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Ph. D. Dissertation in Engineering

Exploring regional innovation and growth patterns from a dynamic knowledge base approach

진화적 지식기반 관점에서의 지역혁신 및 성장에 관한 연구

February 2020

Graduate School of Seoul National University

Technology Management, Economics, and Policy Program

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Exploring regional innovation and growth patterns from a dynamic knowledge base approach

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이 논문을 공학박사학위 논문으로 제출함

2020 년 2 월

서울대학교 대학원

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Abstract

Exploring regional innovation and growth patterns from a dynamic knowledge base approach

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While technological change and innovation have been treated as key to national economic growth, attention to innovation and development at a regional level has grown from the recognition of the importance of geographical space in the innovation process. Theories on regional innovation and growth have been developed under the advantages of regional examination, and regional innovation policies were designed and implemented accordingly. However, the one-size-fits-all approach to regional policies remains troublesome as regions differ widely in terms of their intrinsic characteristics and innovation capabilities. Based on these concerns, this thesis adopts an evolutionary and systematic integrated view to investigate regional innovation and growth patterns focusing on learning processes in regions with different levels of innovation potential.

This thesis adopts three main functional dimensions of access to and efficient use of knowledge in evolutionary theories; that is, absorption of new knowledge, diffusion of innovations, and generation of new knowledge. In accordance with the three dimensions, three studies are included with analyses of regional innovation and development strategies for regions with different levels of knowledge accumulation and diversity.

The first study proposes a framework for the initiation of community-level innovation in a developing country where technological capabilities are few or non-existent, causing mere adaption to external innovations. With a qualitative analysis of an appropriate technology case, the study adopts concepts from grassroots innovation. Grassroots innovation is a community-level bottom-up innovation that has been discussed only in developed countries as a means of socially inclusive innovation for sustainability. However, this study identifies the links between appropriate technology and grassroots innovation and redefines a framework with core constructs: context, driving force, niche, organizational form, and resource base. The case study shows that a social niche plays a significant role in improving the use of technology by creating a local knowledge transfer mechanism through social learning.

The second study investigates regional innovation and growth patterns of regions with clusters in Korea. Clusters have been popular among regional policy makers for promoting greater innovation and growth. In this regard, Korean local governments have also pursued a cluster-based policy for regional development. However, the problem is that clusters are oversupplied without an objective examination of regional conditions and demands, and the existence of clusters does not necessarily secure regional networks or economic growth. Therefore, the study aims to examine the effects of clustering on regional economic performance along with socioeconomic factors and knowledge capacity factors from a systematic perspective. Principal component analysis and panel regression methods are used to analyze Korean regions with clusters. The results indicate that favorable socioeconomic contexts are prerequisites to foster innovation and growth by clusters. In addition, a cluster-based policy may have a smaller effect than expected because R&D capacity has a stronger and longer effect on economic performance. Lastly, specific factors such as a pool of labor, education systems, quality of R&D activities, and agglomeration density of clusters are found to be critical to regional growth in regions in Korea.

The last study focuses on regional capacity for knowledge recombination and its impact on regional productivity in European regions, as novel recombination is assessed to be a new driver for sustainable and long-term regional growth. Consequently, the study specifies regional capacity in technological recombination into exploration and exploitation and compare their effects on regional productivity. For the analysis, a knowledge space is constructed using technology class co-occurrence matrices with patent data, and technical efficiencies are calculated using a stochastic frontier model from socioeconomic data of EU NUTS 2 level regions. The relationship of regional recombination types and technical efficiencies is then regressed, controlling for economy scale, knowledge stock, and periodic effects. The results demonstrate that explorative recombination has a positive and significant influence on productivity gains while exploitative activity has no influence.

Overall, the thesis provides several policy implications for regions from the evolutionary and systematic perspectives. First, in lagging regions with low technological capabilities, the five-construct framework drawn from grassroots innovation can form a basis for absorption of external knowledge, technology, or innovation to adapt to local needs. Second, for intra-regional knowledge spillovers to be effective in intermediate regions, creating a favorable socioeconomic environment should take precedence. Moreover, consistent attention to investment in R&D capacity is required. Third, explorative new knowledge recombination is recommended in regions with a high level of knowledge accumulation and diversity despite its high cost and attendant uncertainties.

Keywords: regional innovation, evolutionary economic geography, grassroots innovation, clusters, knowledge recombination
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Chapter 1. Introduction

1.1 Research background

Technological change and innovation have been treated as a key source for economic growth and as a main factor for explaining divergence in economic performance among the countries in evolutionary economics (Nelson & Winter, 1982). The evolutionary approach was well suited to the study of innovation because of its emphasis on process, dynamics, and variety of economic structures, which contrasts from the static equilibrium rationale of neo-classical economics (Cooke et al., 1997; Lambooy & Boschma, 2001).

Moreover, the evolutionary process determines far beyond simple technological progress, which means that understanding innovation in a systematic and holistic manner with a large extent to changes in organizations, behaviors, relationships, institutions, and so on, is advisable (Dosi & Nelson, 1994; Lundvall, 1992). In this regard, the literature of systems of innovation emerged first as national systems of innovation (NSI) (Freeman, 1987). The study emphasized the role of networks of public and private institutions for developing new technologies. Theoretical and empirical research on systems of innovation were continued successively, figuring out important determinants such as knowledge diffusion and learning (Edquist, 1997; Lundvall, 1992; Nelson, 1993, OECD, 1999).

Besides, by integrating the evolutionary and systematic approaches, knowledge and learning processes are placed at the center with interdependences of organizational, social, political, and economic factors in the innovation process (Dosi, 1982; Edquist, 1997; 2005;

Nelson, 1993). Economies self-transform based on underlying internal processes of knowledge development (Metcalfe et al., 2006); thus, knowledge is the fundamental resource, and learning is the most important process (Lundvall, 1992). Schumpeter, the founding scholar of innovation studies, also has emphasized both the evolutionary and systematic perspectives by arguing that transformations occur endogenously within the socio-economic system. (Schumpeter, 1942). In addition, innovations tend to proceed within a framework and along a path dependent trajectory according to accumulated knowledge and experience (Dosi, 1982).

Most innovation studies have been related to national economic growth; however, scholars have questioned the suitability of national-level analyses for investigating innovation processes (Cooke et al., 1997; Iammarino, 2005). In fact, work on innovation systems has mainly taken place on a national level, regarding, for example, national governance, political hierarchies, networks, and markets (Camagni, 1995). Consequently, findings related to participants, networks, and attributes of innovation processes at the national level, were applied to regions. What is concerning, from this country-level perspective, is that the unique identification of regional (or sub-national) actors, networks, and contexts is ignored by so called "national-bias" (Iammarino, 2005).

For instance, in the case of Italian innovation, Malerba (1993) and Locke (1995) found that innovation occurred on the sub-national level with a substantial gap between regions. Italy had experienced its transformation into an advanced industrial economy over a relatively short period of time in the 1980s and 1990s. While the core R&D system lacked advanced capabilities, thereby blocking full development, small firm networks, which historically grew on a local, regional, and vocational basis, performed successfully and created a virtuous cycle of learning and incremental innovation (Malerba, 1993). The local clusters, which cannot be considered in the NSI, contributed to the relative success of economic growth in Italy at the time.

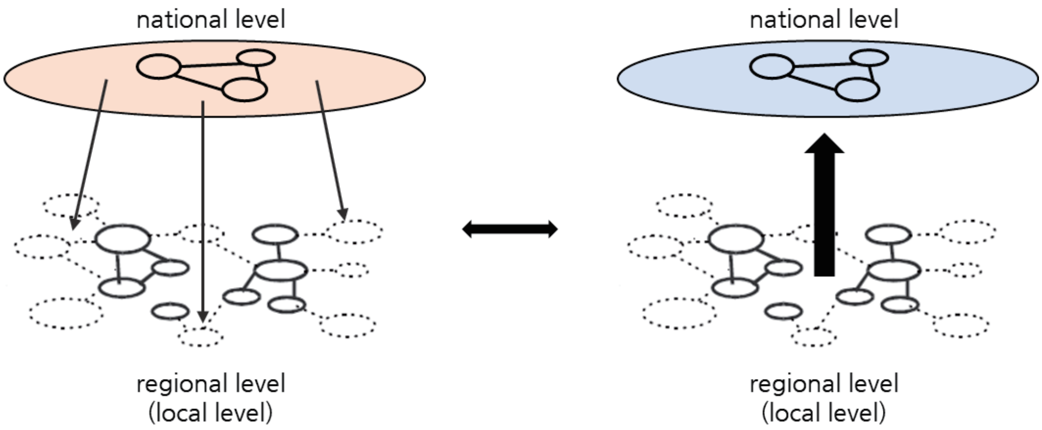


Figure 1-1. Illustration of the national bias

Thus, interests at the sub-national level, that is, regional or even local, have started to appear in numerous fields including evolutionary economic geography and regional innovation systems (Boschma & Martin, 2009; Cooke et al., 1997; Cooke, 2001; Howells, 1999). The literature examines the original and unique patterns and contexts within and outside the regions.

The advantage and importance of regional analysis can be inferred from the discussion of geographical space and innovation or technological activities. First, knowledge spillovers are highly dependent on physical proximity (Fritsch & Franke, 2004; Rodriguez-pose & Comptour, 2012; Storper & Venables, 2004); second, innovations are highly affected by context-specific factors (Iammarino, 2005; Tödtling & Trippl, 2005); and third, high technological density and diversity are the properties of regions rather than of countries (Carlsson & Stankiewicz, 1991; Howells, 1999; Morgan, 2004, Paci & Usai, 2000).

The sub-national approach can avoid problems of loss of information or misunderstanding by homogeneous assumptions about actors and networks using national level analysis. Subsequently, the focus on sub-national level analysis in innovation studies provides a theoretical basis for regional policy in terms of development and economic growth. These policies intend to foster favorable intra-regional conditions rather than relying on resources from external regions such as the EU cohesion policy (Lambooy & Boschma, 2001; McCann & Ortega-Argilés, 2015).

However, ‘one-size-fits-all’ problems still remain in regional innovation policy (Tödtling & Trippl, 2005). Regional policies were often based on approaches such as that of regional milieux (Camagni, 1995) or high-tech clusters (Garnsey & Heffernan, 2007), focusing on analysis of successful stories with emphasis on knowledge-based industries and high-quality research capacity. That is, a homogeneous approach is still applied at regional levels despite the effort to investigate sub-national innovation processes, rather than national-level innovation.

Specifically, the intrinsic characteristics of regions in terms of their knowledge pool or innovation potentials are not sufficiently considered under one-size-fits-all regional development policies. Such successful cases may not be applicable to some regions because technological capabilities and institutional levels differ, sometimes significantly, from the ideal models to fit them properly (Tödtling & Trippl, 2005).

Further, from a sociology perspective of technology, technology has its 'interpretative flexibility,' meaning different groups of people have different understandings and values of that technology under typical social construction (Mackenzie & Wajcman, 1999; Pinch & Bijker, 1984).

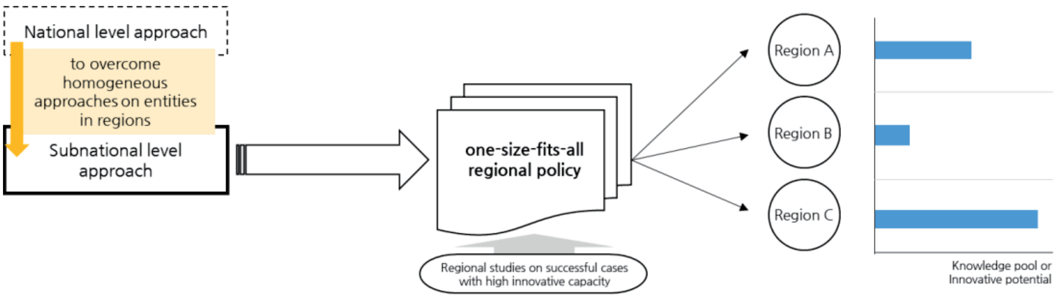


Figure 1-2. One-size-fits-all problems of regional innovation policy

Therefore, regional innovation and development policies should be able to take into account a variety of policy designs across regions because they differ in knowledge base, institutional and social structures, and barriers to innovate. For example, there are lagging regions which possess little technological capabilities and merely adapt to external innovation, and intermediate regions where knowledge base is satisfied but fail to diffuse knowledge (Iammarino, 2005). The studies and policies, however, are highly biased on advanced regions with high technological capabilities (Lundvall, 2007), and only few attempts have been made to differentiate regional types.

1.2 Research objectives

Based on the concerns, this thesis applies evolutionary and systematic perspectives to regional development and growth. The goal of the thesis is to investigate regional innovation and growth patterns on different levels of technological capabilities and knowledge accumulation. Placing innovation and knowledge at the center with other elements, this approach helps to investigate dynamic use of knowledge for regional innovations and thus economic growth.

In order to take the evolutionary and systematic integrated view, this thesis adopts three main functional dimensions of access to and efficient use of knowledge using the evolutionary theories of technological change: first, "absorption of new knowledge, technology, and innovation for adaptation to local needs;" second, "diffusion of innovations throughout all the constituent parts of the regional social fabric to strengthen the existing knowledge base;" and finally, "generation of new knowledge, technology, and innovation" (Iammarino, 2005, p.6).

In accordance with the three dimensions, three different uses of knowledge in terms of regional innovation and economic growth in distinct regions, adoption (absorption), diffusion, and recombination (generation), are depicted in three separate studies in this thesis. Each of these studies covers different systems of rules in diverse environments and regions. Regions with different levels of technological capabilities and knowledge pool or diversity are considered for the analysis.

This evolutionary and systematic approach is expected to support the feasibility of regional development policies and sustainable transitions, suggesting proposals for regional innovation and growth in different types of regions. At the same time, it illustrates an overall picture of regional growth for each stage, which can be sustained through the channels relevant to the dimensions of the learning process.

1.3 Research outline

The remainder of the study is structured as follows: Chapter 2 provides a brief summary of theories and practices related to regional development, evolutionary economic geography, and regional innovation systems. The purpose of Chapter 2 is to provide a broad understanding of regional development theories and policies. Chapter 2 also examines the theoretical background of evolutionary economic geography and regional innovation systems in terms of regional innovation and growth. Lastly, based on the review, contributions of this thesis will be discussed.

Following the literature review, Chapter 3 illustrates the initiation of regional innovation with external knowledge in lagging regions. The study proposes the design and implementation of a framework adopted from grassroots innovation. To do this, first, the study explains how grassroots innovation can be linked to appropriate technology based on a review of the related literature. Then, using the case of an appropriate technology project in Laos, the process of adopting external knowledge is illustrated in detail based on the framework.

Chapter 4 analyzes the effects of a cluster-based policy on regional growth along with socioeconomic and innovation capacity factors in Korea to examine diffusion of intra-regional knowledge. By using principal component analysis and a panel regression model, three composite factors - the social factor, the capacity factor, and the clustering factor - are generated and estimated on their effects on regional economic performance.

Chapter 5 examines the effects of regional capacity for knowledge recombination on productivity gain in EU NUTS 2 level regions. The generation of knowledge is specified into new recombination and existing recombination types, and their effects are compared. For the analysis, a knowledge space derived by technology class co-occurrence matrices is constructed with patent data, and productivity is calculated by stochastic frontier analysis. Then, the relationships are examined by random coefficient models.

Finally, Chapter 6 concludes by summarizing the key findings and presents the implications and contributions of the studies. Limitations and considerations for future research are discussed.

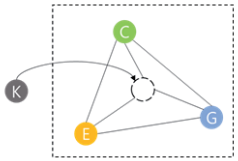
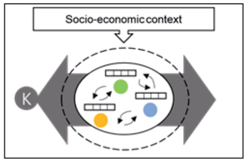
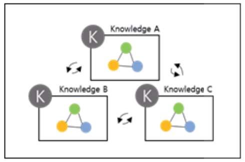
	Essay 1	Essay 2	Essay 3
Conceptualization			
Use of knowledge	**Absorption**	**Diffusion**	**Generation**
Topic	Initiation of regional innovation with external knowledge	Examination on effects of clustering and innovative capacity on regional growth	Comparison or effects of knowledge recombination type on regional productivity
Theoretical background	Evolutionary economic geography ✚ Grassroots innovation	Evolutionary economic geography ✚ Regional innovation systems	Evolutionary economic geography ✚ Knowledge management
Methodology	Qualitative case study	PCA Panel regression	Knowledge space SFA Panel regression
Target regions	**Lagging regions**	**Intermediate regions**	**Advanced regions**

Figure 1-3. Research outline

Chapter 2. Literature Review

2.1 Regional innovation and development

2.1.1 The need for regional analysis

The driving forces of innovation processes and economic growth are fundamentally rooted in "space matters" (Dawkins, 2003, p.132). In the early literature, the regional dimension has been rarely considered, and the findings related to participants, networks, and attributes of the innovation process at a national level were applied to regions. This national bias caused some confusion in the regional policy debate, and thus, interest in regional development became a prerequisite for making feasible policy implications (Iammarino, 2005).

