as the company's CEO indicates.

> *Coxem is a spillover company from KRISS. This government institute developed the technology of SEM (Scanning Electron Microscope). Then, we got the technology license to our company in 2007. Actually, at that time, our company was established with a Daedeok R&D fund for starting up the company. [Korean; CEO of COXEM]*

Even as a small company, Coxem co-developed its technology with an US based company. The company's members made several international business trips to co-develop their technology. Additionally, a Korean/American engineer was invited by the international partner to participate in the technology development project primarily for his technical language skills. The CEO shares his own experience.

> *We co-developed the integrated technologies of SEM (Scanning Electron Microscope) and EDS (Energy Dispersive Spectrometry) in one product through a partnership with a US based company. Firstly, I sent some e-mails to everybody worldwide who had that technology. But no one answered. Secondly, fortunately, we made another contact, and then we got a good partner for co-developing this new technology. We visited them several times, and also they visited us here. Also, we used some software to communicate to each other. Communication in English is not easy for Koreans, so because of that, they provided a Korean/American engineer in their projects. [Korean; CEO of COXEM]*

The KAIST Institute (KI) is another example of promoting cross-sector links. The Institute was created in 2006 based on a generous donation from the Korean-American businessman Dr. Byiung Jun Park[32] and his wife Mrs. Chunghi Hong. It is located at the main campus of

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[32] Dr. Byiung Jun Park is a Korean-American who left Korea in the 1950s after graduating from Seoul National University High School, and he received his bachelor´s degree from Rhode Island School of Design (US), his Master of Science degree from MIT (US), and his PhD degree from University of Leeds (UK). He was executive vice president of the Consumer Testing Laboratory in 1966, founded the Merchandise Testing Laboratory (MTL) in 1986, become the President and CEO of the MTL in 1986, merged the MTL and Bureau Veritas (France) in 2001, became the special adviser of Bureau Veritas Consumer Products Services, Inc. in 2001, and became a member of the KAIST President's Advisory Council in 2007. He is a Korean-American who has been living abroad for many years, and he has contributed to Korean advancement in the R&DB model.

KAIST in Daejeon, and it aims to produce world-class R&D outcomes through interdisciplinary and integrated studies. The KI consists of five research institutes: KI for BioCentury, KI for IT Convergence, KI for the Design of Complex Systems, KI for the NanoCentury, and KI for Optical Science and Technology. Under each of these KI institutes, there are five affiliated research centers: Cancer Metastasis Control Center; Mobile Sensors and IT Convergence Center; Center of Fields of Robotics for Innovation, Exploration, and Defense; Graphene Research Center; and Center of Optics for Health. Currently, approximately 270 faculty members and 300 students and researchers are engaged and working in interdisciplinary research projects and programs with an industry orientation. Along its trajectory (2006 – 2014), this world-class technology institute has generated 97 domestic and 8 international patents and produced 302 domestic and 33 international pending patents. Additionally, during this period, the KI has published 1,377 papers (SCI) and involved 212.7 million USD in 1,314 projects[33].

Based on all of these cluster dynamics, individuals and institutions have been seeking their own career path development. The returning PhDs, for instance, were attracted to key job positions by the benefit packages offered by the government. Currently, there is high competition for these key job positions. This competition is the same for Korean-American scientists and engineers who have lived abroad. The cluster attractiveness for global talent has been increasing over time, but competition has also been increasing. Top Korean universities

[33] All of these numbers and data for the Institute are based on the 2014 KI annual report, which was downloaded on 30th November 2015 from the KI website (https://kis.kaist.ac.kr/).

(such as KAIST[34]) are graduating individuals whose high skills are equal to the skills of those educated at world-class universities abroad. In fact, Daedeok's institutions are currently establishing their own talent development programs, contributing to cluster growth through a global technology commercialization strategy.

4.2.4 From coordinated to organic IBC processes: an evolutionary IBC governance at Daedeok

The IBC governance at Daedeok Innopolis changed throughout its trajectory: from a coordinated effort by a state-led model (early developmental phase), followed by combined public and private coordinated models (middle phase) to the current diversified IBC model driven by the market. In the early phase (1973 – 1989), IBC played an essential role in building S&T research capability, in particular, in both the knowledge learning-diffusion and technology catch-up processes. The government made special policies to promote overseas PhD degrees in advanced economies (mainly in the US) and to attract overseas scientists and engineers back to Korea (reverse brain drain). Those highly skilled people played an important role in these processes (knowledge learning-diffusion and technology catch-up). The global connection (mainly networked to the US) stimulated local cluster development in its early developmental stage. The government supported the PhD exchange programs by offering full packages of scholarships and attracted highly skilled scientists and engineers back to Korea through empowerment (tactical and strategic job positions), the establishment

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[34] KAIST has been ranked in the top 100 universities worldwide through the Times Higher Education (THE) methodology. KAIST´s position in the world university rankings for the 2014 – 2015 period was 52nd (https://www.timeshighereducation.com).

of GRIs (as hosting places), salary advantages, and fringe benefits (such as free housing, relocation expenses, and subsidized educational costs for children). All of these government programs created the seed of a highly skilled labor pool at Daedeok through a clear government intervention. The government promoted and coordinated most of the IBC's activities. The level of government intervention was high at that time; an executive member of the INNOPOLIS Foundation differentiates this from the current situation.

> *Probably at that time, Korean intervention was maybe 80 percent, now it's probably 40 percent. [Korean; director of Global Cooperation at Innopolis Foundation]*

The level of government intervention gradually changed by including the private sector in the second phase (1990 – 2004). The private sector was involved with R&D activities and high-tech start-ups. Both public and private sectors built local R&D capabilities by leapfrogging into high-end technologies (e.g., CDMA systems and 4M DRAM technology). Funding for these R&D activities expanded beyond the government to also include the private sector, as an international professor points out.

> *In this second phase, the R&D expenditures from the government were gradually tilting from approximately 80 percent in the previous phase to 30 percent by the following phase of the cluster development. The other part of the R&D expenditures was funded by the private sector. So giving that, actually the government has successfully been able to shift this R&D budget (or financing) from public towards private. [Pakistani; professor at Solbridge and chair of the Management Science Department]*

The government and private sectors both supported IBC programs. The programs aimed to support PhD degrees overseas for highly skilled Koreans (as in the previous phase) and to attract Korean-American scientists and engineers to work at Daedeok. These highly skilled people were offered good opportunities such as full-time job positions (e.g., professorships at universities), and short- and middle-term assignments (e.g., joint R&D projects). The new IBC dynamics provided the essential combination of local knowledge and global connections to co-develop high end technologies. They co-developed these technologies through cross-sector links between companies, GRIs and universities. All of these local and global networks drove the co-development of some high end technologies and their international commercialization. All of these activities were promoted and coordinated by both the government and cluster members.

After 2005, during the third phase, the IBC governance became diversified and driven by the market. The control mechanisms of IBC were decentralized. The private sector became the central element, and both personal and organizational ties were used to strengthen its global networks. Returning PhDs and Korean-American scientists and engineers have been establishing local capabilities and globally integrating their institutions. Although there is still government intervention (mainly funding driven), these institutions have been developing their own growth path following globalized market dynamics. The IBC has primarily been driven by the market in an organic model, as noted by an executive member of the INNOPOLIS Foundation and a professor at KAIST.

> *Currently, the global brain circulation that I can see is more organic, because different perspectives of R&D projects insert into global networks. The people have been going, for example, to China or even to the United States through the technology institutes, the graduate programs, and the companies themselves. So, it's more organic, it's not so coordinated as in the past. [Korean; director of Global Cooperation at Innopolis Foundation]*
>
> *The process of international talent mobility today is more ecological, is an ecosystem approach … A coordinated process does not work anymore; we are more organic (today). [Korean; professor at KAIST and director of the Future Management Research Institute]*

Even though Daedeok is currently running in an organic IBC model, there are some limitations to this model. The global competition for highly skilled scientists and engineers has been increasing over the last decades, in particular, in the context of high-tech clusters. It is hard for later-developed countries (such as Korea) to compete with such regions in advanced economies (such as the US) in an organic IBC model driven by the market. The Korean government appears to be continuing to pursue its RD&B model to improve the attractiveness of Daedeok with a business friendly policy. In fact, the attractiveness of the cluster must be high to attract and keep talented people. Therefore, the Korean government continues to promote highly skilled people by offering funds (through, for example, joint R&D projects), as a regional government member notes.