The advantage and importance of regional examination comes from the discussion on the relationship between geographical space and innovation or technological activities. First, a spatially bound region is favorable for accumulation of knowledge, creation of industrial atmosphere, diffusion of ideas, and, in turn, facilitating economic growth according to Marshallian externalities (Fritsch & Franke, 2004). Physical proximity plays an important role, because it facilitates interactions to generate intricate systems of collective learning mechanisms, which constructs favorable conditions for innovation (Rodriguez-Pose & Comptour, 2012). In fact, knowledge spillovers that play a key role for innovation processes are usually only effective within spatial bounds (Fritsch & Franke, 2004). Tacit knowledge can be exchanged only through intense personal contacts, and geographic proximity is the prerequisite for such exchanges (Storper & Venables, 2004).

Second, endogenous context specific factors, for example, policy competences, localized structures and institutional factors are bound to subnational spatial boarders and largely affect regional innovation capacity (Iammarino, 2005, Tödtling & Trippl, 2005). Third, industrial specialization patterns and high technological density and diversity are characteristics of regions rather than those on a national level (Carlsson & Stankiewicz, 1991; Howells, 1999; Morgan, 2004; Paci & Usai, 2000).

By assuming a sub-national approach, misunderstanding or loss of information caused by homogeneous assumptions using the national level approach can be avoided (Morgan, 2004). Following this approach, diverse sub-national, or regional, typologies and studies have appeared, such as innovative milieux, (Camagni, 1995), industrial districts (Porter, 1998; 2000), learning regions (Morgan, 2007), and regional innovation systems (Cooke et al., 1997; Howells, 1999).

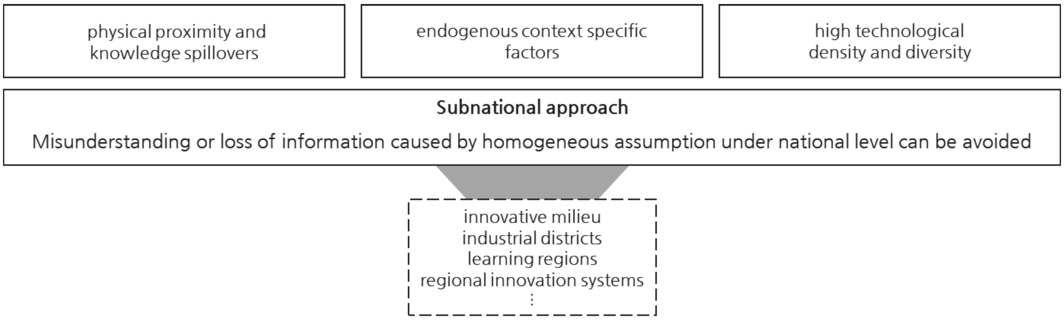


Figure 2-1. Advantage and importance of regional analysis

Based on these regional studies, regional policies have been designed and implemented to create favorable intra-regional innovation and growth conditions rather than relying on diverse resources from other regions (Dawkins, 2003; Richardson, 1979). Subsequently, a spatial dimension of knowledge management to promote local innovations has been introduced to policy intervention (Dawkins, 2003.)

Still, despite the efforts to examine sub-national innovation processes, one-size-fits-all application remains prevalent in regional innovation policies (Tödtling & Trippl, 2005). The policies are often focused on regions with high technological capabilities, for example high-tech clusters (Garnsey & Heffernan, 2007), and thus are adequate and suitable to knowledge-based industries and regions with a high quality of research infrastructure and capabilities. They neglect the heterogeneity and diversity found in regions (Coenen et al., 2017; Morgan, 2004).

However, there is a need for accounting a variety of innovation capacities or potentials between regions as region location, knowledge base, and institutional structures differ (Boschma, 2009). Because of such diversity, under-developed regions and even intermediate regions may not be suitable to refer to using those successful stories of advanced regions. The extent to which less developed regions will benefit from the knowledge created in more developed regions cannot be determined naturally and indiscriminately.

Lagging regions with little to no technological capabilities or knowledge merely adapt to imported innovations, and they are highly dependent on external actors and resources without intra-regional capacity. In addition, even intermediate regions who satisfy the industrial and scientific knowledge base to some degree, are sometimes not eligible for intra-regional knowledge spillovers (Asheim et al., 2016; Iammarino, 2005).

Currently, there is a high technology and modes of innovation bias to advanced regions that are equipped with a high level of technological capability and diversified knowledge. That is, the unique and intrinsic properties of regions in terms of their level of knowledge capacity and innovation potentials are not sufficiently considered in regional development policies, resulting in their ineffectiveness (Tödtling & Trippl, 2005).

Moreover, according to the sociological perspective on the role and value of technology, different groups of people have different understandings regarding technology, such as technical characteristics or so-called interpretative flexibility (Mackenzie & Wajcman, 1999; Pinch & Bijker, 1984; Williams & Edge, 1996). Given social conditions, some technologies are more suitable to some social relations than to others (Winner, 1993). Technology is a particular scientific problem solution that is accepted where beliefs and values are shared by a group of people, and local considerations such as networks and reward structures are immediately relevant to the social shaping of technology (Mackenzie & Wajcman, 1999). Thus, social process in technology and knowledge is also important.

Now that there is no one-size-fits-all best practice, differentiated designs and goals should be implemented in regional innovation and development policies which account for specific local technological capabilities, socioeconomic environments, and typical innovation barriers.

In line with this, few attempts were made to differentiate types of regions (Tödtling & Trippl, 2005). The Organization for Economic Co-operation and Development (OECD) (2011) classified regions into three types: knowledge regions, industrial production zones, and non-scientific and technology driven regions. This approach enables distinguishing the dominant characteristics and features of regional innovation systems and challenges each phase along innovation processes (McCann & Ortega-Argilés, 2015).

2.1.2 Regional economic development theories

From a regional economic development perspective, the term 'region' is often defined based on the concept of 'functional economic area,' which describes a region as a basis for an economic area (Fox & Kumar, 1994). This approach is quite useful; however, local political boundaries rarely match functional economic areas (Dawkins, 2003). Instead, 'planning regions' represent administrative boundaries under policy design and implementation control (Richardson, 1979). Institutional economics and growth literature adopt this approach to define regions (Dawkins, 2003).

Conceptual foundations of regional economic development start from neoclassical trade theory and growth theory. These two theories, together, suggest that differences among regional economies and the prices of economic factors will decline and tend to converge over time. First, the Heckscher-Ohlin-Samuelson (HOS) theorem explains international factor price convergence with static equilibrium trade models using simple assumptions such as the same technology and production functions across regions and zero transaction costs (Samuelson, 1953). The HOS model demonstrates that a comparative advantage in abundant factors for production and specialization with free inter-regional trade will result in convergence of incomes.

A dynamic version of convergence hypothesis is the exogenous growth theory from Solow (1956). Unlike the static convergence of incomes or prices of factors in the previous theories, the exogenous growth theory assumes convergence in growth rates. Growth theories explain convergence as a being a result of decreasing returns to capital investment rather than inter-regional trades. They use supply-side models of investment in regional productive capacity, and technological progress parameters are determined as exogenous. In summary, these convergence theories suggest that trade and investment will ultimately lead to an equalization of the regions.

However, the convergence theories began facing considerable controversy and criticism. Mostly, they were criticized by empirical results. For instance, regions in least developed countries (LDC) experience persistent poverty which is far from convergence of regions. In addition, convergence theories were also criticized for unrealistic assumptions such as constant returns to scale, zero transportation costs, and identical production technologies across regions (Dawkins, 2003).

Afterwards, new divergence theories emerged to overcome earlier criticism of the traditional neoclassical models; the endogenous growth theory. The new perspective assumes economic divergence across regions. The endogenous growth theory regards technological change and innovation as endogenous factors to economic growth.

Schumpeter was the first to emphasize the process of innovation (Schumpeter, 1942), and Arrow (1962) suggested the term 'learning by doing,' which means actors acquire new knowledge through experience in their internal production. For instance, as production is continued over time, the costs would fall because workers accumulate experience and create new knowledge by learning by doing. However, growth rates by learning by doing differ between industrialized regions and lagging regions since institutions promoting learning and diffusion differ across the regions (Stiglitz, 1989). Later Romer (1986) added the stock of knowledge variable with other inputs in the production function, which assumes increasing returns to production of consumption goods and decreasing returns to production of knowledge. In summary, the models predict divergence in regional growth rates.

Other main theories of regional economic development include new economic geography, flexible specialization, and network theories. First, economic geography, proposed by Krugman (1999), suggests static analysis of the driving forces for the emergence of industry clusters, for example, external scale economies and increasing returns. It tries to explain why regions undergo different patterns of economic growth even when there are no geographic environmental differences.

Flexible specialization and network theories focus on inter-relationships of the industrial districts or clusters and how they contribute to regional differences. Firms interact with each other based on flexible labor and capital and dense localized networks where knowledge is shared (Piore & Sable, 1984; Saxenian, 1994). Also, geographic clustering, which relies on proximity, promotes intra-regional knowledge spillovers and diffusion of innovations (Porter, 1998; Scott, 1988; Titze et al., 2011).

So far, the theories discussed, and also other theories that could not be included in this brief summary, largely overlap and have great potential for integration. Indeed, divergence theory was developed into evolutionary economics, and has been further incorporated with economic geography, which considers the role of geography and space in regional growth patterns, finally emerging as evolutionary economic geography.

2.2 Evolutionary economic geography

The new economic geography literature, initiated by Krugman (1999), emphasized the role of geographical features for understanding the dynamics of the economy, for example, increasing returns based on spatial agglomeration of economic activities. However, despite its usefulness to explain different regional patterns on economic growth, it has some restrictions because it is based on a static analysis (Dawkins, 2003). The theory lacks evolutionary perspective, that is, how the process evolves over time.

The evolutionary perspective is fundamental to understanding the geographies of technological progress, dynamics, restructuring of economies, and economic growth (Boschma & Martin, 2009). Evolutionary economics deals with the process and mechanisms by which the economy transforms itself from within (Nelson & Winter, 1982). Schumpeter insisted that transformations arise endogenously within the socio-economic system, and innovation and adaptation processes are the primary mechanisms (Ramlogan

& Metcalfe, 2006). Thus, innovation and knowledge are assumed as central factors, and continuous internal development of knowledge is the underlying process of economic evolution (Metcalfe et al., 2006). In this regard, the ideas and concepts of evolutionary economics were applied to regional development as evolutionary economic geography.

The integration of evolutionary economics and economic geography is a recent development and the body of work is somewhat scattered; however, common sharing principles do exist (Dopfer, 2004). Evolutionary economic geography views economy as an evolutionary process within time and space (Boschma & Frenken, 2011), and therefore adopt three characteristics from the evolutionary perspective (Witt, 2003). First, theories must be dynamic rather than static. Second, the process is irreversible, which means the dynamics of emergence, convergence or divergence and other patterns are considered in real time. Lastly, generation and impact of novelty should be the ultimate source of a region's self-transformation. The creative capacity derives subsequent evolution and adaptation (Metcalfe et al., 2006). To summarize, dynamic, irreversible, and self-transformational systems are applied with spatial contexts in evolutionary economic geography.

In evolutionary economic geography, from a geographical aspect, regions are treated as homogeneous entities in terms of their collective knowledge, economic and institutional structures, and social conventions (Strorper, 1997), and firms are grounded in such regional contexts. Firms or other organizations are context dependent and path dependent. Here, geographical proximity is regarded as fundamental in that it facilitates the process of collective learning by lowering transaction costs and search costs between firms.

Knowledge spillovers and information externalities are stimulated by spatial proximity and thus often specific to the regional context (Audretsch & Feldman, 1996; Boschma & Lambooy, 1999; Feldman, 1994). This is because local accumulation of human resources, tacit knowledge, linkages and networks, and supportive institutions which are hard to imitate, and transfers are all related to competitiveness of a region. From this view, concepts such as clusters (Porter, 1990), innovative milieu (Camagni, 1995), technological districts (Storper, 1997), regional innovation systems (Cooke et al., 1997), and learning regions (Morgan, 2004; 2007) have been introduced.

In addition, key scopes of literature in evolutionary economic geography include spatial clustering with firm and industrial dynamics, knowledge networks, institutions, and structural changes and agglomeration externalities (Boschma, 2015). For instance, compared to economic geography, insights of both external knowledge sources and intra-firm routines are added to clusters (Giuliani, 2007). Additionally, a variety of knowledge based on structural change and industrial dynamics explained by Marshall-Arrow-Romer (MAR) type externalities for intra-industry spillovers and Jacobs type externalities for inter-industry knowledge spillovers, is sought in long-term economic growth.

One can realize that the role of knowledge is profoundly emphasized in evolutionary economic geography, as knowledge is placed at the center of importance. Traditional neoclassical economics regards knowledge as a public good which, in turn, enables convergence across regions. On the other hand, in evolutionary economics, knowledge evolves and is accumulated through learning by doing (Arrow, 1962). These dynamic, irreversible, and cumulative characteristics of knowledge development are correlated with development of capacities of firms or individuals over time (Nelson & Winter, 1982; Dosi & Nelson, 1994).

According to Boschma (2009), exploitation of intangible knowledge and institutions is the primary source of regional growth. Also, the difference in generation and diffusion of knowledge across space explains divergent geography of growth. Thus, the competitive advantage of regions is up to their respective capacity of producing high-value, non-ubiquitous, elaborate, and tacit knowledge (Balland & Rigby, 2017; Lawson & Lorenz, 1999; Storper & Venables, 2004). For instance, Balland and Rigby (2017) shows that as knowledge gains higher complexity it becomes less spatially mobile. Likewise, theoretical literature in evolutionary economic geography links regional competitive advantage to geographical concentrations of tacit and complex knowledge.

In this respect, recent literature has attempted to find differences in the nature of knowledge cores across regions. The underlying logic of such discussions is that the evolution of a region's economic structure relies on its knowledge base, specifically, the path- and place-dependent properties (Kogler et al., 2017). For example, studies utilize patent data to explore evolutions of local knowledge spaces (Balland & Rigby, 2017; Kogler et al., 2013; Kogler et al., 2017; Rigby, 2015). With the trajectories of local knowledge development, the studies investigate how those knowledge structures evolve in terms of 'relatedness,' through internal technological diversification patterns (Boschma et al., 2014; Rigby, 2015).

Relatedness is recognized as a driver of regional diversification and structural change (Boschma, 2017; Kogler, 2017). This is because, for a region to diversify its knowledge base, it is highly dependent on an existing technological knowledge portfolio (Boschma et al., 2014), and transformations reshape every existing interaction and create path-dependent and related changes. Therefore, recently, in the field of evolutionary economic geography, the process of regional diversification through extensions based on relatedness is a research priority (Kogler, 2015).

With regard to the regional diversification process, as knowledge is accumulated, diverse knowledge and novel knowledge recombination become a key source for economic diversification and growth (Ahuja & Lampert, 2001; Kaplan & Vakili, 2015; Levinthal & March, 1993; Quatraro, 2016; Savino et al., 2017). Recombination of knowledge represents the internal dynamics of the regional knowledge structure, which is one of the core competences of the region. Moreover, the change in technological knowledge derived from combinations of a variety of knowledge is closely related to economic structural change (Quatraro, 2016), and both changes are important for the growth of regional economies.

Following the series of studies on technological knowledge spaces and relatedness (Kogler et al., 2013; Kogler et al., 2017), regional recombination of knowledge needs to be explored further in order to provide guidance to sustain long-term regional development and self-transformations.

2.3 Regional innovation systems

Regarding spatial agglomeration advantages in terms of technological progress and innovation, the concept of Marshallian externalities within spatial boundaries had been discussed by traditional economists (Fritsch & Franke, 2004; Krugman, 1999). However, inter-firm or intra-industry knowledge spillovers and inter-industry knowledge transfers based on geographical proximity alone do not secure innovations and economic growth (Boschma, 2009). For example, Freeman (1987) argued that innovation process is involved with interactions of firms and organizations, financing systems, educational facilities, and other institutions.

The origins of innovation system literature can be traced to evolutionary economics and the recognition of the importance of contextual factors and the existence of inter-relationships in the process of emergence and diffusion of innovation, to economic performance (Iammarino, 2005). The systematic nature of innovation became widely accepted and was embedded in socio-economic systems, including economic, social, organizational, and institutional factors (Edquist, 1997; Lundvall, 1992). The territorially embedded factors are crucial in facilitating innovations as they constitute conditions for the generation and the process of innovation.

The literature has been categorized into, first, national level (Freeman, 1987), and then, regional level for sub-national models (Cooke et al., 1997; Cooke, 2001). The regional innovation systems (RIS) have been developed since late 1990s , focusing on spatial dimensions and place-based innovations (Coenen et al., 2017) and has the advantage of explaining territorially embedded factors in a heterogeneous way compared to broad national innovation systems. Unlike national innovation systems, key actors and governance in RIS are embedded within geographical proximity, interactions of firms in the region, and bottom-up processes (Asheim et al., 2016). This is exemplified in the Italian innovation process case (Locke, 1995; Malerba, 1993).

As regional competitiveness relies on innovation-based capacity, and innovations occur from the continuous development of existing knowledge, the approach considers regions' intrinsic technological diversity and properties of knowledge in terms of absorption, diffusion, and creation of knowledge (Carlsson & Stankiewicz, 1991; Coenen et al., 2017; Dopfer et al., 2004). That is, the RIS approach also copes with uneven geography of innovation as evolutionary economic geography and tries to identify factors that promote knowledge production and innovation capacities of regions.

According to Dopfer et al. (2004), there are individual components, their relations, their attributes, and systems of rules in RIS: principal agents of innovation, inter-organizational interactions, institutional background (such as legal, financial, and educational), industrial and spatial structure, and others are considered in the system (Howells, 1999). Besides, the list encompasses a 'macro to meso' view in that it shows the system of innovation with landscape dimensions and networks. On the other hand, the 'micro to meso' view can be integrated which accounts for internal and dynamic structures of individual agents. Here, evolutionary trajectories of access to and efficient use of knowledge are involved, which are absorption, diffusion, and generation of knowledge (Iammarino, 2005).

That is, learning processes and interconnections of organizations and socio-economic factors in innovation processes are considered from the holistic and evolutionary perspectives (Edquist, 2005). RIS may therefore be sustained through these multiple channels based on learning processes at the center. Furthermore, the integrated perspectives provide insights to explain local or regional variety in innovation systems in terms of distinct environments of interaction and institutional settings (Audretsch & Feldman, 1996; Cooke, 2001). Based on this view, related literature analyzes conditions that favor or hinder the initiation and development of RIS.

From the RIS perspective, system failures may result in low innovation performance outcomes in regions (Edquist, 1997; Laranja et al., 2008; Tödtling & Trippl, 2005). In evolutionary economics, market imperfections, or market failures, such as knowledge asymmetries, knowledge spillovers, or monopoly powers by novel knowledge, are not corrected by policy intervention (Boschma, 2009). By contrary, evolutionary economists insist that system failures should be considered for policy intervention in a knowledge-based economy (Asheim et al., 2011; Boschma, 2009).

Lack of relationships and collaborations, and lack of ability to create novel knowledge to renew the economic structures, are considered system failures (Boschma & Lambooy, 1999; Boschma, 2009). It implies that regional innovation policy should be designed and implemented based on these considerations of system failures for effective functioning of complex interactions and also for promoting dynamic and innovation-based regional competitiveness (Coenen et al., 2017).

Further, different types of regions face different types of system failures (Asheim et al., 2016; Tödtling & Trippl, 2005). For instance, 'organizational thinness' in peripheral regions lacks crucial components of an innovation system such as key organizations or institutional factors (Camagni, 1995). These regions often rely on external resources to supplement the lack of local learning opportunities (Grillitsch & Nilsson, 2015). In contrast, other regions may face a lack of networks and knowledge diffusion between heterogeneous actors or may struggle to adapt to new changes in market and technologies if they are highly specialized, leading to negative lock-in problems (Asheim et al., 2016).

Likewise, recent RIS literature emphasizes dynamic applications. In other words, RIS in developing and developed regions should be approached differently. For instance, under-developed regions depend on external inflow of knowledge or resources to a large extent. RIS in developed regions substantially differ in their economic and institutional conditions (Tödtling et al., 2013). However, previous literature was mostly inspired by successful regions that satisfy strong endogenous innovation potentials, networks, and favorable conditions for knowledge production and exchange (Piore & Sabel, 1984; Saxenian, 1994).

One of the contributions of the systematic approach of RIS is that it is able to provide specific regional innovation policy that corresponds to specific regional characteristics and challenges. There is no single permanent best practice policy that is available for every region and context. Recently, to capture additional regional context sensitivity and customize regional innovation policies, RIS has started to increasingly emphasize the importance of differentiated knowledge bases in regions in addition to institutional and organizational contexts (Asheim et al., 2011; Asheim et al., 2016; Coenen et al., 2017).

Eventually, the RIS literature suggests insights to recombinant knowledge dynamics based on a knowledge base approach as in evolutionary economic geography (Asheim et al., 2016; Grillitsch & Trippl, 2014; Tödtling & Grillitsch, 2015). Economic diversification strategies for regions based on relatedness between industries and a combination of knowledge bases are also considered crucial in the RIS perspective (Coenen et al., 2017).

2.4 Contribution of the study

To summarize the review of literature, theories and studies were developed to satisfy the need for regional level analysis in terms of innovation and economic growth. The advantages of regional examination are: first, geographical proximity favors knowledge spillovers and accumulation of knowledge; second, context-specific factors highly affect regional innovation capabilities; and third, regions tend to have specialization patterns of industries and higher diversity in technology compared to the country level. Subsequently, theoretical fields such as evolutionary economic geography and regional innovation systems have appeared to overcome national bias and to seek effective regional innovation and growth policy.

Evolutionary economic geography and regional innovation systems literature pursues the analysis of dynamic, irreversible, and self-transformational features of regional growth patterns with knowledge at the center, to enable sustainable long-term regional development.

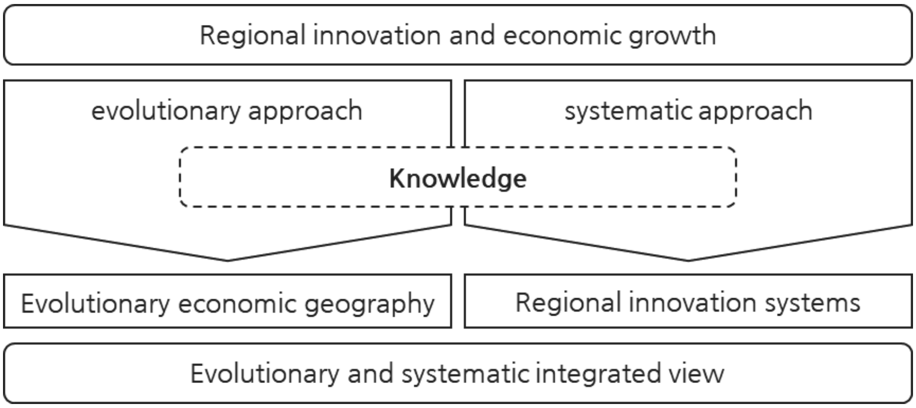


Figure 2-2. Evolutionary and systematic integrated view on regional innovation and economic growth

Yet, the review reveals three main challenges or issues regional innovation and growth policies encounter. First, regions have intrinsic contexts with different levels of knowledge and environmental conditions; thus, there is no one-size-fits-all policy that homogenously suits every region. Rather, an evolutionary and dynamic approach is required to provide feasible policies regarding regional potential. Second, regional innovation policy should deal with system failures because, in many cases, the absence of crucial parts of a regional innovation system results in a low level of innovation performance from a holistic view. Finally, the capacity for novel knowledge recombination of the regions should be explored further in the future, since it is the key for a region to self-transform and sustain long-term growth.

In this regard, this thesis proposes the adoption of an evolutionary and systematic integrated view on regional innovation and growth by investigating innovation and growth patterns in three different level of regions. The approach can provide different implications according to their level of knowledge accumulation and diversity with consideration of surrounding socio-economic conditions. Furthermore, the three studies in a row depict a dynamic and self-transforming illustration of a region based on the three functional dimensions of absorption of external knowledge, diffusion of knowledge within the region, and generation of new knowledge, leading to sustainable transitions and growth.

The first study describes a community-level innovation in a lagging region from a developing country with a case of appropriate technology project. Although there is no scientific or technological innovation breakthrough, a learning process is required for the enhanced efficiency in absorbing and using the external technology. The work on appropriate technology or regional development of LDCs in terms of innovation has gained little to no attention from scholars. This is because it is a non-profit activity that has very little incentive to study, and it lacks available data for quantitative analysis. In this context, the first study proposes a theoretical background for appropriate technology, based on grassroots innovation theory, to suggest the initiation of regional innovation in regions with low technological capability.

The second study focuses on intermediate regions that have a scientific and industrial knowledge base yet lack a regional innovation system that promotes intra-regional knowledge spillovers. A large proportion of literature on intra-regional knowledge spillovers focuses on clusters and their performance but lack insight into the relationship between clusters and regional growth. Here, a systematic approach is applied, discussing the importance of socio-economic contexts to fostering regional growth by cluster-based policy and the relative effectiveness of internal capacity and networking on regional growth.

Finally, the third study aims explain the effects of regional capacity in knowledge recombination on productivity gains in regions with high level of knowledge accumulation and diversity. According to the literature, a generation of novel knowledge is crucial for regional growth, however, not much work has been done on measuring knowledge recombination capacity on the regional level. Therefore, the study specifies knowledge recombination types and analyzes their effects on productivity for sustained economic growth.

Based on the three studies, the ultimate goal of the thesis is to suggest and illustrate self-sustaining dynamics of regional innovation and growth.

Chapter 3. Grassroots innovation for regional development in developing countries: A qualitative study on appropriate technology[1]

3.1 Introduction

In an increasingly sociotechnical world, local and context-appropriate technology implementations are important for sustainable development. The Sustainable Development Goals have replaced the Millennium Development Goals by emphasizing inclusive development and declaring more sustainable methods are required (United Nations (UN), 2017). In this regard, appropriate technology has a strong potential in developing countries in terms of regional development.

The concept of appropriate technology was established along with that of sustainable development in that it considers the capacity of recipients for resilience and persistence. However, failures are many, mostly because it is carried out as a temporary, short-term technology transfer in practice (Murphy et al., 2009; Smith et al., 2014). Thus, the need for examining the comprehensive and social aspects of appropriate technology has gained attention (Marti-Herrero et al., 2014; Wicklein, 1998).

However, although some results of appropriate technology research share mostly common aspects (e.g., technological, structural and local behavioral), there is no formal

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[1] The earlier version of Chapter 3 has been published in *Journal of Cleaner Production*.

consensus, but only implicit agreement. This is because this research strand lacks a theoretical background (Buatsi, 1988; Marti-Herrero et al., 2014; Muga & Mihelcic, 2008; Park & Ohm, 2015). As such, a study based on its theoretical background will show more systematic and objective results and attract attention.

Therefore, this paper analyzes the sustainability of appropriate technology upon a grassroots innovation background. Grassroots innovation is introduced as a community level bottom-up innovation for sustainability (Seyfang & Smith, 2007) and seeks socially inclusive innovation processes within local communities in terms of knowledge, process, and outcomes. People and organizations outside the local area are also included, yet the local community and its knowledge lead the collaborative innovation process (Smith et al., 2014).

The study thus aims to identify relationships between appropriate technology and grassroots innovation by and conduct a case study of an appropriate technology project under the framework of grassroots innovation. At the same time, this approach tries to illustrate how regional innovation can be initiated in regions with low technological capability. Then, implications for appropriate technology and regional development are elicited.

The remainder of the paper is structured as follows. Section 2 reviews the literature and the relationships between appropriate technology and grassroots innovation. In Section 3, a qualitative method is proposed in terms of a framework and data. Section 4 describes the case within the framework in Section 3. The results are discussed in Section 5. Finally, Section 6 concludes the paper.

3.2 Literature review

3.2.1 Appropriate technology

The concept of appropriate technology was first introduced as an 'intermediate technology' in the book *Small is Beautiful* (Schumacher, 1973), because technologies from industrialized countries focused on the innovative efforts of capital-intensive and large-scale technologies were not appropriate for less developed countries (Ilon & Altmann, 2012; Schumacher, 1973). Instead, intermediate technologies would benefit a wider range of individuals in low-income countries by creating jobs, solving poverty problems, and developing self-reliance (Kaplinsky, 2011).

Subsequently, the term changed to "appropriate technology" to avoid a sense of inferiority (Hazeltine, 2015). Still, the meaning remained similar, that is small-scale, labor-intensive, and thus simple and environmentally friendly (Murphy et al., 2009). However, scholars argued that the low productivity and inefficiency of appropriate technology could limit low-income countries' development (Eckaus, 1987).

Then, new approaches for defining appropriate technology have appeared (Lissenden et al., 2015; Mihelcic et al., 2009; Murphy et al., 2009; Park & Ohm, 2015; Ranis, 1980; Shin et al., 2016; Willoughby, 1990). The key and common change in these new definitions of appropriate technology is that it should not be limited to simple technology. Instead, it can be either an advanced or capital-intensive if it satisfies the local context and needs.

Additionally, the new approaches emphasize delivering the necessary scientific knowledge and skills to develop the capacity and knowledge base of beneficiaries (Buatsi, 1988; Murphy et al., 2009). This covers both the hard and soft properties of technology, that is, technology, knowledge transfer mechanism and capacity building for social and cultural aspects (Shin et al., 2016). Definitions of appropriate technology are shown in Table 3-1.

Table 3-1. Definitions of appropriate technology

Sources	Definition
Ranis (1980)	“the joint selection of processes and products appropriate to the maximization of a society’s objectives given that society’s capabilities”
Willoughby (1990)	“a technology tailored to fit the psychosocial and biophysical context prevailing in a particular location and period”
Murphy et al. (2009)	“a strategy that enables men and women to rise out of poverty and increase their economic situation by meeting their basic needs, through developing their own skills and capabilities while making use of their available resources in an environmentally sustainable matter.”
Mihelcic et al. (2009; 2011)	“the use of technology and materials that are environmentally, economically, culturally, and socially suitable to the location in which they are implemented and conducted”

Appropriate technology has received limited attention from scholars (Hazeltine, 2015; Murphy et al., 2009), as most existing research is technology-oriented and focuses on improving technical performance and efficiency through engineers. However, from the definitions of appropriate technology, it requires a deep understanding of the context for sustainability and extensibility (Polak, 2009). So far, social scientific research was conducted on identifying comprehensive factors, such as meeting local needs, utilizing local resources, being culturally appropriate, creating knowledge transfer mechanisms (Madu, 1990; Marti-Herrero et al., 2014; Murphy et al., 2009; Wicklein, 1998).

While most factors were identified by case analysis, most studies are not based on any theoretical background. Only few included a learning-based development approach and diffusion of innovation in terms of rural development (Agarwal, 1983; Ilon & Altmann, 2012; Romijn et al., 2010). Despite this lack of theoretical background, little attention has been paid to appropriate technology. Therefore, theoretical background research is required to improve appropriate technology research and conduct successful or sustainable appropriate technologies in developing countries.

3.2.2 Grassroots innovation

Literature on innovation has focused on technology-oriented innovations at national or industry levels so far; however, the literature on sustainability-oriented bottom-up innovations by the civil society gradually increased (Wolfram, 2018). For instance, Seyfang and Smith (2007) introduced the idea of “grassroots innovation” at the community level for sustainability, which differs from top-down innovations and mainstream or business reforms. It is defined as “networks of activists and organizations generating novel bottom-up solutions for sustainable development; solutions that respond to the local situation and the interests and values of the communities involved” (Seyfang & Smith, 2007, p.585). There is a qualitative difference between grassroots and market-based innovation as per Table 3-2.

Table 3-2. Market-based innovation and grassroots innovation

Variable	Market-based innovation	Grassroots innovation
Context	Market economy	Social economy
Driving force	Profit; Schumpeterian rent	Social need; ideological
Niche	Market rules are different: tax and subsidies temporarily shelter novelty from full forces of the market	Values are different: alternative social and cultural expressions enabled within niche
Organization forms	Firms	Diverse range of organizational types: voluntary associations, co-ops, informal community groups
Resource base	Income from commercial activity	Grant funding, voluntary input, mutual exchanges, limited commercial activity

Source: Seyfang and Smith (2007), p. 592

The theoretical background of grassroots innovation emanates from a niche-based approach that studies niche emergence and development (Smith, 2007). From a multi-level perspective view of sustainable transitions, strategic niche management (SNM) emphasizes the importance of niches created with the intent to preserve and foster emerging sustainable innovations (Geels, 2004; Kemp et al., 1998). It focuses on social networks, learning processes, expectations, and enrollment of actors and resources in emerging niche practices. Additionally, policies to improve the development and influence of niches, including nurturing diverse niches, facilitating greater actor interaction, promoting social learning, or seeking institutional changes, are recommended.