> *We are still remaining a little coordinated global brain circulation process. The place should be more attractive to be an organic global brain circulation process. So, the main incentive for global brain circulation is still the funding base. The Korean government relied on funding as a mechanism to attract scientists, global renowned scientists. But, if we look at Silicon Valley and other attractive places, there are many R&D resources. Many renowned people and knowledge flow processes, but in the late developed countries, we don't have that sort of process and that sort of culture yet. [Korean; senior research fellow at Daejeon Development Institute]*

Appendix B summarizes the cluster development of Daedeok Innopolis from the IBC perspective, as described above, according the dimensions of analysis scheme of this current research. Based on all of this evidence, it is possible to state that IBC governance moved from a coordinated effort to an organic process over Daedeok Innopolis' development.

5 DISCUSSION

The main objective of this study is to analyze the role of IBC governance in promoting the growth and upgrading of clusters in emerging economies. Two generic forms of IBC governance (organic process and coordinated effort) are differentiated in stimulating these processes. Based on the literature review, including the two prior literature cases of IBC – Bangalore and Hsinchu – and on the exploratory case of Sinos Valley, five propositions were formulated that were tested in the case study of Daedeok Innopolis. First, IBC governance is discussed in the cases studied and, second, the research propositions are validated.

5.1 Discussing IBC governance in the cases studied

The form of IBC governance in the two prior literature cases of Bangalore and Hsinchu is identified as an *organic* process. It is characterized as an organic process because it has been mainly driven by shifting market and entrepreneurial opportunities. In the case of Bangalore, whereas the initial brain drain of Indian engineers in the 1980s was driven by domestic oversupply and a growing demand for software services in the US and UK, the reversed brain drain was equally driven by growing job opportunities in India (along with job constraints in the US, in particular) in the late 1990s. Actual circulation through continuous movement between clusters started around the turn of the millennium based on a number of critical enabling conditions. First, a diaspora community already existed thanks to prior 'brain drain'. Second, Bangalore had become an attractive location for job creation and entrepreneurship prior to the return of the migrants. Third, and relatedly, prior MNC investment, a favorable infrastructure, and pre-existing market connections between clusters created attractive conditions for returning entrepreneurs. In contrast to the important role played by market and economic conditions, governance and policies played only a minor role in stimulating IBC (Saxenian, 2005). In this sense, governance was limited to professional associations and Internet platforms, as well as the establishment of cross-regional VC firms facilitating movement and entrepreneurship across locations.

In the case of Hsinchu, in addition, a decentralized industrial system has promoted an *organic* form of IBC governance. The decentralized industrial system of Hsinchu allows flexibility and supports the innovative capacity of the cluster members, protecting them in the volatile high-tech market environment (Saxenian, 2006). This system thus created domestic demand for high-tech industries (such as semiconductors) and subsequent demand and opportunities for returnees (Kenney, Breznitz, & Murphree, 2013; Saxenian, 2006). Actual IBC has contributed to adoption in these high-tech markets since the 1990s through an essential mix of local knowledge and global connections (Saxenian, 2006). Whereas Taiwan was recognized as one of the leading nations experiencing the brain drain of scientists and engineers in the 1960s driven by better facilities, higher salaries and the intellectual atmosphere, in Silicon Valley in particular, a reversed brain drain started in the 1990s driven by growing job opportunities in places like Hsinchu Science-based Industrial Park and research and technology institutes (e.g. ITRI). Although the returnees contributed to new policy formulation (e.g., the science park model) in the early developmental stages of Hsinchu (Saxenian & Hsu, 2001), the actual interactions between these 'Argonauts', US-educated Taiwanese scientists and engineers, and US-based scientists and engineers have contributed to cluster members (such as entrepreneurs, SMEs and MNCs) and to the clusters as a whole on both sides of the Pacific (Saxenian & Hsu, 2001). All of these complex IBC interactions have mainly been driven by shifting market and entrepreneurial opportunities (similar to Bangalore), and governance in the case of Hsinchu was limited to create facilitating conditions for cluster growth, such as laying the state-led groundwork for indigenous entrepreneurship and MNC investment.

Similar forms of organic IBC have been observed between Silicon Valley and a number of other emerging clusters in Israel and other countries (Bresnahan et al., 2001; Saxenian & Hsu, 2001), as well as between Bollywood and Hollywood (Lorenzen & Mudambi, 2013). Yet, Saxenian (2005) argues that the transferability of this model is limited. First, IBC of the type studied by Saxenian and colleagues relies heavily on prior investment in higher education and on politically and economically stable environments that immigrants will want to return to. For this reason, for example, politically unstable countries, e.g., in Africa, are unlikely to benefit from IBC dynamics. Second, Saxenian (2005) argues that large urban areas in particular, such as St. Petersburg and Buenos Aires, may benefit from IBC whereas smaller places may lack a sizeable labor pool, market access and general attractiveness for IBC and other facilitating conditions, such as MNC investment, to occur in the first place. Third, it is argued that most of the clusters whose growth has been attributed partly to IBC were already growing or established when the first wave of migrant entrepreneurs and professionals returned. For example, Bangalore and Hsinchu had already succeeded in attracting major MNC investments before IBC was set in motion. In addition to these arguments, this study also indicates a new IBC governance perspective in steering the growth and upgrading of smaller/nascent clusters, before starting a self-reinforcing dynamic typically in larger/growing clusters, as discussed next.

Although Sinos Valley is not a success high-tech cluster, being in its early developmental stage, it is assumed that the IBC governance is a *coordinated* effort. It is coordinated because the alliance between Sinos Valley and Korea has primarily been driven by a deliberate design and governed through cluster policies and a strategic alliance of organizational actors, for example, firms, universities, and governments. The connectivity between these two globally opposite regions illustrates this effort. The learning-diffusion processes of knowledge and technology were promoted via tie formation – both within and between clusters – through strategic agreements. These agreements have created an interdependent and sophisticated 'IBC architecture' that has stimulated cross-sector links between firms, universities and governments at the local and global levels. This IBC architecture also has stimulated the alignment of career paths through a combination of international talent mobility (as academics and interns) and local job opportunities. Although this cluster initiative could build on existing capabilities, resources and initiatives to a degree, one objective was to avoid prior mistakes. First, efforts were needed to make local employment less dependent on a volatile global competitive market (as experienced by the shoe manufacturing industry in that region). Second, measures needed to be put in place to prevent harmful brain drain (as experienced by the IT industry in the same region). The coordinated effort with regard to IBC was engaged to overcome these prior mistakes, as well as, to increase local high-tech capabilities and promote the cluster's insertion in global production system. Although this is an initial developmental process, this coordinated effort can be seen as a seed for attracting other business initiatives and increasing the local entrepreneurship capacity in this segment for cluster growth.

In the success case of Daedeok, arguably, IBC governance has changed over the cluster's evolution from a coordinated effort (initial developmental stage) to an organic process (mature developmental stage). Unlike the organic IBC process at Bangalore and Hsinchu, the coordinated IBC effort in the early developmental stage of Daedeok was driven by the government. Whereas the brain drain in Korea during the 1960s was driven by conditions similar to those in Taiwan (such as better facilities, higher salaries and the intellectual atmosphere, mainly in the US), the reversed brain drain in Korea started earlier than that in Taiwan and Bangalore (the late 1960s in Korea compared to the 1990s in the other two cases), and it was driven by a state-led model while the other cases were driven by bottom-up processes (such as growing local job opportunities by promoting indigenous entrepreneurship and MNC investment). The government created a number of facilitating conditions in the early developmental stage to build local S&T capabilities. First, they supported attending PhD programs through scholarships to promote overseas PhD degrees in advanced economies (mainly the US). Second, they built S&T research infrastructure by developing the GRI (such as ETRI and KAIST). Third, they attracted returning PhDs by offering them strategic job positions, salary advantages, and fringe benefits (such as free housing, relocation expenses, and subsidized educational costs for children). All of these facilitating conditions created the seed for a highly skilled labor pool at Daedeok through clear government intervention. The level of IBC coordination was thus high in this early developmental stage of Daedeok.

The level of government intervention in IBC processes gradually changed in the second phase. The returnees were attracted by both sectors (public and private) offering them good opportunities such as full-time job positions (e.g., professorships at universities) and short- and middle-term assignments (e.g., joint R&D projects). Based on their personal ties, the returnees and US-based scientists and engineers combined local knowledge and global connections to co-develop high-end technologies and to promote private R&D and high-tech start-ups. Whereas other high-tech clusters grew thanks to MNC investments (e.g., Haifa in Israel and Oulu in Finland), Daedeok grew thanks to government effort and the networks within and between clusters promoted by returnees and by university-industry-GRI linkages. In particular, it grew thanks to the IBC networks that stimulated indigenous entrepreneurship capacity to generate cluster growth. In this sense, IBC was now promoted and coordinated not only by the government (as in the early developmental stage) but also by cluster members in a bottom-up process. This organic process, combining with the coordinated effort, began to play a prominent role in cluster upgrading and growth.

An organic IBC process prevailed in the mature developmental stage of Daedeok. Although the government still supports some IBC activities, mainly through funding (e.g., joint research R&D projects), the level of IBC coordination was much lower in this stage than in the previous ones. High-tech firms and entrepreneurs have promoted their own growth path in high-end markets. Similar to Hsinchu, actual IBC has contributed to adoption in these markets through an essential mix of local knowledge and global connections. In this sense, the circulation of talent between clusters has been much higher (in terms of numbers) than in the previous stages. For example, the number of foreign PhD holders dramatically increased from 432 in the 1960s to 15,612 in the 1990s (Jin et al., 2006). After 2000, the number has stabilized at approximately 1,500 per year (data from 2000 to 2004 according Jin et al., 2006). The majority of them (approximately 80%) return to Korea after studying and working, usually in the US (Jin et al., 2006). Whereas foreign PhD holders were attracted by a coordinated government effort in the early developmental stage, they are currently attracted by growing job opportunities (in world-class universities, firms and leading research institutes) and by an innovation and business-friendly environment. This example shows that not only has the level of governance changed but also the level of IBC has increased over the cluster's evolution. In fact, the actual IBC dynamics have increased and become more diversified with the new market-driven orientation than they had with the coordinated effort of the state-led model in the emergent stage. Based on this process, figure 18 illustrates the level of each form of IBC governance (coordinated effort and organic process) over the cluster's formation (from the emergent to the mature developmental stages) taking a relative view according the IBC dynamics.

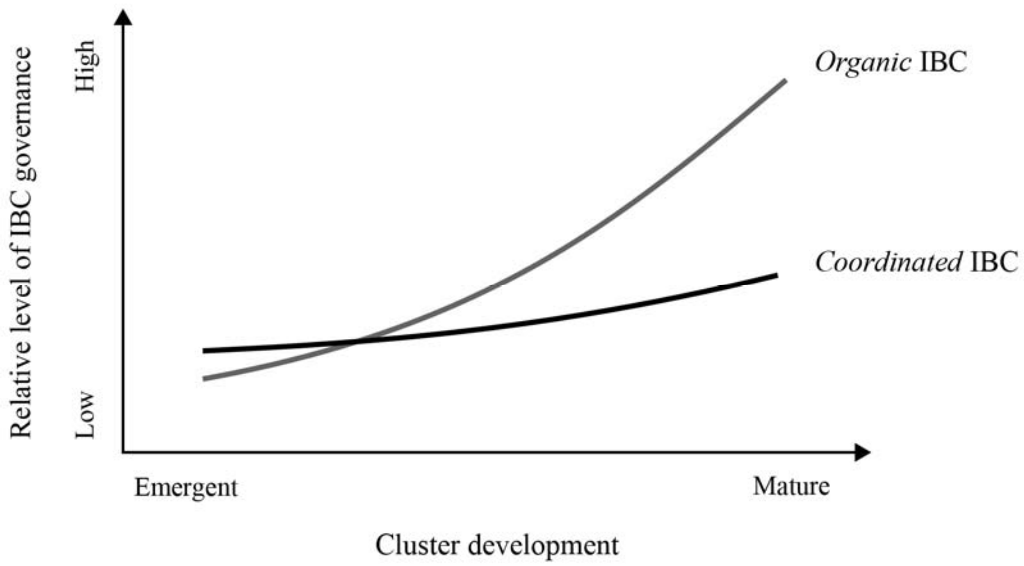

Figure 18. Relative level of IBC governance over the cluster's evolution

Based on the Daedeok case, it can be argued that the dynamics, role and governance of IBC have changed over the cluster's evolution. The IBC dynamics changed in particular by increasing the circulation of talent between clusters during the development of Daedeok. Because the number of cluster members (e.g., firms, universities, research institutes) increased during this period, the IBC dynamics also increased based on the critical role of IBC in the upgrading and growth of Daedeok. IBC governance changed in particular in terms of the level of intervention in promoting IBC over the cluster's evolution. In the emergent stage, arguably, the Korean government's intervention in IBC was higher than its intervention during the mature developmental stage, when IBC instead became a market-driven process. This behavior is thus plotted in Figure 18. Because cluster development is a heterogeneous process (Menzel & Fornahl, 2010), and not linear, the lines plotted (organic and coordinated IBC) are slightly curved and not straight. Based on this behavior, first, it can be observed that the relative level of both forms of IBC governance (organic and coordinated) increases over the cluster's evolution. Second, in the emergent stage, both forms of IBC governance are at a lower relative level, and in the mature developmental stage, both forms of governance are at a higher relative level. Third, organic IBC governance is at a higher relative level than the coordinated effort in the mature stage and at a lower relative level at the emergent stage because the Korean government's intervention has been gradually decreased while the market-driven process has spontaneously increased over the cluster's evolution. It should be noted that the turning point of the relative level of IBC from a coordinated effort to an organic process is difficult to precisely identify in the Daedeok case (see the intersection point of the two curves in figure 18), but it appears to occur in the growth stage. This figure thus elucidates the two distinct forms of IBC governance and their relational effects in the cluster's upgrading and growth over its evolution.

5.2 Validating the research propositions

Based on the empirical evidence from the case study of Daedeok, in short, it is argued that three of the proposed propositions are confirmed and two are not confirmed, as follows. First, the relationship between local cluster growth and global IBC is reciprocal, interdependent and mutually reinforcing. This case study offers a systemic view of their interplay. Whereas the Korean government promoted the initial one-way flow of talent seeking overseas PhD degrees, this flow was later replaced by a more dynamic and complex two-way circulation of talent seeking high-end markets and global knowledge and technology networks. Both types of circulation were critical for Daedeok's growth, and Daedeok's growth was critical to generating this circulation. It is thus confirmed that g*lobal IBC and local cluster growth are mutually reinforcing. IBC can promote cluster growth, and cluster growth can promote brain circulation* (*proposition 1).*

Following the two distinct forms of IBC governance, second, whereas a coordinated effort of IBC promoted by the government was more effective in promoting cluster growth and upgrading in the emergent stage of Daedeok, an organic IBC process was equally more effective in this process in the cluster's mature developmental stage. The form of IBC governance changed over Daedeok's evolution, in particular, through a gradual decrease in the Korean government's intervention and a spontaneous increase in the market-driven process over the cluster's evolution (as described above). It is thus confirmed that *organic IBC particularly benefits cluster development when the cluster is already growing, whereas coordinated IBC particularly benefits clusters at an early emergent stage (proposition 2).*

Third, whereas smaller clusters are much less likely to see IBC dynamics stimulated by an organic approach (e.g., Bangalore and Hsinchu), a coordinated IBC effort could compensate for the size disadvantages of Daedeok. IBC was not set into motion by a market-driven process in the early period of Daedeok because of the small local labor pool and the small community of local and foreign firms. Government intervention was necessary to promote and begin the circulation of talent between clusters. IBC started even before local R&D infrastructure (e.g., KAIST and ETRI) and local firms had been established. Unlike Bangalore and Hsinchu, the Korean government carefully designed policies to promote IBC dynamics even though the cluster was small and not attractive. Further, because the number of firms and research institutes at Daedeok increased significantly over time, the complexity of the required management intervention became higher due mainly to the need to align incentive systems, prevent free-riding, and administer processes. It is thus confirmed that o*rganic IBC particularly benefits cluster development when clusters have a large labor pool and a significant number of firms, whereas coordinated IBC particularly benefits the development of clusters with a small labor pool and a limited number of firms (proposition 3).*

Fourth, regardless of local and global linkages (Lorenzen & Mudambi, 2013) and the ties between universities and firms (Feldman, 2001), in the emergent developmental context, it is observed that local and global linkages played a critical role in stimulating the growth and upgrading of Daedeok. However, the ties between universities and firms were relatively weak at that time. Local cross-sector ties were neither intentionally nor spontaneously promoted at the early developmental stage of Daedeok, mainly due to the scarce talent resources and the weak local ties between the GRI, universities and industry. In contrast, there was strong local competition for talent between these sectors at that time. This context elucidates possibilities for further research exploring this phenomenon in different and more recent contexts, for example, comparing the linkages and ties in emergent clusters across different types of market economies – coordinated (such as Germany) versus liberal (such as the US). It is thus not confirmed in the context of Daedeok's development that *at an early emergent stage of clusters, IBC can be promoted through both local and global linkages between firms and* *universities. Coordinated IBC can facilitate these linkages better than organic IBC (proposition 4).*

Finally, for essentially the same reasons that local cross-sector ties were neither intentionally nor spontaneously promoted at the early developmental stage of Daedeok, organizational ties were not in line with individual career paths. Although the Korean government promoted programs for obtaining overseas PhD degrees and led a reverse brain drain (Yoon, 1992) at that time, there was no intentional coordination seeking this alignment. For example, whereas returnees were attracted to strategic job positions, salary advantages, and fringe benefits, they experienced no intentional alignment between their overseas experience and their local career progression. In addition, the majority of Korean US-educated scientists and engineers had both academic and professional experiences abroad (in particular in leading high-tech companies in the US). Although there was no intervention from the Korean government in individuals' selection of foreign universities and firms, these international experiences were an important asset strengthening local capabilities and global knowledge and technology networks even in the early developmental stage of Daedeok. It is thus not confirmed in the context of Daedeok's development that *at an early emergent stage of clusters, IBC can be promoted when organizational linkages are in line with individual career paths. Coordinated IBC can facilitate building these linkages better than organic IBC (proposition 5).*

6 CONCLUSION

This study is embedded in the interplay of local cluster development, in particular in the context of high-tech industries in emergent economies, and global connectivity, in particular in the context of the dynamics and role of IBC. Of particular interest is the controversial role of IBC governance in stimulating the growth and upgrading of larger/growing versus smaller/nascent clusters (Kenny et al., 2012; Saxenian, 2006). The focus of this study was on the forms of IBC governance used to steer these processes with consideration of the different stages of cluster development. The study thus introduces a governance perspective of IBC to complement the prior, mostly evolutionary, approaches to cluster development.