Usually, a niche refers to technological innovations and niches. However, green niches for more sustainable practice appear in societies with wide public participation and a focus on social learning (Smith, 2004). Similarly, grassroots innovation consider community level activities as innovative niches, which leads to the usage of technology in a more efficient way.

For example, a “co-housing model” is suggested by Seyfang and Smith (2007) as describing the situation of residents living in a common house. The structure of co-housing model combines privacy with communal activities and potentially reduces overall consumption in the house. This is essentially a social innovation—a restructuring of the social institutions of housing—rather than a technological innovation. A notable point is that social innovation and the diffusion of technological innovation are closely linked. By extending niche innovation analysis into innovation from a social context, grassroots innovation consists of community actions as a promising niche for innovation for sustainability.

Most research conducted case studies to determine the factors or the contexts and innovation activity of successful grassroots innovation in urban contexts at community level in developed countries, such as the UK or the Netherlands (Hoppe et al., 2015; Hossain, 2016; Monaghan, 2009; Seyfang et al., 2013; Seyfang et al., 2014; White & Stirling, 2013). Some studies were conducted in the rural contexts of China and India (Gupta, 2012; Jain & Verloop 2012; Ustyuzhantseva, 2015; Wu & Zhang, 2013). However, it is difficult to find research covering the developing countries.

3.2.3 Bridging appropriate technology and grassroots innovation

Successful appropriate technology activity resembles grassroots innovation, being usually discussed in developed countries, in the aspects of motivation, objectives, and required factors or mechanisms. Smith et al. (2014) describe grassroots innovation as "reminiscent of debates within the appropriate technology movements. (p.118)" Successful appropriate technology should not only bring immediate benefits but also empower and increase the capabilities of a region for subsequent activities and social transformations, which is somewhat similar to grassroots innovation.

Therefore, grassroots innovation should be considered when conducting appropriate technology planning and implementation by supporting several perspectives. First, grassroots innovation supplements the weak or not considered points of appropriate technology. Even the attempts to promote successful appropriate technology activities considering social context have problems. It remains unclear whether appropriate technology, as a development tool, will promote further societal transformation of the region. That is, appropriate technology struggled to trigger further innovation dynamics and capabilities of fulfilling basic needs and solving problems (Smith et al., 2014). However, this drawback is superficially analyzed in the literature on appropriate technology. Although there are several studies exploring the success factors of appropriate technology implementation at one point (Marti-Herrero et al., 2014; Murphy et al., 2009), research on continuous or succeeding innovativeness with appropriate technology is scarce. Often, appropriate technology lacked grassroots innovativeness in that neither local ingenuity nor local community empowerment was engaged. Innovative design and a participatory process are required for appropriate technology (Smith et al., 2014).

Second, appropriate technology movements and grassroots innovation movements share similar visions and principles (Seyfang & Smith, 2007; Smith et al., 2014) in that the final goal of appropriate technology and the benefits of grassroots innovation overlap to a large extent. According to Devine-Wright (2006), grassroots innovation has intrinsic benefits, namely socio-economic impacts for a sustainable community such as job creation, skill development, self-esteem, and confidence growth, a sense of community, social capital, and greater civic engagement. These make possible for a community to improve its quality of life. Further, the diffusion benefits of grassroots innovation include developing new ways of working towards sustainable development, greater empowerment and confidence for individuals, and capacity for subsequent community-based action by first- and second-order learning (Monaghan, 2009). These benefits show how appropriate technology should be.

Additionally, appropriate technology and grassroots innovation share a similarity of the bottom-up process. Grassroots innovation emanates from niches, which are individuals' motivations for actions different from mainstream values (e.g., green niches in developed countries). This point makes grassroots innovations have an advantage of sustainability, whereas top-down measures cannot have it. Bottom-up efforts allow communities to find better solutions that fit their social contexts based on local knowledge (Burgess et al., 2003). Many scholars highlight that appropriate technology should start from the local needs and be based on user-led participation; however, most appropriate technology projects are based on engineers' and developers' assumptions of local needs (Smith et al., 2014).

Moreover, grassroots innovation engages diverse organizations, such as voluntary associations, firms, and community groups. Usually, appropriate technology activities are performed by a head organization that directs the overall project, local government agencies, communities, co-operations, and volunteering associations. Because of their similarity, appropriate technology and grassroots innovation also share enduring challenges. For example, funding programs are often short termed and the particular combination of skills, key individuals, and supportive contextual factors required are sometimes challenging (Seyfang & Smith, 2007).

Finally, appropriate technology and grassroots innovation are similar in that they are different from mainstream. That is, as grassroots innovation is different from conventional market innovation, as indicated in Table 3-2, appropriate technology is different from commercial technology transfer. The most prominent difference in the former is whether it is financial or non-financial. Usually, technology transfer in terms of diffusion of innovation is promoted based on commercial goals: technologies are financially profitable and adopters acquire direct financial benefits (Agarwal, 1983). Additionally, technology transfer has been recognized as a treatment of economic goals in management and has been used by firms to secure competitive advantage or positions in industries and countries (Baughn & Osborne, 1989; Reisman, 1989; Zhao & Reisman, 1992). Further, its definition involves the meaning of technology "sales," which means a commercialization of technology (Farrell, 1979).

However, appropriate technology is a non- or less-profit seeking activity in that it satisfies the basic needs of rural areas and the adopters obtain indirect production benefits more often than direct financial benefits. For example, clean piped drinking water helps beneficiaries drink clean water, thus enhancing health and productivity, which provide indirect benefits in the long run (Agarwal, 1983). Similarly, grassroots innovation differs from mainstream innovations in that it is intended to meet social needs that may differ from the dominant regime, is driven from ideological commitments, involves communal structures, such as communities, voluntary inputs, and grants; and encourages progress in the social economy (Seyfang & Longhurst, 2016).

3.3 Methodology and data

3.3.1 Framework: Common constructs

To bridge grassroots innovation and appropriate technology, this paper suggests five common constructs: context, driving force, niche, organizational form, and resource base based on Seyfang and Smith (2007) and typically used when comparing market to grassroots innovation. These criteria show differences between market and grassroots innovation and, thus, highlight the unique properties of grassroots innovation. The authors also identify the relationships between appropriate technology and grassroots innovation.

Context

Grassroots innovations are predominantly social innovations developed at community level (Seyfang & Haxeltine, 2012) that seeks context-sensitive solutions, which lie within the social economy (Fressoli et al., 2014). The social economy represents “a wide family of initiatives and organizational forms, showing that the economy is not limited to the market but includes principles of redistribution and reciprocity” (Moulaert & Ailenei, 2005, p.2044). Redistribution and reciprocity thus depend on different social and cultural perspectives.

Appropriate technology should be implemented and conducted where it is environmentally, economically, culturally, and socially suitable (Mihelcic et al., 2009, 2011; Muga & Mihelcic, 2008) because it should meet the local basic needs and guarantee sustainability. Consequently, the effect of the context is significant for both the initiatives of grassroots innovation and appropriate technology.

In this paper, *context* is defined as *a typical social landscape of a community that requires flexible and localized goods and services.*

Driving force

The driving forces of grassroots innovation are social need and ideology (Seyfang & Smith, 2007). Social need is derived from the social economy, which provides flexible and localized services in situations where the market cannot. Additionally, ideological commitment to develop alternative values, which may differ from mainstream priorities, becomes a driving force (Kirwan et al., 2013).

Commercial technology transfer usually seeks profit or economic growth, while appropriate technology also seeks alternative values such as sense of independence and quality of life. Therefore, the driving forces of appropriate technology remain to solve problems in the real life of communities or residents and improve living conditions that the market could not provide satisfactory solutions to (Moulaert et al., 2013; Wolfram, 2018). This would accompany a degree of ownership, which would enable long-term support from the community (Reed, 2008).

In this paper, *driving force* is defined as *a social need based on the context that triggers ownership.*

Niche

A niche is an unusual situation, where the change or succession of a regime tends to begin from a network of organizations, technologies, and users. New ideas, technologies, and practices develop from these niches in "protected spaces" (Geels, 2004; Rip & Kemp, 1998). These alternatives may become sufficiently robust to create niche markets and, finally, reach the mainstream, if successful (Schot et al., 1994). This characteristic of niches makes it possible to explain that movement toward sustainable development in developed countries emanates from the strategic management of niches (e.g., creating green niches) (Kemp et al., 1998; Smith, 2004). Green niches are different from technical solution niches due to their focus on participation and social learning (Seyfang & Smith, 2007).

As previously mentioned, SNM intentionally develop niches to protect emerging sustainable innovations and is applied in grassroots innovation studies to identify successful factors for creating and nurturing grassroots niches (Hossain, 2016; Seyfang & Longhurst, 2016). According to Seyfang and Smith (2007), niche practices in grassroots innovation start from "social networks, learning processes, expectations and enrollment of actors and resources, (p.590)" that is, overall, niches in grassroots innovation are community-level activities. Then, nurturing niches, promoting greater participation and social learning, and inquiring institutional changes are required to develop these niches. Niche values are different in that alternative social and cultural expressions are enabled within them (Smith et al., 2014).

Appropriate technology was also promoted as a bottom-up approach that provides solutions for sustainable development in developing countries. While it should meet the needs, interests, and values of regions, most appropriate technology activities failed because they did not include the community. Instead, decisions were held by engineers and planners. Similar to grassroots innovation, community-level activities play a significant role in appropriate technology in terms of sustainability because community actions promote participation in decision making, volunteering, capacity building, information sharing, and community mentoring (Department of Environment, Food and Rural Affairs (DEFRA), 2005).

In this paper, *niche* is defined as *community-level actions towards sustainability.*

Organizational forms and resource base

Key participants or members in market innovations are clearly distinguished: firms that seek financial profit from selling products and innovation. However, actors in grassroots innovation are complex. Different organizations or institutions are included, such as social enterprises, cooperatives, informal communities, and voluntary associations (Hossain, 2016; Martin et al., 2015). This shows that participants are not homogeneous. Grassroots innovation includes external organizations, that is, organizations from outside local communities that engage in the grassroots innovation process by providing ideas from the outset and help utilize local knowledge for collaborative innovation (Smith et al., 2014). Often, participating groups in grassroots appear to be small-scale, low-profile, voluntary, and community driven (Seyfang & Smith, 2007).

Since organizational forms are diverse, the resource base is also pluralistic. It includes grant funding, voluntary labor, limited commercial activity, and mutual exchanges (Seyfang & Longhurst, 2016). Every resource varies in its degree of funding, professionalism, and official recognition (Seyfang & Smith, 2007).

Usually, appropriate technology projects are carried out by several organizations because of appropriate technology's intrinsic characteristics. That is, developing countries lack the capacity to develop their own technology or systems for well-being, which is why appropriate technology is locally implemented by external organizations. Therefore, it is inevitable that diverse groups participate (e.g., central governments, local governments, NGOs, firms, and volunteer associations). Additionally, the resource base is provided by those diverse groups, and is, thus, similarly pluralistic.

In this paper, *organizational forms* are *all the organizations and participants or stakeholders of a project,* and the *resource base* is *all the grants and physical, financial, and human resources provided by the stakeholders of a project.*

The overall variables and their definitions are shown in Table 3-3.

Table 3-3. Definition of variables

Variable	Definition
Context	A typical social landscape of a community that requires flexible and localized goods and services
Driving force	A social need based on the context that triggers ownership
Niche	Community level actions towards sustainability
Organizational forms	All the organizations and participants or stakeholders of a project
Resource base	All the grants and physical, financial, and human resources provided by the stakeholders of a project

3.3.2 Methodology and data

The explanatory nature of this research and the aim of this paper to use grassroots innovation to address sustainable appropriate technology induces qualitative analysis. The case of an irrigation dam and channel construction project in Meun District, Laos by the Korea International Cooperation Agency (KOICA) is analyzed. The project aimed to build the capacity of the community and enhance agricultural productivity by constructing an irrigation dam and a canal and providing education and training on the technology and water management. The outline of the project is shown in Table 3-4.

Table 3-4. Outline of the project

Project title	The irrigation dam and canal construction project in Meun District, Vientiane Province, Laos
Beneficiaries	Residents in Namhee village, Meun District
Project period	2008-2001
Project budget	USD 3.2 million
Institutional forms	• KOICA (development agency) • Dongho Inc. (construction manager, CM) • Global Community Development Research Institute (project management consultant, PMC) • Guangdong No. 3 (construction company) • Provincial Agriculture and Forestry Office in Vientiane Province

Source: KOICA (2016a)

For the case study, government publications from Korea and Laos, articles, and reports from international organizations were reviewed. Important events and some general information were retrieved from media articles and international reports. Government publications contained resources to explore the underlying context of the process. Specifically, the results of program evaluations are included in those publications. The evaluations were conducted for three times, in the middle of the project, right after the project, and five years after the termination of the project.

Especially, the ex-post evaluation makes it possible to assess sustainability of the project, compared to the first and second evaluation. Additionally, this objective evaluation helps draw lessons for future projects. It contains five evaluation criteria, suggested by OECD Development Assistance Committee (OECD/DAC): relevance, efficiency, effectiveness, impact, and sustainability. The process and performance of the project are evaluated based on these criteria.

The literature review, interviews with local and external stakeholders, user surveys targeting 131 households in the community, and results of local field work and local workshops were used abundantly in the report. Reviewed documents include a project concept paper, feasibility study report, and statistical and policy data on water and agriculture in Laos.

Interviewees include two KOICA officials, the construction manager and project management consultant, and evaluator from Yooshin Engineering from Korea. Several government officials of Vientiane Province and Meun District, village residents, and other donor agencies in Laos, such as the Asian Development Bank (ADB) and Japan International Cooperation Agency (JICA) are also included for the interview. The interviews were conducted on experts and stakeholders of total 34 people, five from Korea and others from Laos, to gather views and opinions on the project. The lists of interviewees and discussions are shown in Appendix 1.

The questionnaire survey was carried out to 131 households among 142 households in the village to gather the views and feedbacks from beneficiaries and to evaluate impacts. The evaluation team visited each household for the survey within period of 11 days. The questionnaire includes household information, evaluation of the activities and intervention achievements of KOICA.

Also, among the field works, managers and members of water user group were interviewed. Based on these activities, the data were retrieved primarily from evaluation reports (KOICA, 2009; 2013; 2016a).

3.4 Case study

Here, the case of grassroots innovation in appropriate technology in a community in Laos is described. According to the results of survey, in terms of productivity, the area of agricultural fields rose from 86 hectare at first to 307 hectare. Of all households, 48.1% are supplied with sufficient agricultural water, and 52.7% said that they were able to use more agricultural water than before the project. Regarding income growth, 51.9% of 131 households gave a positive answer and the number of households with an annual income of 5 million LAK[2] increased from 21 (30.9%) to 56 (82.3%) out of 68 households[3] (KOICA, 2016a).

In addition, the assessment results show that this project is successful measured by the five criteria of OECD/DAC. Each criterion has scale point of one to four, and this project achieved point of 11.6 out of total 16, which is categorized as a successful performance. The rating result is appended in Appendix 1.

[2] 1 USD=8,340 LAK (October 2016)
[3] Beneficiaries were total 142 households (608 people) in October 2016.

Specifically, the development needs and goal of Laos and Korea's development cooperation strategy aligned well, thus promoting a high ownership of the partner country. The overall efficiency of the project appeared high in terms of time and costs, and generated positive effects on performance. Additionally, the active engagement of participants was considered significant for the sustainability of the project.

At last, the case of appropriate technology is illustrated to show potentials as a tool for grassroots innovation in a developing country by the five constructs of context, driving force, niche, organizational form, and resource base.

Context

The region, Namhee village, Meun District, Vientiane Province, is located about 170 km northwest of Laos' capital, Vientiane, and near the border with Thailand, facing the Mekong River. Approximately 75% of the households in Vientiane Province are located in rural areas and Namhee village is located on a wide basin-shaped plain with sufficient land resources. According to the survey, 117 out of the 131 households (89.3%) engaged in agriculture for a living.

Although Meun District has a wealth of water resources, land use rate or rainfall utilization rate is low due to seasonal rainfall, which makes water management and utilization of irrigation facilities a necessity. However, there has been no separate irrigation or inhabitant development program of the state government to increase income within agricultural production (KOICA, 2009).

As one of least developed regions, the Vientiane government requested the construction of an irrigation dam and channel in Namhee village for its modernization and to make it a district-wide development model for other communities. The dam was designed as uniform, 16 m height, 620 m length, holding about 1.87 million tons of irrigation water. The irrigation channel has a total length of 14 km (6.3 km from the main line, 7.7 km from the branch line). Although it was not originally planned, it carried out one bridge and bank protection construction during the course of the project.

The context of Namhee village triggered some changes in technology selection. At first, there were some suggestions of the canal being built with concrete, which is the most popular for canal construction. However, earth was used instead because an earth canal was appropriate considering the budget and capacity of the local residents in the village. In other words, instead of common and commercial technologies, an "appropriate" technology that suited to local conditions was chosen and used. Additionally, through field check-ups, design was changed and adjusted to fit the local conditions.