Based on the four cases studied and through the lens of the network governance literature (following Provan & Kenis, 2008), the underlying mechanisms of two forms of IBC governance are identified: an 'organic process' and a 'coordinated effort'. Both cases of IBC in Bangalore and Hsinchu can be described in hindsight as embodying a rather organic, market-driven process with minimal direct governance intervention. To the contrary, in the cases of Sinos Valley and Daedeok Innopolis, IBC was achieved through a coordinated effort during the emergent developmental stage. Based on this comparison, it is first proposed that organic IBC is likely to be effective in particular when clusters are already larger/growing, whereas coordinated IBC is primarily effective for smaller/nascent clusters. Furthermore, based on the Daedeok Innopolis case, it is proposed that IBC governance changes over the cluster's evolution, gradually decreasing the intervention in steering IBC from a 'coordinated effort' at the early stage of cluster development to allow the market-driven process of IBC to spontaneously increase as an 'organic process' during the mature stage of cluster development. As an evolutionary IBC process, organic IBC has little governance and in particular benefits clusters of larger size that are already growing and attracting both local and foreign firm investment. By contrast, coordinated IBC is an effort that is deliberately designed and managed through cluster policies and administrative organizations and that appears to be effective in particular for small, nascent clusters that are unlikely to benefit from organic IBC.

This study has important implications for three streams of research: (i) the interplay of local cluster growth and global IBC, intertwining different types of ties, (ii) the role of governance in cluster growth and upgrading, and (iii) the effective catch-up strategies of emerging economies. These research implications are explored next, with some detailed recommendations for further studies.

First, this work provides nuance to prior research that has shown the importance of different types of ties for cluster growth and upgrading: individual and organizational ties (Lorenzen & Mudambi, 2013), local and global ties (Bathelt et al., 2004), and cross-sector ties, in particular between firms and universities (see also Feldman, 2001; Manning et al., 2012). In addition to that research, this work suggests that not only the 'co-existence' of these ties but also the systematic approach through which they are interconnected, plays an important role for IBC and cluster growth and upgrading. This systemic approach creates a reciprocal relationship between these ties rather than just a causal effect and/or complementary. Arguably, there is interplay between local cluster growth and global IBC. Going further, all of these ties can develop and interact in a more or less 'organic' or 'coordinated' fashion. Future research thus needs to take the role of governance and coordination in establishing such ties more seriously (see also Schüßler et al., 2013). However, in addition to this gap, future studies are encouraged to reintegrate some of the key structural features of these tie configurations, including 'weak' versus 'strong' as well as 'central' versus 'marginal' ties. Grabher (1993) and Grabher & Powell (2004), for example, suggested that strong ties between firms and local institutions may stabilize growth but also hinder change.

Second, this study needs to be seen in line with the growing interest of cluster scholars in the role of governance and leadership, in particular, at an early stage of cluster development (Schüßler et al., 2013; Sydow et al., 2010). Rather than attributing early cluster growth to being a matter of 'luck' (Pouder & St John, 1996) or 'chance' (Porter, 2000), this study suggests that a series of deliberative governance efforts could reduce the role of 'luck' quite significantly. Certain facilitating conditions that apply to organic IBC and are partly based on 'luck', such as prior foreign MNC investment, do not apply as strongly to cases where coordinated BC is successfully implemented. First, based on the case of Sinos Valley, this study suggests that the notion of 'anchor firms or institutions' acting as a magnet for outside talent and investments (Foster et al., 2012; Porter et al., 2012) should be complemented with the idea of 'anchor alliances' between firms and local institutions, which not only serve to attract talent but also encourage the 'cross-boundary transposition' of ideas and knowledge (Powell et al., 2012). Second, based on the case of Daedeok Innopolis, this study also suggests that a coordinated IBC strategy can be developed to overcome an initial lack of indigenous capabilities and cluster attractiveness for firms or institutions; this can be effective for promoting IBC dynamics as well as for building enabling conditions to further cluster growth and upgrading. In addition to these elements of governance, future research should also focus on potential transitions between different levels, modes and intensities of governance. Clearly, distinguishing between 'organic' and 'coordinated' is only a first step toward categorizing various modes. A better understanding of how coordinated modes of IBC (and other cluster stimulating dynamics) turn into more organic modes and vice versa (as plotted in figure 18) is also needed.

Third, this study plays a role in a longer-term quest towards understanding the effective catch-up strategies of developing countries (see, e.g., Humphrey & Schmitz, 2002; Lorenzen & Mudambi, 2013; Mudambi, 2008;). This study suggests that, particularly in the absence of prior related technologies and capabilities, coordinated 'leveraging' strategies may support the catch-up process. In particular, alliances with 'aspiring peers' (Korea for Brazil, in the case of Sinos Valley; and the US for Korea, in the case of Daedeok Innopolis) appear to be an interesting means of learning and accelerating the catch-up process. This study also brings smaller, less metropolitan locations back into the discussion. Despite size and development disadvantages, 'smart governance' may help these second-tier locations to build local and global alliances to 'leap-frog' over the development process. This strategy parallels the business world, where strategic alliances can help firms diversify, gain market share and accelerate innovation (Dyer et al., 2003). Similarly, in the Sinos Valley case, an alliance architecture between/across firms and universities may add to the 'market development' of catching-up economies. Additionally, in the Daedeok Innopolis case, the coordinated effort in steering IBC dynamics and building indigenous capabilities as facilitating conditions may also add to the 'market development' of catching-up economies. Of course, future research needs to also investigate how 'inclusive' such coordinated strategies are. Who benefits from these efforts, and who is left behind?

In conclusion, this study brings governance back into the discussion of cluster growth and economic development. Combined with the notion of increased global connectivity and the importance of diaspora networks, taking a governance perspective provides an understanding of how even those locations that are disadvantaged in terms of size or development can benefit from what has been called here as ‘inter-cluster brain circulation’. This work thus elucidates both further research perspectives and policy formulations, in particular for emergent economies.

REFERENCES

Adams, W. 1968. *The brain drain*. New York, NY: Macmillan.

Altenburg, T., & Meyer-Stamer, J. 1999. How to promote clusters: Policy experiences from Latin America. *World Development*, 27(9): 1693–1713.

Altenburg, T., Schmitz, H., & Stamm, A. 2008. Breakthrough? China's and India's transition from production to innovation. *World Development*, 36(2): 325–344.

Amin, A., & Thrift, N. 1992. Neo-Marshallian nodes in global networks. *International Journal of Urban and Regional Research*, 16(4): 571–578.

Arora, A., Arunachalam, V. S., Asundi, J., & Fernandes, R. 2001. The Indian software services industry. *Research Policy*, 30(8): 1267–1287.

Asheim, B., Cooke, P., & Martin, R. 2006. *Clusters and regional development: Critical reflections and explorations*. New York, NY: Routledge.

Athreye, S. S. 2005. The Indian software industry and its evolving service capability. *Industrial and Corporate Change*, 14(3): 393–418.

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

Bauböck, R., & Faist, T. (Eds). 2010. *Diaspora and transnationalism: Concepts, theories and methods*. Amsterdam: Amsterdam University Press.

Bell, G. G. 2005. Cluster, networks, and firms innovativeness. *Strategic Management Journal*, 26(3): 287–295.

Belussi, F., & Sedita, S. R. 2009. Life cycle vs. multiple path dependency in industrial districts. *European Planning Studies*, 17(4): 505-528.

Bhagwati, J., & Hamada, K. 1974. The brain drain, international integration of markets for professionals and unemployment: A theoretical analysis. *Journal of Development Economics*, 1(1): 19–42.