Driving force

The driving force of this appropriate technology project emanates from the social need of the village. Based on the environmental conditions for agriculture, an efficient irrigation system and water management is necessary for the region, which is also determined by the fact that it is the local government that requested the project first. Vientiane Province submitted a specific proposal with a few project sites, which were narrowed down to

Namhee village. Based on social needs and consequent ownership, Laos participated in the basic design of the dam and canal system.

According to the results of an interview with 23 villagers during the interim evaluation, the villagers showed high interest in their business, commitment to participate, strong organizational power in the village, and active participation of women (KOICA, 2009). This made it possible to create a water management organization with one person per household to monitor the project.

Additionally, a survey on whether the project considered and reflected social needs was conducted for post evaluation by the residents in Namhee village, of which 69.4% answered "yes," 25.2% answered "fair," and 5.2% answered "no" (KOICA, 2016a). The report concluded that the project sufficiently reflected the social needs, which became a driving force for participation.

This is clearly a bottom-up process, which is an essential form of successful appropriate technology project and grassroots innovation. Social need as a driving force makes the project a bottom-up process and consequently induces ownership.

Niche

Niches in grassroots innovation refer to community-level activities. That is, instead of technology innovation as a niche in conventional innovations, social innovation becomes a niche in grassroots innovation (Seyfang & Smith, 2007). In terms of social innovation, participants can create or operate innovations that might lack technological improvement but are significant in that they directly fulfill users' needs and accumulate and embody indigenous knowledge or skills than would be used in the long run (Agarwal, 1983). These niches are formed by social networks, learning processes, and enrollment of actors and resources according to SNM (Kemp et al., 1998; Smith, 2007; Hossain, 2016).

A unique aspect of this appropriate technology case is that it fostered and operated the "water user group" as a niche, composed of Namhee village residents for the usage, management, and maintenance of the irrigation dam. Water managing experts were dedicated to nurturing and activating the water user group. One of the outcomes is that a new provision to charge water usage fees was added to water user group regulations.

The water user group included 71 habitants from 71 households, one from each household. They gathered regularly for meetings, which made possible the systematic maintenance and management of waterways. Since the completion of the project, the main canals have been found to be in a good condition. Additionally, the flow of water through canals showed no problems. Based on interviews, these positive outcomes were confirmed to be a result of the water user group's active participation.

Water management experts were sent to the village to educate the locals. Specialists calculated the water flow rate, installed a water level chart, prepared water management charts and guide maps, posted them in the town hall, and creates and distributes water management manuals so that residents could efficiently manage water. Additionally, training was provided on topics such as basics of irrigation, operation plan of water user group, repairing facility maintenance, facility operation management practices, and water system maintenance and management. Experts on water management and agriculture technology were sent to Laos for six to eight months, respectively, and carried out five rounds of education and training for the Namhee village residents. A survey on the topic of the training was conducted in advance to set up its direction.

In the group, all 71 people enrolled actively. They financed the deficient budget by collecting 90,000 LAK per 1 ha as water fee each year and jointly utilized it as maintenance budget. The water user group holds regular meeting every three months. Additionally, on May 20 each year, residents gathered to conduct maintenance and cleaning of the water canals led by water user group. Previously, some sections of the canals have been damaged due to flooding; however, it has been confirmed that the residents are repairing them continuously. The water user group has authority power over water supply as well as maintenance of canal, and establishes a standard for supplying agricultural water, taking water at the end of the waterway first. In the event of floods, the water gate is closed to prevent damage to the downstream waterway.

Local residents, including the water user group members, have a clear understanding of how they should manage their facilities and operate and manage the organization, that is, the water user group, systematically to keep facilities in optimal condition. Finally, they are doing their best for an efficient water supply. Therefore, the water user group is a successful factor for sustainability in this appropriate technology case (KOICA, 2016a).

Overall, SNM features can be found in the water user group. The group was intentionally created for the sustainable use of the irrigation dam and canals. Activities, such as, collecting water fees, regular meetings and gatherings by the users, and participating in education and trainings, contain features of social networks, learning process, and enrollment of actors and resources, which are important components for grassroots niches. These niche practices led to the efficient use of technology, such as setting standards for supply and keeping canals in good condition, by a clear understanding of management and by having authority.

Organizational form

Similar to grassroots innovation, appropriate technology projects require diverse participants from both outside and inside the community. Communities in LDCs usually lack capacity to develop technologies on their own, although there is a social need. Thus, diverse actors participate, such as volunteering associations, co-operations, local groups, and government.

In this case, KOICA, Dongho Inc., and Global Community Development Research Institute participated from Korea as external agencies. KOICA was the leading implementing agency of this project and discussed the overall management and scope of responsibility with Laos. Continuous monitoring through workshops were held by KOICA, which was also in charge of field surveys and evaluations throughout the process. Dongho Inc., the cooperative, was chosen as construction manager, and the Global Community Development Research Institute was chosen as the management consultant. They had expertise as, agricultural engineers, design expert, geologists, and irrigation and agricultural experts, and performed efficiently based upon their experiences.

From Laos, Vientiane Province Department of Planning and Investment, Department of Agriculture and Forestry, and Meun District Agriculture Department were in charge of the preparation of the project as implementing entities. They participated in planning and designing from the outset of the project. Additionally, the water user group in Namhee village, the informal community group, had a significant role in managing the water supply and keeping the facilities in good condition.

Finally, Guangdong Co., Ltd, a Chinese company in Laos, was chosen through an international bidding process as the constructor to carry out the construction works for the project.

For a smooth process, a project steering committee operated by Laos was formed for efficient communication among stakeholders. During the project implementation, meetings were held to discuss the operational status of the project and future plans. Further, meetings with Lao officials were held on a regular basis so that cooperation between actors would promote efficient implementation.

Resource base

Associated with diverse organizations, the resource base also varied, including grant funding and physical, financial, and human resources. A total of 3.2 million USD was set as the budget for infrastructure construction and education and training. Tools and materials were provided by Korea. Additionally, Laos provided physical resources such as land and electric power and administrative support for a smooth procedure.

Regarding human resources, construction managers and project management consultants were sent to Laos, including a project manager, design expert, watergate expert, geologist, water management expert, and agriculture expert. They were sent to Laos from one to a maximum of nine months to provide training on water management and agricultural techniques.

Specifically, a farming specialist was dispatched to educate residents on four occasions on subjects such as rice growth technique, corn cultivation method, and pest control. Additionally, a water management specialist was dispatched to conduct water user organization operations and maintenance training for irrigation waterways on five occasions. The existing water user regulations were reflected in the request to add a new provision for imposing a fee on water use.

Further, the project included 15 days of invitation training for eight people, including state government officials and the leader of Namhee village. The main contents of the training were management and training on irrigation facilities, training on rice cultivation technology, and methods of distribution of agricultural products.

3.5 Discussion

A case of appropriate technology has shown how grassroots innovation can emerge in developing countries. This approach’s uniqueness is that it considered continuous activities and sustainable transition, unlike extant studies related to appropriate technology, which have mostly considered only the technical aspects and short-term activities or outcomes.

As a result of the analysis, the case included features and appearance of grassroots innovations. First, it refers to further innovativeness and capabilities of fulfilling needs and solving problems by cultivating grassroots niches. Second, the purpose and well-functioning points of this case resemble the goals and advantages of grassroots innovation. Third, it follows the social needs and ideology that deviate from the existing mainstream of pursuing profit.

Throughout the project, the water user group acted as a niche for grassroots innovation in Namhee village, which is a novel aspect, as it was composed of actual end users who should be the ones to use the appropriate technology continuously and make themselves available for maintenance.

Social learning through regular meetings and education was held by the authority given to the group. Continuous mutual learning, including training and meetings by project stakeholders and the local people, acted as a local knowledge transfer mechanism and gave residents the empowerment to take charge of facilities on their own. It also made it possible to ensure responsiveness to reflect local needs. This kept facilities clean and water use efficient. However, there was no technological advancement from the activities by water user group, but irrigation dam and canals were operated in optimal conditions, leading to an improvement in the quality of life and increase in income.

Scholars have found three conditions to develop and diffuse grassroots niches empirically (Bai et al., 2010; Seyfang & Haxeltine, 2012; Seyfang et al., 2014; Wolfram, 2018). First, expectations on achievement should be widely shared by participators, such as members, stakeholders, and specific target users. Second, networking among members in grassroots innovation is required for broad and diverse support for innovation. Additionally, networking makes it possible to gather diverse resources, for example, human resources, skills, financial, and institutional resources. Finally, the process of learning should occur within niches and the role of intermediaries is crucial for this process.

Here, the project shows the conditions mentioned above throughout the process. Specific appropriate technology was chosen within a bottom-up process, which in turn provided the right solution for the specific local context. The capacity of specific users, the village residents, was also considered for the sustainable maintenance of the dam and waterways. Further, it is inevitable that there are various actors and resources associated with projects in developing countries. For the participating organizations, such as leading organization, government, construction cooperatives, and research institutes, networking and clear division of task between are important for efficient communication.

While appropriate technology activities showed difficulties in overcoming dependency problems regarding donor funds (Abrol, 2005), the case developed an autonomous space using the water usage fee, which made users able to operate the facilities continuously even after external actors and volunteers were no longer associated. Additionally, training and education held by experts from Korea helped them acquire knowledge through learning.

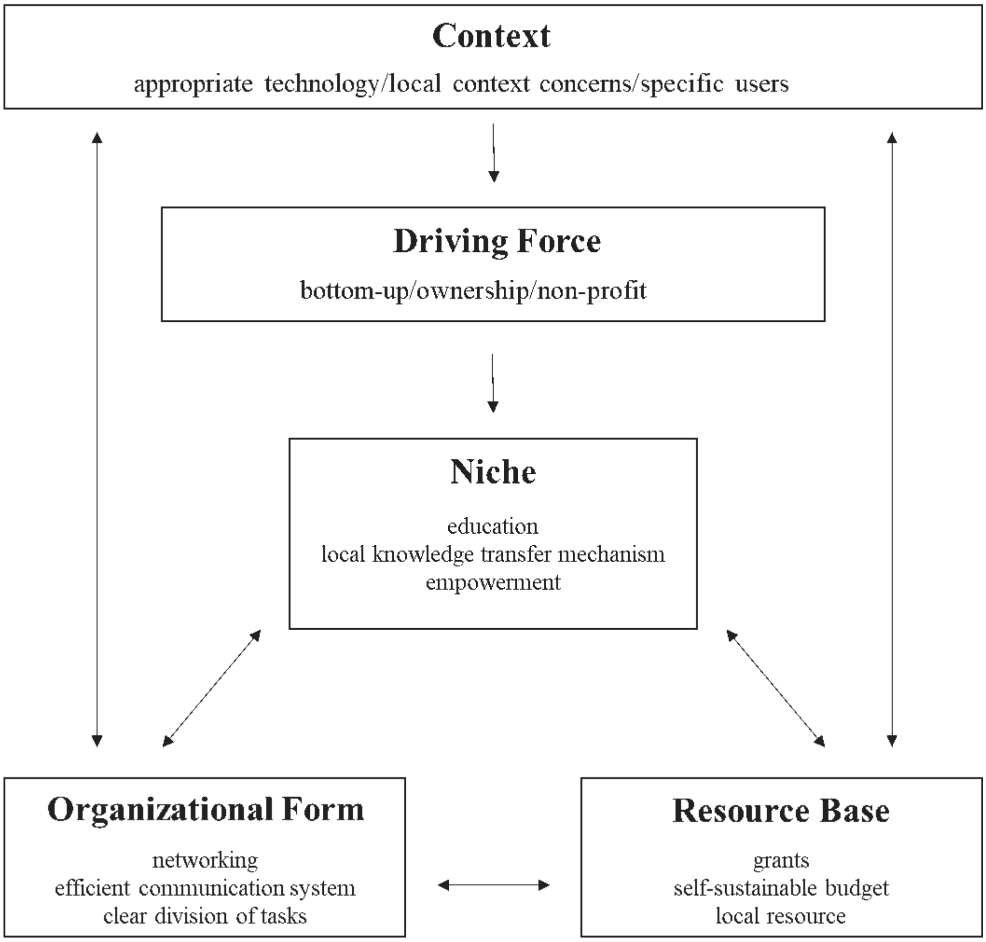


Figure 3-1. The framework of constructs bridging between appropriate technology and grassroots innovation

All of the findings and discussions are summarized in Figure 3-1. The keywords provide important implications to practitioners and developing countries in appropriate technology activities.

3.6 Conclusion

Although the role of appropriate technology has been emphasized for sustainable development in developing countries, there has been limited academic attention paid to appropriate technology and regional development. Additionally, to the best of author's knowledge, the literature on appropriate technology lacks theoretical background. Therefore, this study applied the theoretical background of grassroots innovation to appropriate technology to show that developing countries can achieve sustainable development in terms of regional innovation through appropriate technology since appropriate technology and grassroots innovation share the same vision and complement each other.

By reviewing a successful case of appropriate technology, this study concluded that the framework of underlying principles of grassroots innovation can be applied to appropriate technology projects as an impetus for sustainable development in developing countries: context, driving force, niche, organizational form, and resource base.

The theoretical and practical contributions of this study are as follows. First, it bridged grassroots innovation and appropriate technology by reviewing the literature on both. The two concepts can be related to each other, although grassroots innovation has been only considered in developed countries. Therefore, this approach showed a possible theoretical background when practicing appropriate technology.

Further, context, driving force, niches, organization forms, and resource base can become a guide that practitioners, such as government officials in developing countries, construction managers, and leading organization of donors, can refer to for sustainability in such projects.

However, this study is not without limitations. This is because we have focused on how successful cases can relate to grassroots innovation, ignoring the negative aspects. Therefore, expanding the scope of the study to explore some failure cases would also help figure out critical points for further research. Additionally, although this paper illustrated in-depth an only one appropriate technology case. Thus, further qualitative research in diverse fields and types of appropriate technology is needed to show the advantages of grassroots innovation in developing countries.

Chapter 4. Illusions of clustering: Investigating regional innovation and growth patterns in Korea from a systematic perspective

4.1 Introduction

Local research and development (R&D) capacity and intra-regional innovative networks are often mentioned as important regional innovative sources for regional growth (Rodriguez-Pose & Crescenzi, 2008). Subsequently, R&D investment and clusters are used as tools for regional innovation and economic growth (Fritsch & Franke, 2004; Krugman, 1999; Porter, 2000).

As one of the tools, clusters which is defined as “geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions” (Porter, 2000, p.15) are evaluated to have advantages of capacity to promote greater innovation and economic development (Porter, 2000). The argument was supported by number of studies that suggest co-operations between regional actors based on spatial proximity facilitate knowledge spillovers, which in turn leads to competitiveness in markets (Fritsch & Franke, 2004; Jorde & Teece, 1990; Porter, 1998). Here, proximity plays an important role, because it generates interaction and networks that lead to intricate systems of collective learning mechanisms, thus become an important factor for constructing favorable conditions for innovation (Rodriquez-Pose and

Comptour, 2012).

However, it doesn’t mean that constructing clusters always secure regional networks and growth. Saxenian(1994) compared the case of Silicon Valley and Route 128, both being electronics innovation leaders in the 1970s, about why the former succeeded to experience dynamic growth while the latter failed. In spite of their similarity in origins, diverged outcome demonstrates that local factors such as social and institutional settings play an important role. The case gives insights into the structure and dynamics of regional conditions surrounding the cluster (Saxenian, 1994).

Korea has pursued cluster-based policy since late 1990s for industrial competitiveness and alleviating development gaps between the regions. The policy now has been developed as a tool for establishing regional innovation systems. However, clusters are often oversupplied by local governments under political purpose and development of underdeveloped areas, without an objective examination of the demands and conditions of the region, and without providing residential environment to employers (Kwon & Choi, 2014; Ryu et al., 2018). According to articles from several main press in Korea, cluster policy appears to be indiscriminate, as it turns out that clusters fail to achieve full occupation of firms, however local governments keep on building clusters.

Based on these concerns, this study aims to analyze the effects of clusters on regional growth in Korea along with socioeconomic factors and innovative capacity factors. The analysis enables us to investigate the relationship and interactions between regional R&D capacity, clustering activities, and socioeconomic context, and to figure out specific factors that promote regional economic growth. The analysis scope lies within the regions with clusters in Korea for the period between 2010 and 2016, and thus, panel data analysis was conducted.

The structure of this paper is as follows: Section 2 reviews literature on regional innovation and growth, and clusters. Section 3 describes the methodology, and Section 4 explains the data set used for the study. Section 5 demonstrates results of the analysis and Section 6 discuss the results further. Lastly, Section 7 concludes.

4.2 Literature review

4.2.1 Regions, innovation, and growth

Traditionally, the neoclassical growth models regarded technological element as an exogenous variable (Solow, 1956). However, empirical studies found out that there was a highly unexplained part of long-run economic growth within the models, thus, treating technological change and innovation as explanatory factors (Fagerberg, 1994; Trajtenberg, 1990). In this respect, endogenous growth models have emerged, and this view could explain divergence in economic performance and wealth among the nations (or regions) (Grossman & Helpman, 1991; Romer, 1986; Verspagen, 2005).

From this perspective, R&D investment became a significant issue since higher investment in R&D would lead to increase in technological progress and innovations, and finally, economic growth. Studies on this linear perception applied econometric analysis on the link between R&D expenditure and economic performance, such as GDP or productivity growth on firms, sectors, or countries level (Griliches 1979; Verspagen, 1995). Even though it tends to ignore other key factors or contextual conditions that affect generation of innovations (Morgan, 2007), this approach maintains its reputation because of its simplicity and powerfulness (Rodriguez-Pose & Crescenzi, 2008).

However, systematic nature of innovations was adopted widely that innovation is embedded in socio-economic system, such as “the structure of production” and “the institutional set-up” (Lundvall, 1992, p.10). Edquist(1997) defined (national) systems of innovation (SI) as “all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations (p.14)”. In this systematic approach, territorially embedded factors are critical issues in facilitating innovations, in that those factors can explain the conditions and process of innovations (Camagni, 1995; Cooke et al., 1997). Further, by accepting holistic and evolutionary perspective, it places learning processes at the center and highlights interdependence among organizational, social, political and economic factors in innovation process (Edquist, 2005). Factors such as networks, education and training systems, research infrastructures, financial and legal institutions, and policies are significant (Camagni, 1995; Iammarino, 2005).

Then the concept of SI has been specified into national level (Freeman, 1987), sectoral level (Breschi & Malerba, 1997), and regional level (Cooke et al., 1997). Among them, regional systems of innovation takes meso-level approach compared to macro-level (national) and micro-level (individual actors), and this meso-level analysis enables us to explain territorially and socially embedded context and institutions in a heterogeneous way (Iammarino, 2005). Since socio-economic context are unique in each region, regional SI was derived from the broader national level SI, and it accounts for region's intrinsic characteristics in terms of absorption, diffusion, and generation of knowledge (Dopfer et al., 2004). Thus, it is defined as "localized networks of actors and institutions in the public and private sectors whose activities and interactions generate, import, modify, and diffuse new technologies within and outside the region" (Iammarino, 2005, p.4).

Related literature focus on essential elements that favor or hinder the emergence and development of regional innovation systems. Studies suggest that proximity, local synergies, and interactions among social and institutional conditions are relevant (Cooke et al., 1997; Iammarino, 2005; Rodriguez-Pose, 1999).

4.2.2 Clusters and regional growth

The concept of networks has been discussed within diverse research fields, however it started to increasingly appear in economics and innovation studies for the last two decades (Baek et al., 2014; Giuliani, 2010). Studies have emphasized that networks and innovative performance are highly inter-connected, and the actors involved in networks are more likely to be creative and innovative (Kim & Altmann, 2019; Kim et al., 2019). Since the 1980s, it has been associated with industrial agglomerations (Scott, 1988), and Camagni (1995) emphasized regional networks enhance the innovative capacity of the region through collective and synergetic learning process.

Consequently, the influence of local networks on innovative performance led to the emphasis on the role of territory. Geographic proximity is considered to generate the emergence of interactions and formation of firm networks leading to innovations through collective learning mechanisms (Storper & Venables, 2004). Further, it enhances diffusion of knowledge and local spillovers, thus making economic actors gather in a limited geographical area to be involved in the generation, absorption, and diffusion of knowledge, which is, in turn, the clusters (Rodriguez-Pose & Comptour, 2012).

Geographical clusters, especially industrial clusters, are considered as a key player in economic growth in terms of productivity and innovative networks (Giuliani, 2010; Krugman, 1999; Porter, 1998; Titze et al., 2011). Successful clusters were revealed have benefits in transaction costs and knowledge diffusion within the localized networks and local institutional environment (Iammarino & McCann, 2006; Kim & Altmann, 2019; Lawson & Lorenz, 1999; Saxenian, 1994). Also, clusters have been analyzed to reinforce regional competitiveness, which made it easier to look for new partners for further innovations and new businesses (Slaper et al., 2018).

For example, Slaper et al. (2018) developed clusters measures for US regional industrial clusters: diversity, strength, and growth. Those are measured by Shannon Evenness Index (SEI), location quotient (LQ), and percentage of employment growth in a region, respectively. Using county-based data of 366 metropolitan statistical area (MSAs) between 2002 and 2013, four regression models were estimated. The dependent variables include GDP growth, GDP per employee growth, compensation per employee growth, and per capita income growth, and control variables are percentage of population with high school diploma, percentage of population with bachelor's degree, number of accredited research universities, unemployment rate and population density. The results indicate that 40~60% of variation in dependent variables is explained by cluster measures.

In Europe, Borghi et al. (2010) evaluates clusters in terms of regional innovative performance and economic cohesion with employment levels. Expenditures in R&D and patent application are used as innovation output, and regional and cluster characteristics, size, focus, and specialization of clusters, are included. Total 1,763 clusters are included for the analysis in 2005. The study finds that presence of clusters are relevant in fostering innovation and regional employment. Variables and results are shown in Table 4-1.

Lately, clustering effect is determined to be stronger not only among firms, but among other innovative actors, such as, universities, public R&D agencies, and institutions. This is because the holistic cluster creates multi channels of knowledge diffusion with diverse innovative activities within a regional innovation system (Rodriguez-Pose & Comptour, 2012). Therefore it is significant to identify clusters within a comprehensive approach by investigating spatial dynamics of clusters and their effects on regional growth (Titze et al., 2011).

Table 4-1. Studies on clusters and regional growth

	Dependent variable	Cluster variable (definition)	Remarks(results)
Slaper et al. (2018)	Growth of GRDP	Diversity (SEI)	0.1133
		Specialization (LQ)	-0.2020*
		Growth (⊿cluster employment/⊿regional employment)	0.2801*
Borghi et al. (2010)	Regional employment	Size (cluster employment / total EU cluster employment)	1.717***
		Focus (cluster employment / regional employment)	-0.743***
		Number (number of clusters in a region)	0.045***
Kwon and Choi	GRDP	National clusters dummy	6,410,880.02***
(2014)		Private clusters dummy	1,472,153.42***
		Agricultural clusters dummy	1,653,385.21**
Lee et al. (2012)	Growth of GRDP per capita	National clusters dummy	0.185***
Park (2005)	GRDP	Size (total area)	0.094***

However, systematic approach with quantitative analysis has been few because of complexity, and interactions among clusters and other factors such as R&D investment or social institutions has also been under shortage (Rodriguez-Pose & Comptour, 2012). Cluster-based policies build on adequate economic policies, and they cannot substitute missing parts of such as labor market institutions and education which upgrade regional competitiveness (Ketels, 2008). Few studies, though, have conducted a comprehensive analysis quantitatively. Crescenzi et al. (2007) and Fritsch and Franke (2003) have tried to measure agglomeration effects and regional spillovers with social factors and R&D factors. The effects were estimated not only individually, but also with other factors in terms of interdependencies. Also, Rodriguez-Pose and Comptour (2012) has conducted analysis on clusters in EU NUTS2 level regions, proposing that socio-economic factors are prerequisite for clusters to be effective in regional economic performance.

In the same vein, Korean government has implemented cluster-based development policy in order to achieve the two goals of industrialization and balanced regional development, and today's industrial clusters policy aims to establish regional innovation systems. Unlike the development policy was carried out by the government in the past, local governments plan and carry out the industrial clusters policy on their own recently.

However, local governments are oversupplying clusters under political purposes without an objective and thorough examination of the contextual conditions and regional demands (Kwon & Choi, 2014). Sternberg and Litzenberger (2004) also points out clusters are often built due to political intent, thus, robust assessment is needed to avoid oversupply of clusters in too many regions.

Nevertheless, the main focus of studies on clusters has been limited to measurement of cluster's performance and firm's performance in Korea (Kwon & Choi, 2014; Lee et al., 2012; Lee et al., 2017; Park, 2005). In addition, there is also little research on a comprehensive approach to evaluate clusters' effects on regional growth in Korea. Specifically, Kwon and Choi (2014) investigates impact of industrial complexes types, whether it is national complex or agricultural complex, on regional economic growth and performance of clusters in terms of production size, employment, and export value. Park (2005) also estimates impact of clusters on firms' production and employment level. Lastly, Lee et al. (2012) includes dummy variables of presence of clusters to evaluate their impact on regional economies. Variables and results from previous studies are shown in Table 4-1.

4.3 Methodology

Literature on sources of innovation and growth can be specified into three big theoretical strands, R&D investment, innovative networks, and socioeconomic context (Kim et al., 2019; Rodriguez-Pose & Crescenzi, 2008; Verspagen, 1995). This study aims to figure out complementary, or at the same time, contrasting effects of those three factors on regional innovation and economic growth in Korea.

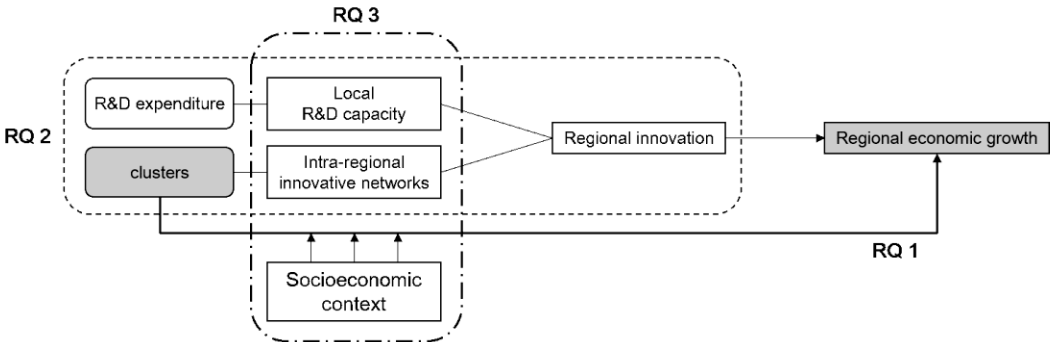


Figure 4-1. Research questions

Specific research questions are illustrated in Figure 4-1: first, do clusters always affect regional growth?; second, which one, internal innovative capacity or networking, is more effective on regional growth?; and third, what are the specific variables that promote regional growth?

Five dimensions were derived to structure the components of the analysis model for a comprehensive approach on the overall process from a systematic perspective, which is from inputs to process and to outputs (input → process →output) (Ahn, 2019). Resources and environment dimensions are the inputs, which represent socioeconomic context factor of the region. Then, capacity and clustering dimensions belong to process stage, standing for R&D capacity and clustering factors for the region, respectively. Lastly, output is the economic performance of the region. The structure of the all the variables are shown in Figure 4-2.

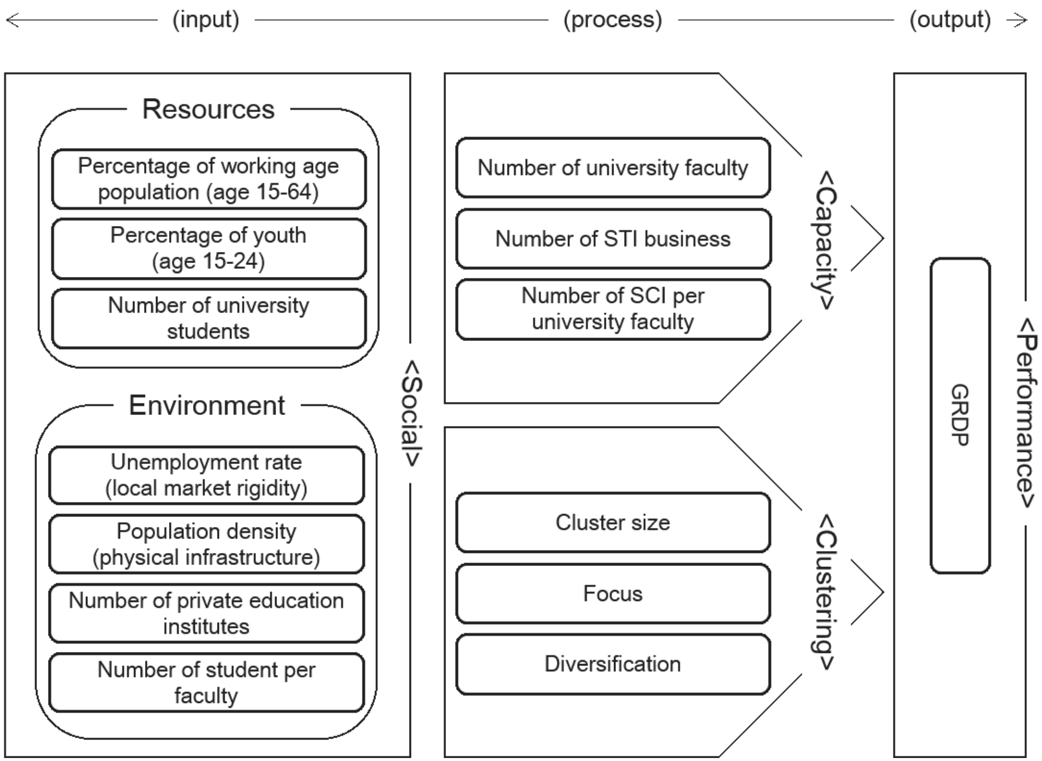


Figure 4-2. Structure of the variables

Based on research questions, the study conducts a panel regression with the model:

$$\ln GRDP_{it} = \beta_1 + \beta_2 Social_{it} + \beta_3 Capacity_{it} + \beta_4 Clustering_{it} + \beta_5 Control_{it} + e_{it}$$

Eq. (1)

Logarithm of regional gross domestic product (GRDP) of region *i* and year *t* ($\ln GRDP_{it}$) is the dependent variable, and the three crucial explanatory variables are - $Social_{it}$ for socially and territorially embedded variables, $Capacity_{it}$ for internal innovative capacity variables, and $Clustering_{it}$ for spatially bound clustering variables of region *i* and year *t*. Total population was added as the control variable.

In the model, *social*, *capacity*, and *clustering* factors are added as composite indexes that combines a bundle of related individual variables. By using this model, it enables us to adopt a comprehensive approach to examine clustering effects along with social contexts and R&D capacity quantitatively. In detail, interdependency of clusters and social factors and comparison of clustering effect and R&D capabilities can be examined. This approach is differentiated from existing literature on relationship of clusters and growth, because most of existing models focus on solitary effects of clusters (Borghi et al., 2010; Kwon & Choi, 2014; Lee et al., 2012; Park, 2005; Slaper et al., 2018; Titze et al., 2011).

First of all, the *social* factor represents socio-economic contextual conditions of a region that make a region favorable to innovation. In this regard, Crescenzi et al. (2007) and Rodriguez-Pose and Crescenzi, (2008) proposed a ‘social filter’ variable for proxies of level of education, productive employment and demographic structure. In detail, education achievements measured by percentage of population with higher education and population participating in lifelong learning account for local's skill level (Lundvall, 1992; Rodriguez-Pose & Crescenzi, 2008), and productivity of employment is measured by long-term unemployment and agriculture employment which indicate local market rigidity and presence of individuals ruled out of labor market (Fagerberg et al., 1997; Gordon, 2003). Moreover, percentage of young people represents demographic structure of a region, which proxies for new pool of labor, skills and knowledge and economic potential of a region (Rodriguez-Pose, 1999; Rodriguez-Pose & Crescenzi, 2008). Other variables include and human resources in science and technology (S&T) field (Rodriguez-Pose & Comptour, 2012).

In the same context, this study constitutes the social factor with territorially embedded variables relevant to regional capacity building in Korean context. The variables of resource and environment of regions are included (Ahn, 2019). First, percentage of working age population (age 15-64) (Lee et al., 2012; Lee et al., 2017), and percentage of youth (age 15-24) and number of university students (Crescenzi et al., 2007; Lee et al., 2012; Lee et al., 2017; Rodriguez-Pose & Comptour, 2012; Rodriguez-Pose & Crescenzi, 2008) are indicators for existence of labor pool and demographic characteristics.

Moreover, instead of long-term unemployment, unemployment rate was included to measure rigidity of local labor market and labor force with inadequate skills (Crescenzi et al., 2007). Population density accounts for physical infrastructure (Lee et al., 2012), and number of private education institutions per thousand people and number of students per faculty were included for proxies of education environment of regions (Lee et al., 2017).