Biao, X. 2005. Promoting knowledge exchange through diaspora networks (the case of People's Republic of China). In C. Wescott & J. Brinkerhoff (Eds), *Converting migration gains into drains: Harnessing the resources of oversees professionals:* 33-72. Philippines: Asian Development Bank.

Boschma, R., & Fornahl, D. 2011. Cluster evolution and a roadmap for future research. *Regional Studies*, 45(10): 1295–1298.

Boschma, R., & Frenken, K. 2011. The emerging empirics of evolutionary economic geography. *Journal of Economic Geography*, 11(2): 295–307.

Brenner, T. 2004. *Local industrial clusters: Existence, emergence and evolution*. London and New York: Routledge.

Bresnahan, T., Gambardella, A., & Saxenian, A. 2001. "Old economy" inputs for "new economy" outcomes : Cluster formation in the new silicon valleys. *Industrial and Corporate Change*, 10(4): 835–860.

Breznitz, D. 2007. *Innovation and the state: Political choice and strategies for growth in Israel, Taiwan, and Ireland*. New Haven, CT: Yale University Press.

Brusco, S. 1990. The idea of Industrial district: Its genesis In F. Pyke, G. Becattini, & W. Sengenberger (Eds), *Industrial districts and inter-firm co-operation in Italy*: 10–19. Geneva, Switzerland: International Institute for Labour Studies.

Brynjolfsson, E., & McAfee, A. 2014. *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. New York, NY: W. W. Norton & Company.

Byung, M. B. 1994. Growth and recent development of the Korean semiconductor industry. *Asian Studies*, 34(8): 706–720.

Campanario, M. D. A., Muniz, M., & Costa, T. R. 2009. Política industrial de apoio ao desenvolvimento da indústria Brasileira de semicondutores. *Revista de Ciências da Administração*, 11(24): 69–101.

Chang, S. L. 1992. Causes of brain drain and solutions: The Taiwan experience. *Studies in Comparative International Development*, 27(1): 27–43.

Chang, Y. 2003. Benefits of co-operation on innovative performance: Evidence from integrated circuits and biotechnology firms in the UK and Taiwan. *R and D Management*, 33(4): 425–437.

Chen, Y. 2008. The limits of brain circulation: Chinese returnees and technological development in Beijing. *Pacific Affairs*, 81(2): 195–215.

Cooke, P. H., & Huggins, R. 2001. High technology clustering in Cambridge (UK). In A. Amin, S. Goglio, & F. Sforzi (Eds), *The institutions of local development*. London: IGU.

Crouch, C., & Farrel, H. 2001. Greater Britain: Falling through the roles in the network concept In C. Crouch, P. L. Gales, C. Trigilia, & H. Voelzkow (Eds), *Local production system in Europe: Rise or demise?*: 161–211. Oxford: Oxford University Press.

Daugeliene, R., & Marcinkeviciene, R. 2009. Brain circulation: Theoretical considerations. *Engineering Economics,* 63(4). http://www.ktu.lt/lt/mokslas/zurnalai/inzeko/63/1392-2758-2009-3-63-49.pdf. Accessed 26 August 2014.

Aquino, M. F. 2011. For the dialogue between philosophy and empirical - formal science viewing the reinvention of the university in the information era. In *International presidential forum on global research universities: Borderless and creative education.* Seoul, KR: 41-47.

Delgado, M., Porter, M. E., & Stern, S. 2014. Clusters, convergence, and economic performance. *Research Policy,* 43(10): 1785-1799.

Delgado, M., Porter, M. E., & Stern, S. 2016. Defining clusters of related industries. *Journal of Economic Geography*, 2015: lbv017.

Dicken, P. 1994. The Roepke lecture in economic geography global-local tensions: Firms and states in the global space-economy. *Economic Geography*, 70(2): 101–128.

Dicken, P. 2008. Global shift: Mapping the changing contours of the world economy. *Scottish Geographical Journal*, 124(1): 96–100.

Dicken, P., Kelly, P. F., Olds, K., & Yeung, H. W. C. 2001. Chains and networks, territories and scales: Towards a relational framework for analysing the global economy. *Global Networks,* 1(2): 89–112.

Dicken, P., & Lloyd, P. E. 1997. *Location in space. Theoretical perspectives in economy geography*, third ed. New York, NY: HarperCollins.

Dossani, R., & Kenney, M. 2007. The next wave of globalization: Relocating service provision to India. *World Development*, 35(5): 772–791.

Eisenhardt, K. M. 1989. Building theories from case study research. *Academy of Management Review*, 14(4): 532–550.

Enright, M. J. 2000. Regional clusters and multinational enterprises: Independence, dependence, or interdependence? *International Studies of Management & Organization*, 30(2): 114–138.

Enright, M. J., & Ffowcs-Williams. 1996. Local partnership, cluster and SME globalisation. In *OECD Workshop Paper*.

Ethiraj, S. K., Kale, P., Krishnan, M. S., & Singh, J. V. 2005. Where do capabilities come from and how do they matter? A study in the software services industry. *Strategic Management Journal*, 26(1): 25–45.

Feinson, S. 2003. National innovation systems overview and country cases. In B. Bozeman, M. Gaughan, & B. Sampat (Eds), *Knowledge flows and knowledge collectives: Understanding the role of science and technology policies in development*: 13–38. New York NY: A Project for the Global Inclusion Program of the Rockefeller Foundation.

Feldman, M. P. 2001. The entrepreneurial event revisited: Firm formation in a regional context In S. Breschi & F. Malerba (Eds), *Cluster, networks, and innovation*: 136–168. Oxford: Oxford University Press.

Feldman, M., & Francis, J. L. 2009. Entrepreneurs as agents in the formation of industrial clusters In B. Asheim, P. Cooke, & R. Martin (Eds), *Cluster and regional development: Critical reflections and explorations*: 115–136. London and New York: Routledge.

Feldman, M., Francis, J., & Bercovitz, J. 2005. Creating a cluster while building a firm: Entrepreneurs and the formation of industrial clusters. *Regional Studies*, 39(1): 129–141.

Feser, E. J. 1998. Old and new theories of industry clusters. In M. Steiner (Ed.), *Clusters and regional specialisation: On geography, technology and networks*: 18–40. London: Pion.

Fielding, N., & Fielding, J. 1986. *Linking data.* Beverly Hills, CA: Sage.

Fink, D. 2013. [*Brazil-Korea S&T knowledge production profiles and patterns of collaboration*]. PhD Dissertation, Korea Advanced Institute of Technology, KAIST, Daekeok Innopolis, Daejeon, South Korea.

Fink, D., Hameed, T., So, M., Kwon, Y., & Rho, J. J. 2012. S & T collaboration in developing countries: Lessons from Brazilian collaboration activities with South Korea. STI Policy Review, 3(2): 92–110.

Fochezatto, A., & Grando, M. Z. 2008. *Diagnóstico do setor de tecnologia da informação no Rio Grande do Sul*. Porto Alegre: FEE–Fundação de Econômica e Estatística.

Freeman, C. 1995. The national system of innovation in historical perspective. Cambridge *Journal of Economics*, 19: 5–24.

Freeman, C. 2004. Technological infrastructure and international competitiveness. *Industrial and Corporate Change*, 13(3): 541–569.

Friedman, T. L. 2007. *The world is flat, 3:0: A brief history of the Twenty-First Century*. New York, NY: Macmillan.

Fromhold-Eisebith, M., & Eisebith, G. 2005. How to institutionalize innovative clusters? Comparing explicit top-down and implicit bottom-up approaches. *Research Policy*, 34(8): 1250–1268.

Gereffi, G. 1994. The organization of buyer-driven global commodity chains: How U. S. retailers shape overseas production networks In G. Gereffi & M. Korzeniewicz (Eds), *Commodity chains and global capitalism*: 36. Westport, CT: Praeger.

Gereffi, G. 2005. The global economy: Organization, governance, and development. In N. J. Smelser & R. Swedberg (Eds), *The handbook of economic sociology*: 162-182. Princeton, NJ: Princeton University Press.

Gereffi, G., Humphrey, J., & Sturgeon, T. 2005. The governance of global value chains. *Review of International Political Economy*, 12(1): 78–104.

Ghemawat, P. 2011. *World 3.0: Global prosperity and how to achieve it*. Boston, MA: Harvard Business Review Press.

Giuliani, E. 2005. Cluster absorptive capacity: Why do some clusters forge ahead and others lag behind? *European Urban and Regional Studies*, 12(3): 269–288.

Giuliani, E., Pietrobelli, C., & Rabellotti, R. 2005. Upgrading in global value chains: Lessons from Latin American clusters. *World Development*, 33(4): 549–573.

Global Services. 2008. *The topology 50 emerging global outsourcing cities*. Global Services Report.