Second, the *capacity* factor reflects research and development capacity of the region. As a measure of innovative capacity, R&D expenditure or R&D intensity is probably the most popular indicators (Fritsch & Franke, 2004; Griliches, 1979). However, this study uses substitute variables because of data availability in si·gun·gu level regions, which are number of university faculty (Mathews & Hu, 2007), number of SCI per university faculty (Mathews & Hu, 2007), and number of science, technology, and innovation (STI) business (Riddel & Schwer, 2003) in the region. These variables indicate capacity of innovation actors or technological level, thus, literature focusing on si·gun·gu level of regions in Korea use these variables instead (Kwon & Choi, 2014; Lee et al., 2012; Lee et al., 2017).

The third factor, *clustering*, is a composite index reflecting clusterization effects (Rodriguez-Pose & Comptour, 2012). Regional industrial clusters influence regional growth based on spatial proximity benefits, thus being an important factor in regional innovation systems (Krugman, 1999; Storper & Venables, 2004; Titze et al., 2011; Tödtling & Trippl, 2005). European Cluster Observatory assesses clusters in EU27 with different criteria, for example, specialization, focus, and diversification indexes (Crawley & Pickernell, 2012; Rodriguez-Pose & Comptour, 2012). Due to data availability, the study adopts focus and diversification indexes which is the share of specific cluster's employment to total employment of the region, and the number of clusters in the region, respectively. Also, size (Park, 2005) is included to the analysis of this study to see if cluster size has effects on regional growth as it is assumed to be related to firm's performance (McCann & Folta, 2011).

The three explanatory factors are generated by principal component analysis (PCA). PCA is a statistical procedure to reduce dimensions by using an orthogonal transformation to extract the dominant patterns of a data matrix of observations of possibly correlated variables (Abdi & Williams, 2010). For the variables with strong correlations, the method calculates the percentage of variance explained by each component, which is the eigenvalues, then drop out components with eigenvalues below 1 according to Kaiser's criterion (Altmann et al., 2017). Thus, PCA prevents the multicollinearity problem, which is inevitable when including and merging possibly inter-correlated variables simultaneously, and so, composite variables are created by PCA (Crescenzi et al., 2007; Rodriguez-Pose & Crecsenzi, 2008; Rodriguez-Pose & Comptour, 2012).

The results of the three PCAs are given in from Table 4-2 to Table 4-7. The Kaise-Meyer-Olkin (KMO) index measures sampling adequacy of PCA, and it is assumed to be confident when it is over 0.5. All three PCA variables satisfy sampling adequacy.

However, one of limitations PCA has is that it cannot explain a composite variables effect in detail. To overcome this limitation, single individual variables are added one by one, and analyzed in separate regression models.

Table 4-2. Eigenanalysis of the correlation matrix: Social factor

Component	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7
Eigenvalue	4.35528	0.810648	0.734097	0.468535	0.375073	0.134527	0.121837
Proportion	0.6222	0.1158	0.1049	0.0669	0.0536	0.0192	0.0174
Cumulative	0.6222	0.7380	0.8429	0.9098	0.9634	0.9826	1.0000

Table 4-3. Coefficients of the principal components analysis: Social factor

Variable	$unemp$	$popdens$	$youth$	$wapop$	$priedu$	$stupf$	$univstu$
Comp1	0.3658	0.2866	0.3951	0.4399	0.3631	0.4313	0.3414

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy = 0.8246

Table 4-4. Eigenanalysis of the correlation matrix: Capacity factor

Component	Comp1	Comp2	Comp3
Eigenvalue	2.03016	0.507061	0.462775
Proportion	0.6767	0.1690	0.1543
Cumulative	0.6767	0.8457	1.000

Table 4-5. Coefficients of the principal components analysis: Capacity factor

Variable	$numf$	$scipf$	$bussti$
Comp1	0.5744	0.5854	0.5722

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy = 0.6952

Table 4-6. Eigenanalysis of the correlation matrix: Clustering factor

Component	Comp1	Comp2	Comp3
Eigenvalue	1.63495	0.964772	0.400278
Proportion	0.5450	0.3216	0.1334
Cumulative	0.5450	0.8666	1.000

Table 4-7. Coefficients of the principal components analysis: Clustering factor

Variable	$size$	$focus$	div
Comp1	0.6872	0.6893	0.2296

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy = 0.5148

With all the variables, this study introduced the panel regression model. Several tests were conducted to test the panel model. No multicollinearity was detected (vif=2.98<10), and Breusch-Pagan test for heteroscedasticity did not reject $\mathrm{H_0}: constant\ variance$ (Prob>chi2=0.6634). However, Wooldridge test for autocorrelation in panel data rejected $\mathrm{H_0}: no\ first\ orderautocorrelation$ (Prob>F=0.0000). Thus, to control for the autocorrelation problem, GLS estimation method with common AR(1) coefficient for all panels was used for the regression.

In addition, in advance of the model estimation, stationarity of the panel has been checked by using Levin-Lin-Chu (LLC) unit root test, regarding that the period includes only seven years. LLC unit root test results for dependent variable and independent variables in Equation 1 showed that the panel generally satisfies stationarity, which means the panel is statistically stable. The results of model test statistics and LLC unit root test are appended in Appendix 2.

The whole analysis procedure first starts with a static analysis with eight regression models. It tries to capture aggregate interaction between the three composite factors, examine social factor and clustering factor, and measure individual correlation of variables in the social factor. Second, another static analysis is followed with six regression models, to compare composite capacity factor and clustering factor on their effects on regional growth. Again, individual correlation between each variable in the two factors are estimated.

Finally, a dynamic analysis is conducted by regressing GRDP on lagged factor variables, $n \in [1,3]$, to estimate long-term effects. According to Kim et al. (2019), assuming the existence of time lags in a diffusion process of innovation itself and within networks is reasonable. Thus, it is worth to examine the effect of composite variables with time lags. Figure 4-3 demonstrates the whole process.

Static analysis 1 [Regression 1-8]
- Capture aggregate connection between each composite factor (Regression 1) - Individual correlation between each individual variable included in social factor variables (Regression 2-8)
↓
Static analysis 2 [Regression 9-14]
- Compare capacity composite factor and clustering composite factor on their effects on regional growth - Individual correlation between each individual variable included in capacity and clustering factor
↓
Dynamic analysis
- A dynamic analysis by regressing GRDP on lagged filter variables, $n \in [1,3]$

Figure 4-3. Analysis procedure

4.4 Data

Cooke et al. (1997) discussed the evolution of boundary of regions in terms of regionalization and regionalism, and defined regions as "territories smaller than their state possessing significant supra-local governance capacity and cohesiveness differentiating them from their state and other regions (p.480)". Besides, capacities to develop policies and organizations supporting innovation are one of the most important governance powers of such regions.

Korea's administrative districts are divided into three levels: first, special · metropolitan cities and provinces (do); second, cities and counties (si·gun·gu); and third, towns (eup·myeon·dong). The smallest unit that has independent local government with its capacity to develop policies and organizations is the second level regions, the si·gun·gu level. Accordingly, this study conducts analysis on the si·gun·gu regions[4] of eight provinces, excluding regions in special administrative districts, special and metropolitan cities. This is because the regions of provinces and those of special and metropolitan cities vary a lot in their economic performance and capacity (Lee et al., 2012).

Data was collected for all of the variables from the regions where clusters existed as of 2016. Out of total 156 regions in the eight provinces, 142 regions, which is a very high proportion, had clusters. Local statistics of the si·gun·gu level varied greatly in their data collection period, so information for 14 variables were aggregated for seven years, from 2010 to 2016. The clusters included in the analysis are the ones in 'completed' stage at the first quarter of each year.

Data for social factor and capacity factor were collected from statistical database of Korean Statistical Information Service (KOSIS) and Higher Education in Korea, and data for clustering factor variables were collected from Korea Industrial Complex Corporation (KICOX). KOSIS is Korea's official national statistical database and provides one-stop service of full range of domestic statistics of 417 agencies and 1,089 sections and international statistics from organizations, such as, OECD, World Bank, and IMF. Moreover, data on number of SCI per faculty was collected from and official organization

[4] This level of regions corresponds to NUTS3 level in Europe.

called Higher Education in Korea, which delivers information services of universities. In addition, KOCIX provides complete enumeration data of every clusters in Korea including, name, location, size, number of employers and firms, rate of operation, and other information quarterly. Data of each clusters were aggregated into regional level by author's calculation.

By omitting missing data, the final data set contains data from 59 regions between 2010 and 2016, thus making 413 observations in total. The number of regions included in the final data set is depicted in Table 4-8, and definition and source of data are shown in Table 4-9.

Table 4-8. Regions for the analysis

	Provinces	Number of regions
1	Gyeonggi-do	7
2	Gangwon-do	10
3	Chungcheongbuk-do	1
4	Chungcheongnam-do	2
5	Jeollabuk-do	5
6	Jeollanam-do	13
7	Gyeongsangbuk-do	14
8	Gyeongsangnam-do	7
	Total	59

Table 4-9. Definition and source of variables

Variable	Definition	Source of data
GRDP(log) ($lnGRDP$)	Logarithm of GRDP	KOSIS
Unemployment rate ($unemp$)	Percentage of unemployment	KOSIS
Population density ($popdens$)	Total population / size	KOSIS
Percentage of young ($youth$)*	Percentage of population aged 15-24	KOSIS
Percentage of working age population ($wapop$)	Percentage of population aged 15-64	KOSIS
Number of private education institutions ($priedu$)	Number of private education institutions per thousand people	KOSIS
Number of students per faculty ($stupf$)	Number of students per faculty	KOSIS
Number of university students ($univstu$)	Number of university students	KOSIS
Number of university faculty ($numf$)	Number of university faculty	KOSIS

Number of SCI per university faculty ($scipf$)*	Number of SCI per university faculty	Higher Education in Korea, KOSIS
Number of STI business ($bussti$)	Number of STI business	KOSIS
Cluster size ($size$)*	Aggregate area of cluster(s)	KICOX
Focus ($focus$)*	Number of employees of cluster(s) / total number of employees in the region	KICOX
Diversification (div)*	Number of cluster(s)	KICOX
Total population ($tpop$)	Total population	KOSIS

* Based on author’s calculation from source of data

4.5 Results

The panel model with 413 observations were analyzed to figure out innovation sources of regional growth in Korea. In specific, clusters and its effect on regional economic growth (RQ1), comparison between R&D capacity and clustering effects (RQ2), and individual significant variables for growth (RQ3) are investigated. The results of static analysis panel regressions models are presented in Table 4-10 and Table 4-11. Then, Table 4-12 shows dynamic analysis results.

To start with, according to Table 4-10, the first model (Model 1) reveals results of the relation of three explanatory factors for innovation and regional growth. As identified from the literature review, territorially embedded social factor, R&D capability factor, and clusters had significant effect on economic growth.

Next, for Model 2 – 8, the composite social factor was excluded, and each individual variable in the social factor was regressed one at a time. What's remarkable in these models is that when social factor variable is excluded, clustering factor tends to be insignificant (Model 3, 4, 5, 7, 8). This can be interpreted that clustering is only effective when social factor exists together. This result is consistent with other studies in Europe (Rodriguez-Pose & Comptour, 2012), and they intended that existence of clusters has positive effect on regional economic growth only with adequate social context, which shows the interdependence of presence of clusters and adequate social context.

Specifically, variables of population density (Model 3), percentage of working age population (Model 5), and education level (Model 6, 7) of the region showed significant effect on economic growth. While population density had relatively small influence, pool of labor force showed huge impact on regional economic growth. Also, higher number of private education institutions and smaller number of students per teacher in schools, which stand for good education environment or high interest in education, had significant influence. However, population aged 15-24 and number of university students didn’t have significant impact, showing the presence of youth doesn’t matter much. Instead, people who actually participate in production activities seem to have more significant impact on region’s economic performance.

Furthermore, when it comes to the comparison of R&D capacity factor and clustering factor (Model 1 of Table 4-10, Model 9-14 of Table 4-11), it appeared that capacity to conduct R&D seems to have greater influence on growth than presence of clusters. In other words, in Korea, regions with higher innovative capacity in terms of R&D capabilities tend to have higher incomes. Fritsch and Franke (2004) also showed greater influence of R&D investment on growth than knowledge spillover impacts.

Among variables in Capacity factor, human resource for R&D and number of SCI per faculty in the region had positive and significant effect, while the number of SCI had much bigger effect than the number of faculty. In other words, it can be interpreted that qualitative level of R&D, measured by SCI performance, has strong association with the growth. Instead of how big is the university or how many faculty they have, the actual and core element is the quality of R&D activities.

Table 4-10. Results of static analysis 1

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Constant	13.994***	13.966***	13.845***	13.907***	13.86***	13.921***	14.142***	13.938***
$tpop$	3.28e-06***	3.35e-06***	4.95e-06***	6.28e-06***	1.4e-06***	3.29e-06***	4.26e-06***	3.60e-06***
$Social$	0.03*							
$Capacity$	0.179***	0.198***	0.127***	0.032***	0.167***	0.197***	0.131***	0.162***
$Clustering$	0.02*	0.033***	0.005	0.008	0.005	0.033***	0.004	0.01
$unemp$		0.009						
$popdens$			-.0001 ***					
$youth$				1.35				
$wapop$					2.686***			
$priedu$						0.063**		
$stupf$							-.021***	
$univstu$								1.26e-06

*p<.1, **p<0.05, ***p<0.01

When looking into clustering indexes, the size, focus, and diversification are positively related to the economic growth. Especially, the density of clusters of a region turned out to be significant the most, and follows the diversification. That is, the higher employment intensity facilitates knowledge diffusion between firms, which in turn promotes economic growth (Rodriguez-Pose & Comptour, 2012). The impact of size was also positive and significant, however, it could be hardly recognized.

Table 4-11. Results of static analysis 2

	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14
Constant	13.815***	13.858***	13.87***	13.91***	13.836***	13.615**
$tpop$	3.99e-06***	3.79e-06***	3.81e-06***	2.76e-06***	3.76e-06***	3.67e-06***
$Social$	0.024	0.051***	0.052***	0.071***	0.07***	0.054**
$Capacity$				0.179***	0.114***	0.132***
$Clustering$	0.022*	0.024**	0.028**			
$numf$	0.0004***					
$scipf$		0.871***				
$bussti$			0.0002			
$size$				2.57e-06***		
$focus$					0.259***	
div						0.081***

*p<.1, **p<0.05, ***p<0.01

Finally, dynamic analyses with time lags up to three years were conducted to capture long-term effects. Table 4-12 shows regressions with lagged variables of the three factors. The results showed that the importance of social and capacity factor endures for regional economic growth in Korea. Particularly, the capacity factor showed continuous and mainly significant factor among the composite variables. Its coefficients are the highest, and the gaps between the coefficients are quite high. The social factor also showed the importance of creating favorable and supportive environment, albeit it's significance level at 10%, and its impact grows slightly in the long-term. However, the clustering factor shows the least and the shortest influence on the regional growth. In a three-year time lag, the clustering factor no long has relativeness to the growth.

Table 4-12. Results of dynamic analysis

	Lag 0	Lag 1	Lag 2	Lag 3
Constant	13.994***	14.043***	14.065***	14.084***
$tpop$	3.82e-06***	3.10e-06***	3.13e-06***	3.20e-06***
$Social$	0.03*	0.04***	0.042**	0.041*
$Capacity$	0.179***	0.184***	0.182***	0.182***
$Clustering$	0.02*	0.03***	0.03**	0.017

4.6 Discussion

4.6.1 Summary of results and policy implications

In brief, panel regressions with both static and dynamic analysis were conducted to investigate the effect of socio-economic context, R&D capacity, and clusters on regional growth in Korea. Turing back to the research questions of this paper, first, clustering effect was conditional in the regions. The results showed that adequate social context surrounding the clusters were important, for example, pool of working age population, number of private education institutions, and lower number of students per faculty. That is, the presence of clusters itself do not guarantee regional growth, but instead, it is only effective when favorable socioeconomic environment is accompanied. This is consistent with other studies that looked into the relation between clusters or knowledge spillovers and social factors (Cresenzi et al., 2007; Rodriguez-Pose & Comptour, 2012).

Second, capacity factors are more effective than clustering factors. It has stronger and longer effect on regions in Korea. This is also consistent with the work of Fritsch and Franke (2004), which compared the impacts of R&D expenditure and knowledge spillovers in regions in Germany.

Third, pool of labors, education level, quality of R&D activities, and density and diversity of clusters were the major individual elements that promote regional growth in Korea.

According to the findings, the study gives important implications on regional development policies of local governments in Korea. First of all, the governments are currently trying to create industrial clusters competitively without an objective examination under the belief that clusters will create new jobs and increase population, and, in turn, promote regional growth. In other words, it seems that they believe the presence of clusters will promote regional growth, representing ‘people follow jobs’.