Gordon, I. R. G. P., & McCann, P. 2000. Industrial clusters: Complexes, agglomeration, and/or social networks? *Urban Studies*, 37(3): 513–532.

Grabher, G. 1993. The weakness of strong ties the lock-in of regional development in the Ruhr area. In G. Grabher (Ed.), *The embedded firm: On the socioeconomics of industrial networks*: 255-277. London and New York: Routledge.

Grabher, G., & Powell, W. W. (Eds). 2004. *Networks*. London, UK: Edward Elgar Publishing House.

Granovetter, M. S. 1973. The strength of weak ties. *American Journal of Sociology*, 78(6): 1360–1380.

Gray, J. 2009. *False dawn: The delusions of global capitalism*. London: Granta.

Guarnizo, L. E., & Smith, M. P. 1998. The locations of transnationalism. In M. P. Smith & L. E. Guarnizo (Eds), *Transnationalism from below*: 3–34. New Brunswick, NJ: Transaction Publishers.

Guellec, D., Cervantes, M., Auriol, L., & Garson, J. P. 2002. International mobility of the highly skilled. *OECD Policy Brief*, 1–8.

Guerrieri, P., Iammarino, S., & Pietrobelli, C. 2001. *The global challenge to industrial district: Small and medium-sized enterprises in Italy and Taiwan*. Northampton, MA: Edward Elgar Publishing House.

Gulati, R. 1998. Alliances and networks. *Strategic Management Journal*, 19(4): 293-317.

Hall, P. A., & Soskice, D. 2001. *Varieties of capitalism: The institutional foundation of comparative advantage*. Oxford: Oxford University Press.

Han, P. 2007. The mobility of highly skilled human capital in Taiwan. *Applied Economics*, 39(9): 1195–1205.

Hirst, P., & Thompson, G. 2002. *The future of globalization. Cooperation and Conflict*, 37(3): 247–265.

Humphrey, J., & Schmitz, H. 2002. How does insertion in global value chains affect upgrading in industrial clusters? *Regional Studies*, 36(9): 1017–1027.

Iammarino, S., & McCann, P. 2006. The structure and evolution of industrial clusters: Transactions, technology and knowledge spillovers. *Research Policy*, 35(7): 1018–1036.

Ingstrup, M. B., Freytag, P. V., & Damgaard, T. 2009. Cluster initiation and development : A critical view from a network perspective. In IMP 2009 - *Conference at Euromed Management*, France: 1–19.

James, H. 2009. *The creation and destruction of value: The globalization cycle*. Boston, MA: the President and Fellows of Harvard College.

Jin, M., Lee, S., Yoon, H., Kim, N., & Oh, H. 2006. *Careers of Korean PhDs with degrees of foreign countries and the HRD policy of the highly skilled in Korea* (Research Report, No. 2006-3). Sejong, Republic of Korea: Korea Research Institute for Vocational Education and Training (in Korean).

Kapur, D. 2001. Diasporas and technology transfer. *Journal of Human Development*, 2(2): 265–286.

Karaev, A., Koh, S. C. L., & Szamosi, L. T. 2007. The cluster approach and SME competitiveness: A review. *Journal of Manufacturing Technology Management*, 18(7): 818-835.

Kenney, M., Breznitz, D., & Murphree, M. 2013. Coming back home after the sun rises: Returnee entrepreneurs and growth of high tech industries. *Research Policy*, 42(2): 391–407.

Kilduff, M., & Tsai, W. 2003. Social networks and organization. London: Sage.

Kim, L. 1997. *Imitation to innovation: The dynamics of Korea's technological learning*. Boston, MA: Harvard Business School Press.

Krugman, P. 1991. *Geography and trade*. Cambridge, MA: MIT Press.

Kuznetsov, Y. 2006. *Diaspora networks and the international migration of skills: How countries can draw on their talent abroad*. Washington, DC: The World Bank, The International Bank for Reconstruction and Development.

Kuznetsov, Y., & Sabel, C. F. 2006. Diaspora networks as entry point to knowledge-based development. *Innovation: Management, Policy & Practice*, 8(1-2): 45–61.

Lazonick, W. 2007. Foreign direct investment, transnational migration, and indigenous innovation in the globalization of high-tech labor. In *International Forum of Comparative Political Economy of Globalization*, 1-3 September 2006, Renmin University of China, Beijing: 1-3.

Lazzeretti, L., Sedita, S. R., & Caloffi, A. 2014. Founders and disseminators of cluster research. *Journal of Economic Geography*, 1–23.

Le, T. 2008. 'Brain drain' or 'brain circulation': Evidence from OECD's international migration and R&D spillovers. *Scottish Journal of Political Economy*, 55(5): 618-636.

Lee, H.-B. 1968. Korea: *Time, change, and administration*. Honolulu, HI: East-West Center Press, University of Hawaii.

Leslie, S. W., & Kargon, R. H. 1996. Selling Silicon Valley: Frederick Terman's model for regional advantage. *Business History Review*, 70(4): 435–472.

Lin, H., Huang, H., Lin, C., & Hsu, W. 2012. How to manage strategic alliances in OEM-based industrial clusters: Network embeddedness and formal governance mechanisms. *Industrial Marketing Management*, 41(3): 449–459.

Linden, G., Kraemer, K. L., & Dedrick, J. 2007. *Who captures value in a global innovation system?* The case of Apple's iPod. Irvine, CA: Personal Computing Industry Center, UC Irvine.

Lorenzen, M., & Mudambi, R. 2013. Clusters, connectivity and catch-up: Bollywood and Bangalore in the global economy. *Journal of Economic Geography*, 13(3): 501–534.

Lundvall, B.-A. 1996. *National systems of innovation*: Towards a theory of innovation and interactive learning. Thomson Learning.

Mahroum, S. 2005. The international policies of brain gain: A review. *Technology Analysis & Strategic Management*, 17(2): 219–230.

Malecki, E. J. 2010. Global knowledge and creativity: New challenges for firms and regions. *Regional Studies*, 44(8): 1033–1052.

Malmberg, A., & Maskell, P. 1997. Towards an explanation of regional specialization and industry agglomeration. *European Planning Studies*, 5(1): 25–41.

Manning, S. 2013. New Silicon Valleys or a new species? Commoditization of knowledge work and the rise of knowledge services clusters. *Research Policy*, 42(2): 379–390.

Manning, S., Ricart, J. E., Rique, R., & Lewin, A. Y. 2010. From blind spots to hotspots: How knowledge services clusters develop and attract foreign investment. *Journal of International Management*, 16(4): 369–382.

Manning, S., Sydow, J., & Windeler, A. 2012. Securing access to lower-cost talent globally: The dynamics of active embedding and field structuration. *Regional Studies*, 46(9): 1201–1218.

Markusen, A. 1996. Sticky places in slippery space. *Economic Geography*, 72(3): 293–313.

Marshall, A. 1920. *The principle of economics*, eighth ed. New York, NY: Macmillan.

Martin, R. 1999. The new 'geographical' turn in economics: Some critical reflections. *Cambridge Journal of Economics*, 23: 65–91.

Martin, R., & Sunley, P. 2003. Deconstructing clusters: Chaotic concept or policy panacea? *Journal of Economic Geography*, 3(1): 5–35.

Martin, R., & Sunley, P. 2006. Path dependence and regional economic evolution. *Journal of Economic Geography*, 6(4): 395–437.

Martin, X., Salomon, R. M., & Wu, Z. 2010. The institutional determinants of agglomeration: A study in the global semiconductor industry. *Industrial and Corporate Change*, 19(6): 1769–1800.

Maskell, P. 2001. Towards a knowledge-based theory of the geographical cluster. *Industrial and Corporate Change*, 10(4): 921–943.

Maskell, P., Bathelt, H., & Malmberg, A. 2006. Building global knowledge pipelines: The role of temporary clusters. *European Planning Studies*, 14(8): 997–1013.

Mason, E. S., Kim, M. J., Perkins, D. H., Kim, K. S., & Cole, D. C. 1980. *The economic and social modernization of the Republic of Korea*. Cambridge, MA: Council on East Asian Studies, Harvard University.

Maxwell, J. 2013. *Qualitative research design: An interactive approach*, third ed. London, UK: Sage Press.

Menzel, M. P., & Fornahl, D. 2010. Cluster life cycles--dimensions and rationales of cluster evolution. *Industrial and Corporate Change*, 19(1): 205–238.

Mudambi, R. 2008. Location, control and innovation in knowledge-intensive industries. *Journal of Economic Geography*, 8(5): 699–725.

Myers, M. D. 2009. *Qualitative research in business & management*. Thousand Oaks, CA: Sage Publications, Inc.

Myrdal, G. 1957. Rich lands and poor. In *World perspective series*. New York, NY: Harper Brothers.

Nelson, R. R. 1993. *National innovation systems*: A comparative analysis. New York, NY: Oxford University Press.

Organisation for Economic Co-operation and Development (OECD). 1997. National innovation systems. Paris, France.

Organisation for Economic Co-operation and Development (OECD). 2001. *International mobility of the highly skilled*.

Organisation for Economic Co-operation and Development (OECD). 2008. *The global competition for Talent: Mobility of the highly skilled*.

Oh, D.-S., & Yeom, I. 2012. Daedeok Innopolis in Korea: From science park to innovation cluster. *World Technopolis Review*: 141–154.

Ong, A. 1999. *Flexible citizenship: The cultural logic of transnationality*. Durham, NC: Duke University Press.

Orsenigo, L. 2001. The (failed) development of a biotechnology cluster: The case of Lombardy. *Small Business Economics*, 17(1/2): 77–92.

Owen-Smith, J., & Powell, W. W. 2004. Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community. *Organization Science*, 15(1): 5–21.

Patibandla, M., & Petersen, B. 2002. Role of transnational corporations in the evolution of a high-tech industry: The case of India's software industry. *World Development*, 30(9): 1561–1577.

Perroux, F. 1950. Economic space: Theory and applications. *Quarterly Journal of Economics*, 64(1): 89–104.

Perry, M. 1999. Clusters last stand. *Planning Practice and Research*, 14(2): 149–152.

Pietrobelli, C., & Rabellotti, R. 2011. Global value chains meet innovation systems: Are there learning opportunities for developing countries? *World Development*, 39(7): 1261–1269.

Porter, K., Whittington, K. B., & Powell, W. W. 2012. The institutional embeddedness of high-tech regions: Relational foundations of the Boston biotechnology community. In S. Breschi & F. Malerba (Eds), *Cluster, network and innovation*: 51. Oxford: Oxford University Press.

Porter, M. 1990. *The competitive advantage of nations*. New York: Free Press.

Porter, M. 2003. The economic performance of regions. *Regional Studies*, 37(6-7): 545–546.

Porter, M. E. 1985. *The competitive advantage: Creating and sustaining superior performance*. New York, NY: Free Press.

Porter, M. E. 1998. *Clusters and the new economics of competition*. Boston, MA: Harvard Business Review.

Porter, M. E. 2000. Location, competition, and economic development: Local clusters in a global economy. *Economic Development Quarterly*, 14(1): 15–34.

Pouder, R., & St. John, C. H 1996. Hot spots and blind spots: Geographical clusters of firms and innovation. *Academy of Management Review*, 21(4): 1192–1225.

Powell, W. 1990. Neither market nor hierarchy: Network forms of organization. *Research in Organizational Behavior*, 12: 295–336.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. 1996. Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, 41(1): 116–145.

Pries, L. 1999. *Migration and transnational social spaces*. Aldershot, UK: Ashgate.

Provan, K. G., Fish, A., & Sydow, J. 2007. Interorganizational networks at the network level: A review of the empirical literature on whole networks. *Journal of Management*, 33(3): 479–516.

Provan, K. G., & Kenis, P. 2008. Modes of network governance: Structure, management, and effectiveness. *Journal of Public Administration Research and Theory*, 18(2): 229–252.

Reddy, P. 1997. New trends in globalization of corporate R&D and implications for innovation capability in host countries: A survey from India. *World Development*, 25(11): 1821–1837.

Roelandt, T., & den Hertog, P. 1999. Cluster analysis and cluster-based policy making in OECD countries: An introduction to the theme. In *Boosting innovation: The cluster approach*: Paris, France: 9–23. Organisation for Economic Co-operation and Development.

Rosenfeld, S. A. 2002. *Creating smart systems: A guide to cluster strategies in less favoured regions*. Carrboro, NC: Regional Technology Strategies.

Sako, M. 2006. Outsourcing and offshoring: Implications for productivity of business services. *Oxford Review of Economic Policy*, 22(4): 499–512.

Sassen, S. 1988. *The mobility of labor and capital: A study in international investment and labor flow*. New York, NY: Cambridge University Press.

Saxenian, A. 1994. *Regional advantage. Culture and competition in Silicon Valley and Route 128*. Cambridge, MA: Harvard University Press.

Saxenian, A. 2001. Taiwan's Hsinchu region: Imitator and partner for Silicon Valley. *Economic Policy*, 00: 0–59.

Saxenian, A. 2002. Transnational communities and the evolution of global production networks: The cases of Taiwan, China and India. *Industry and Innovation*, 9(3): 183–202.

Saxenian, A. 2002. *Brain circulation and Chinese chipmakers: The Silicon Valley-Hsinchu-Shanghai triangle*. Berkeley, CA: University of California at Berkeley.

Saxenian, A. 2005. From brain drain to brain circulation: Transnational communities and regional upgrading in India and China. *Studies in Comparative International Development*, 40(2): 35–61.

Saxenian, A. 2006. *The new Argonauts: Regional advantage in a global economy*. Cambridge, MA: Harvard University Press.

Saxenian, A. 2007. The international mobility of entrepreneurs and regional upgrading in India and China. In A. Solimano (Ed.), *International mobility of talent, types, causes, and development impact*: 117–144. Oxford: Oxford Scholarship.

Saxenian, A., & Hsu, J. 2001. The Silicon Valley-Hsinchu connection: Technical communities and industrial upgrading. *Industrial and Corporate Change*, 10(4): 893–920.

Schmitz, H. 1999. Global competition and local co-operation: Success and failure in the Sinos Valley, Brazil. World Development, 27(9): 1,627–650.

Schüßler, E., Decker, C., & Lerch, F. 2013. Networks of clusters: A governance perspective. *Industry and Innovation*, 20(4): 357-377.

Sedita, S. R., & Lazzeretti, L. 2012. The birth and the rise of the cluster concept. In *DRUID* Copenhagen, Denmark: 21.

Shapero, A. 1984. The entrepreneurial event. In C. Kent (Ed.), *The environment for entrepreneurship*: 21–40. Texas, USA: Lexington Publishing House.

Shin, G.W., & Nak Choi, J. 2015. *Skilled labor as social capital in Korea*. Stanford, CA: Stanford University Press.

Simmie, J., & Sennett, J. 1999. Innovation in the London Metropolitan region. Working Paper no. 182. In D. Hart, P. Simmie, P. Wood, & J. Sennett (Eds), *Innovative clusters and competitive cities in the UK and Europe*. Oxford: Oxford Brookes School of Planning.

Sonderegger, P., & Täube, F. 2010. Cluster lifecycle and diaspora effects: Evidence from the Indian IT cluster in Bangalore. *Journal of International Management*, 16(4): 383–397.

Song, J., Almeida, P., & Wu, G. 2003. Learning-by-hiring: When is mobility more likely to facilitate interfirm knowledge transfer? *Management Science*, 49(4): 351–365.

Stoerring, D. 2007. [*Emergence and growth of high* technology clusters]. PhD Dissertation, Aalborg University, Aalborg, Denmark.

Straussman, J. D. 1978. *The limits of technocratic politics*. New Brunswick, NJ: Transaction Publishing House Books.

Sturgeon, T. J. 2002. Modular production networks: A new American model of industrial organization. *Industrial and Corporate Change*, 11(3): 451–496.

Sturgeon, T. J., & Kawakami, M. 2010. Global value chains in the electronics industry: Was the crisis a window of opportunity for developing countries? *World Bank Policy Research Working Paper Series*. http://ssrn.com/abstract=1676652.

Sturgeon, T., Van Biesebroeck, J., & Gereffi, G. 2008. Value chains, networks and clusters: Reframing the global automotive industry. *Journal of Economic Geography*, 8(3): 297–321.

Swann, G. M. P., Prevezer, M., & Stout, D. 1998. *The dynamics of Industrial clustering: International comparisons in computing and biotechnology*. Oxford, UK: Oxford University Press.

Swann, P., & Prevezer, M. 1996. A comparison of the dynamics of industrial clustering in computing and biotechnology. *Research Policy*, 25(7): 1139–1157.

Sydow, J., Lerch, F., & Staber, U. 2010. Planning for path dependence? The case of a network in the Berlin-Brandenburg optics cluster. *Economic Geography*, 86(2): 173–195.

Taeube, F., & Sonderegger, P. 2010. Cluster lifecycle and diaspora effects: Evidence from the Indian IT cluster in Bangalore. *Journal of International Management*, 16(4): 383-397.

Täeube, F., Karna, A., & Sonderegger, P. 2011. Evolution of innovation networks across geographical and organizational boundaries: Knowledge flows in the Bangalore IT cluster. In *DRUID*, Copenhagen, Denmark: 23.

Taiwan Semiconductor Industry Association (TSIA). 2015. Overview on Taiwan semiconductor industry, 2015 Edition. http://www.tsia.org.tw/en/index.php.

Tan, H. 2011. Cyclical industrial dynamics in the global IT sector: Origins and sequencing. *Industrial and Corporate Change*, 20(1): 175–200.

Teferra, D. 2005. Brain circulation: Unparalleled opportunities, underlying challenges, and outmoded presumptions. *Journal of Studies in International Education*, 9(3): 229-250.

Ter Wal, A. L. J., & Boschma, R. 2011. Co-evolution of firms, industries and networks in space. *Regional Studies*, 45(7): 919–933.

Tomlinson, J. 2003. Globalization and cultural identity. In D. Held & A. McGew (Eds), *The global transformations reader*: 269–277. Cambridge: Polity.

Tung, R. L. 2008. Brain circulation, diaspora, and international competitiveness. *European Management Journal*, 26(5): 298–304.

Tung, R. L., & Lazarova, M. 2006. Brain drain versus brain gain: An exploratory study of ex-host country nationals in Central and East Europe. *International Journal of Human Resource Management*, 17(11): 1853 – 1872.

Van den Berg, L., Braun, E., & Van Winden, W. 2001. Growth clusters in European cities: An integral approach. *Urban Studies*, 38(1): 186–206.

Viotti, E. 2002. National learning systems industrializing economies and evidences from the cases of Brazil and South Korea. *Technological Forecasting and Social Change*, 69(7): 653-680.

Wasserman, S., & Faust, K. 1994. *Social network analysis: Methods and applications*, Vol. 8. Cambridge: Cambridge University Press.

West, J. 2001. Qualcomm´s standard strategy, standardization and innovation in information technology. In *2001 2nd IEEE Conference,* IEEE Xplore: Institute of Electrical and Electronics Engineers: 62-76.

Yeung, H. W. C., & Coe, N. M. 2015. Toward a dynamic theory of global production networks. *Economic Geography*, 91(1): 29-58.

Yin, R. K. 2009. *Case study research: Design and methods*. Thousand Oaks, CA: Sage Publishing House.

Yoon, B. S. L. 1992. Reverse brain drain in South Korea: State-led model. *Studies in Comparative International Development*, 27(1): 4–26.

Yun-Chung, C. 2008. The limits of brain circulation: Chinese returnees and technological development in Beijing. *Pacific Affairs*, 81(2): 195-215.

Zaheer, S., Lamin, A., & Subramani, M. 2009. Cluster capabilities or ethnic ties? Location choice by foreign and domestic entrants in the services offshoring industry in India. *Journal of International Business Studies*, 40(6): 944–968.

Zweig, D., Fung, C. S., & Han, D. 2008. Redefining the brain drain: China's 'diaspora option'. *Science, Technology & Society*, 13(1): 1–33.

APPENDIX A

Interview's questions: Daedeok Innopolis (Korea) - US connection
General aim of the study
It aims to propose forms of IBC governance that promote the growth and upgrading of clusters in emerging economies.
Dimensions of analysis
[D1] Determinants and dynamics of cluster development: general information about the development process of Daedeok Innopolis, such as its dynamics, starting point, evolution, initiators, members, expectations and goals.
[D2] Dynamics and role of IBC: the dynamics of international talent mobility and its role in transfer technology, knowledge diffusion, and local cluster upgrading.
[D3] Control mechanisms of IBC: governance systems of IBC, such as formal and informal control mechanisms, the coordination of IBC for achieving goal consensus and conflict resolution, local policies and programs (including public funding) and regulatory and legislative pressures.
[D4] Cross-sector links of IBC: links, for example, between companies and universities, to facilitate the interplay of global and local ties, communication and cooperation between actors, and types of knowledge to be transferred across levels.
[D5] Alignment between the career paths development and IBC: Career paths such as alignment between organizational and individual ties, opportunities for communication and cooperation on and across organizational and individual ties, rules, guidelines and practices for developing a career path.
[D6] IBC as a coordinated effort versus an organic process: the role of, and limitations to, deliberate intervention and coordination in the IBC process.

Interview's questions

1st BLOCK - Respondent Profile

Please specify your age.

Where were you born?

What is your current job?

What is your highest educational degree?

Where did you obtain your highest educational degree?

When did you obtain your highest educational degree?

2nd BLOCK - Development of Daedeok Innopolis and Its International Connections

Based on the three main developmental stages of Daedeok Innopolis:

70' - 80' *Daedeok Science Park: R&D groundbreaking (government/public R&D)*

90' - 00' *Daedeok Valley: Innovation (private R&D, start-ups)*

2005 - *Daedeok Innopolis: Innovation Cluster (technology commercialization, business hub)*

1. What were the main determinants of the cluster development?
2. What was the role of the international talent mobility on cluster development process? And was their role in particular at the early stage of cluster development? And later?
3. Was there a formal and/or informal control mechanism (such as policy) to the international talent mobility? Do they differ over the cluster's evolution?
4. Which was the main country (or cluster) where there were personal ties? And organizational ties (such as company, university, government)?
5. Which was the main country (or cluster) where there were organizational ties (such as company, university, government)?
6. Were all of these ties coordinated by someone (such as government, agency, company, university)? Or were they organic process?
7. Do you have an idea of the number of high skilled people involved with GBC?
8. Were there cross-sector links (such as between companies and universities)? Was it intentionally promoted? Or was it a sporadic, independent and entrepreneurial effort?
9. Were the organizational linkages of GBC in line with local individual career paths? Was it intentionally promoted? Or was it sporadic, independent an entrepreneurial effort?
10. Could you differentiate the GBC as a coordinated process in the early stage of cluster development and later as an organic process?

APPENDIX B

Phase	Phase 1	Phase 2	Phase 3
Period	**1973 - 1989**	**1990 - 2004**	**2005 - current**
Name	**Daedeok Science Park**	**Daedeok Valley**	**Daedeok Innopolis**
Strategy	**R&D**	**Innovation**	**Innovation Cluster**
Activities	**Groundbreaking R&D Government/public R&D**	**Private R&D High-tech start-ups**	**Technology commercialization Business hub**
Determinants and dynamics of cluster development	Driven by Central Government. Strategy of cluster as a center for S&T in Korea. Building S&T research capability, and promoting R&D initiatives with public funds. S&T research infrastructure by means of developing the GRIs (such as ETRI and KAIST).	Driven by the central government with the partial involvement of local government. Cluster strategy approach as the innovation hub. Promoting private R&D and high-tech start-ups. Linking university-industry-GRI network. National Special R&D Zone.	Central and local government involved in supporting cluster activities (mainly by offering funding) such as R&D, business, and production. Consolidating as a high-tech cluster with a technology commercialization strategy. Global hub for technology commercialization. National R&DB special zone.
Dynamics and role of IBC	IBC´s role in building S&T research capability, in particular, in knowledge diffusion and technology catch-up processes. Attracting overseas scientists and professionals (reverse brain drain) mainly with government policies. Promoting overseas PhD degrees in advanced economies (mainly the US). Promoting global networks (mainly with the US) by means of personal ties.	Returning PhDs in key government and university positions. Building Korean R&D capabilities by leapfrogging into state-of-the-art technologies. Recruiting Korean-American scientists and engineers for short- and middle-term assignments for particular R&D projects.	Diversified IBC model driven by the market. Private sector as a central element. Both personal and organizational ties are strengthening the global networks. Returning PhDs and Korean-American scientists and engineers are establishing local capabilities and global integration.
Control mechanism of IBC	Supporting PhD exchange programs through government scholarships . Attracting returning PhDs by means of empowerment (strategic job positions), building GRIs (as hosting places), salary advantages, and fringe benefits (such as free housing, relocation expenses, and subsidized educational cost for children).	Both Government and private sector supporting programs for Korean-American scientists and engineers. Attracting local PhDs for job positions at KAIST by reducing the duration of army service.	Market-driven orientation. Decentralized control system of IBC (driven by the market).

Cross-sector links of IBC	Unlikely cross-sector links. No intentional relationship between the GRIs, universities and industry.	Promoting the relationship between companies, GRIs and universities by giving them particular grants and funds (from the government) through joint project programs. Global networks between cross-sector links driven by some cases of high-end technology development and international commercialization.	Increment of cross-sector links by spillover processes resulting in small- and medium-sized high-tech companies. Creating world-class technology institutes (such as KAIST Institute) with an industry-orientation.
Alignment between career path development and IBC	No intentional alignment between the individual career path and IBC, only generically through S&T fields.	No intentional alignment between individual career paths and IBC, only occasionally in some cases.	Individuals and institutions are seeking their own career path development.
IBC as 'coordinated effort' versus 'organic process'	Coordinated IBC by state-led model.	Coordinated IBC by combining public and private models.	Diversified IBC model driven by the market.