However, what the results indicate is opposite, which is ‘jobs follow people’. Clusters have significant effects when adequate social contexts are supported. The regions where there are rich pool of labor and favorable education systems tend to be successful in deriving positive results from clustering. That means jobs can be created continuously when there are people with adequate skills. Therefore preliminary investigation on regional demands and conditions is required (Kwon & Choi, 2014; Lee et al., 2017). Further, for instance, regions should possess favorable residential environment and competent education environment to attract inhabitants and to settle employees in the clusters in that region.

In addition, local governments should also focus on developing consistent and stable R&D investment policies instead of only sticking to cluster-based policies, since R&D capacity showed much more impact on regional growth. While striving for establishing favorable socio-economic conditions, the regions should try to strengthen R&D investment to enhance capacities of individual economic actors. Then, substantial and effective synergies are expected when industrial clusters and extended clusters among firms, universities, and research agencies are implemented by creating innovative networks within the region.

Focusing on clusters, clusters with high intensity of employment tend to be effective on economic performance of regions. High intensity of employment of clusters indicate that a large proportion of employers in regions are employed in firms in clusters, which point out to similar implications; preliminary examination on regional demands is crucial. Also, since diversification of clusters are important, regions should try to diversify in policymaking for different types of clusters since different clusters have different forms of relations and cost structures according to their technological and knowledge base (Iammarino & McCann, 2006).

Finally, the study suggests additional practical implications based on effective individual elements that facilitate regional growth. First, the effect of percentage of working age population was found out to be significant and strong while percentage of young people had no effect. These results indicate that regions should develop vocational training and education systems to raise human resources with adequate skills and invest in trainings for employees. Also, number of SCI per university faculty had significant effects while the number of university students and number of university faculty had little or no effects. That is, quality of university education matters, and concerns on quantity such as the size and number of universities are not important for regional economic performance.

4.6.2 Other variables

Further, this study tried to consider many variables that have possibility of affecting regional growth, however failed to cover some factors. First, this article used substitute variables for R&D investment with number of university faculty, number of SCI, and number of business in STI. Therefore the study conducted an additional analysis with Korean patents variable. Usually, patents data from USPTO or EPO are used as a proxy for capacity of knowledge generation along with R&D expenditure, despite the controversy of application of patents as a measure (Rodriguez-Pose & Comptour, 2012). In case of regions in Korea, the tendency of patent applications and R&D expenditure in the upper level, at provinces level, were similar according to Figure 4-4 with data from 2016. Subsequently, this study assumes that patents data has same tendency with R&D expenditure for si·gun level as well.

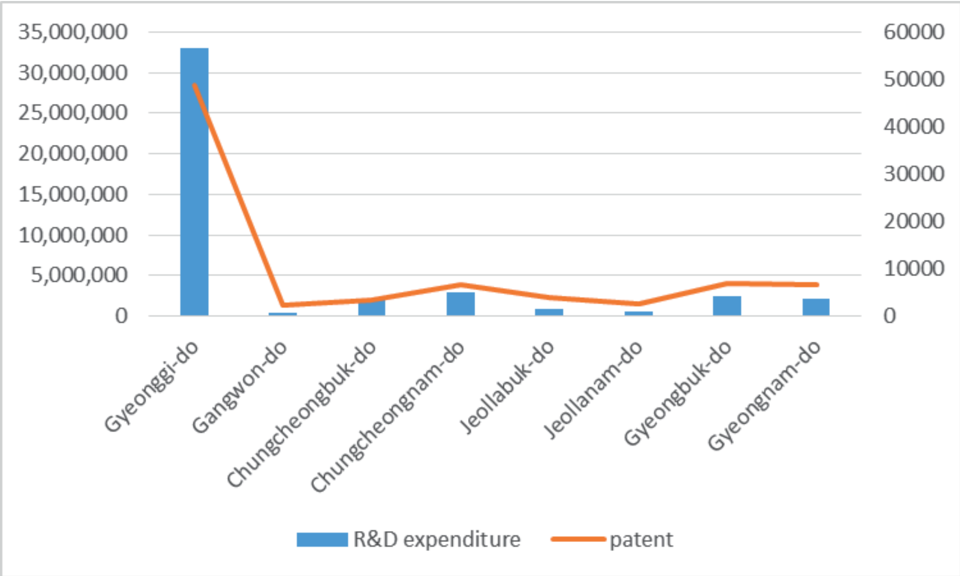


Figure 4-4. R&D expenditure and patent application (2016)

Due to data availability, however, patents data from Korean Intellectual Property Office (KIPO) from 2011 to 2016 were substituted to capacity factor. Subsequently, the capacity factor with number of patent applications of KIPO and number of SCI per faculty was set, and the panel model with 354 observations was analyzed. The supplementary result is appended in Appendix 3, and the results showed no difference in general with the results in Section 5. Thus, this also confirms the appropriateness of the analysis and use of substitute variables.

Another important factor that is not included in this paper is the role of intermediary organizations in innovation systems. Since innovative goals, activities, and outputs are fragmented among actors or agencies throughout the system, intermediaries take a role of supporting creation, diffusion, and collaboration of knowledge among them, thus, being a very significant actor in the process of innovation (Howells, 2006). Types of intermediaries would include, technology agencies, public organizations, or any organizations that support networking, co-operations and interactions between agents (Bathelt et al., 2004; Malmberg & Power, 2005; Saxenian, 1994). Moreover, their functions can be specified into, first, supporting in terms of finance, either direct or indirect funding by collaborations, and second, building partnerships and networks for knowledge dissemination (Inkinen & Suorsa, 2010). According to Vonortas (2002), intermediaries often lie between government and private sectors, and have significant effect on performance of the firms.

Especially, importance of intermediaries should be even more emphasized in regional innovation systems than those for national level, because of regions' unique contexts, specifications, and interests (Inkinen & Suorsa, 2010). For instance, national organizations functions may be too broad, thus inappropriate for local conditions, however, it is regional intermediary's task to develop a specific and unique supporting and funding system. Further, national level organizations focus on national competitiveness in global markets, however, regional organizations look for regional success factors (Smedlund, 2006).

Put together, regional level intermediate organizations utilize and transfer knowledge to specific economic structures and influence success factors inside the region. For example, Inkinen and Suorsa (2010) introduces the Finnish Funding Agency for Technology and Innovation (TEKES) as the key intermediating organization in regions in Finland. TEKES has extensive regional offices which operate on different territorial tasks, and it aims to improve national competence based on understanding of regional contexts and specifications. Also, it often collaborates with regional employment and economic development offices to provide financial services and network and collaborations services.

If put in this study, the role of intermediary organization would be connecting social contextual background, R&D capacity, and clusters of firms as illustrated in Figure 4-5. Like many literature on role of intermediaries (Inkinen & Suorsa; 2010, Smedlund, 2006; Vonortas, 2002), the role is often examined in case studies. Therefore, if consideration of these organizations were to be included, a qualitative analysis could be added to explain the interplays of the factors.

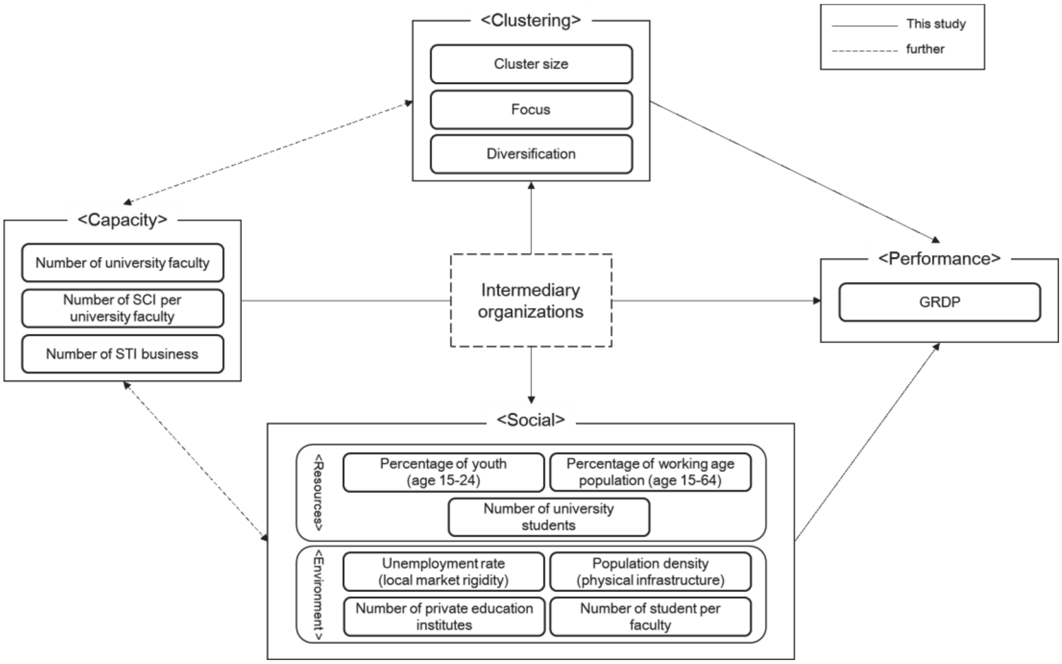


Figure 4-5. A potential role of intermediary organizations

4.7 Conclusion

To conclude, this paper aimed to figure out the effects and interdependencies of the factors related to regional innovation and growth in Korea. By using a PCA method and a pooled OLS regression model, three composite factors, the social factor, the capacity factor, and the clustering factor, were generated and estimated on their effects on regional economic performance. For the analysis, data of socioeconomic contexts, innovative capacity, and clusterization for 59 regions between 2010 and 2016 were aggregated.

The results showed that it is important to have a favorable socioeconomic setting to foster innovation and growth by clusters. Thus, this paper confirms the argument of 'jobs follow people' instead of 'people follow jobs'. In addition, cluster-based policy may have less effect than expected, because influence of R&D capacity turned out to be stronger and longer on regional growth. Finally, specific elements that affect economic growth in the regions of Korea were percentage of working age people, education systems, quality of R&D activities, and density and diversification of clusters.

This study gives several contributions. First, it conducted a regional level study by a systematic perspective with both static and dynamic analyses in Korea. To the best of the authors' knowledge, very few trials have been done in this approach. Also, this research has constructed the aggregate dataset of regional structures, R&D capacity, and clustering information, which is also assumed to be the novel trial, and then created composite factors which merged diverse source of information with PCA to conduct an econometric analysis. Last but not the least, the results provide important policy implications, which were discussed in Section 6, showing that the regional development policy in Korea counters the truth of regional growth patterns, and that investment on R&D capacity should be even more strengthened or remained for economic growth.

However, this study also has some limitations. It has limited use of variables such as R&D expenditure for measuring R&D capacity of the regions. Yet, this study used substitute variables, and tried to confirm the robustness of the model and the variables with an additional analysis with patent data, albeit its smaller sample size, which is still reasonable.

Finally, further research, such as consideration of the role of intermediate organizations to interconnect the factors would give more fruitful implication to local governments. Also, the methodology used in this paper can be expanded to innovation cities or special economic zones in Korea and in other countries.

Chapter 5. The effects of regional capacity in knowledge recombination on productivity gains in Europe

5.1 Introduction

The importance of knowledge structure, such as triple helix, followed by innovation as an explanatory factor for regional economic performance and productivity gains has gained attention continuously (Capello & Lenzi, 2015; Etzkowitz, 2012). While innovations largely depend on recombination of existing knowledge of knowledge structure (Nelson & Winter, 1982), however, questions concerning the relationship between the recombinant types of knowledge and the regional productivity remain unanswered.

Most novel innovations, the creation of new knowledge, originate by combining previously unconnected technologies (new recombination), or via reconfiguration of and improvement on already existing technological knowledge combinations (exploiting the related recombination space) (Aharonson & Schilling, 2016; Carnabuci & Operti, 2013). Indeed, in the firm level, firms' recombinant capabilities are a key source of firms' innovative performance. (Carnabuci & Operti, 2013; Henderson & Clark, 1990; Yayavaram & Ahuja, 2008). By virtue of knowledge space methodology, stochastic-frontier analysis, and a newly updated patent database, it is now feasible to investigate the effects of explorative and exploitative capacity in recombination on productivity at the regional level.

Thus, this paper aims to explore how regional type in technological recombination is related to the regional productivity. That is, does different technological recombination type make significant difference in region's technical efficiency? For the analysis, PATSTAT and regional socio-economic data for the period between 1980 and 2014 are utilized to investigate regional knowledge spaces and their productivity of European NUTS 2 level regions. With the accumulated pan-European knowledge space, each regional capability in new recombination and exploitative recombination is measured. Then technical efficiencies are estimated with stochastic frontier analysis, and finally, the effect of recombination type on productivity is regressed to figure out which type has positive and significant relationship with productivity gains.

The remainder of the study is structured as follows: Section 2 reviews literature on knowledge recombination type, exploration and exploitation, and then the relationship of recombination type and productivity. Next, Section 3 describes the methodology and data used in the analysis, and Section 4 shows the results. Finally, Section 5 discusses further and concludes.

5.2 Literature review

Knowledge recombination has been discussed widely in terms of firm's innovative capacity and organizational learning in knowledge management literature (Arthur 2007; Fleming 2001; Kaplan & Vakili 2015; Rosenkopf & Nerkar 2001; Savino et al., 2017), as Nelson and Winter (1982) said "innovation consists to a substantial extent of a recombination of conceptual and physical materials that were previously in existence (p.130).” Those studies mainly introduce two types of knowledge recombination, that is, exploration and exploitation of knowledge. Exploration is defined as “the pursuit of new knowledge, of things that might come to be known,” and exploitation as “the use and development of things already known” (Levinthal & March, 1993, p.105).

From the knowledge recombinant perspective, recombinant activities start from the exploitation of an existing accumulated knowledge (Levinthal & March, 1993; March, 1991). In other words, seeking for new knowledge starts with exploration of already existing knowledge, and firms often develop new combinations initially through incremental processes (Arthur, 2007; Dosi 1982; Fleming 2001; Fleming & Sorenson 2004). Furthermore, Kogut and Zander (1992) emphasized a firm’s combinative capability to create novel applications from previously existing knowledge to further acquiring new knowledge.

In fact, innovative performance can be achieved by improving the recombination set of knowledge that can be easily accessed (Ahuja et al., 2008). That is because exploitation of knowledge has been proven to secure certain returns and therefore reduces the risk and uncertainties (Audia & Goncalo, 2007). Since it is the refinement and expansion of existing capabilities, technologies, and applications, the results are mostly positive, proximate and likely to be guaranteed (March, 1991). However, this repeated mechanism of learning would lead to decreasing returns due to the problems of overlooking distant times, distant places, and failures (Levinthal & March, 1993).

On the other hand, most breakthrough innovations come from new recombination.

Explorative approach facilitates new breakthrough opportunities due to its extended variety of knowledge base (Ahuja & Lampert, 2001). Linking distant and diverse sources increases creativity, which in turn creates breakthroughs and thus, brings economic wealth, Schumpeterian rents, and also social welfare (Ahuja & Lampert, 2001; Audia & Goncalo, 2007; Kaplan & Vakili, 2015). While exploration enables to discover novel ideas, technologies and solutions, however, is not always positive in the short-run because of high uncertainty and degradation of performance (Aharonson & Schilling, 2016).

Put together, exploitation increases short-term productivity but exclusively engaging in exploitation is not good for long-term productivity. In contrast, exploration decreases shot-term productivity but it may bring long-term productivity and greater returns.

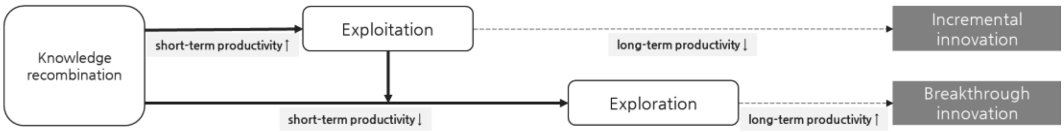
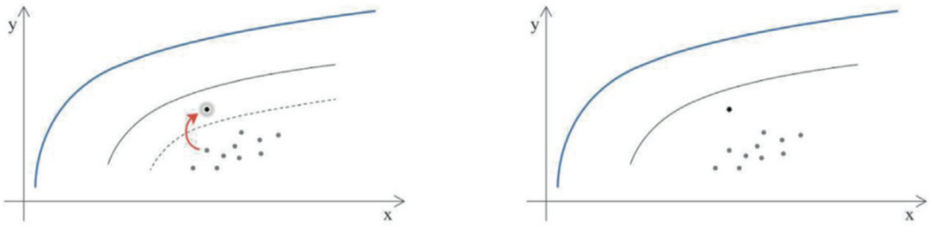


Figure 5-1. Knowledge exploitation and exploration

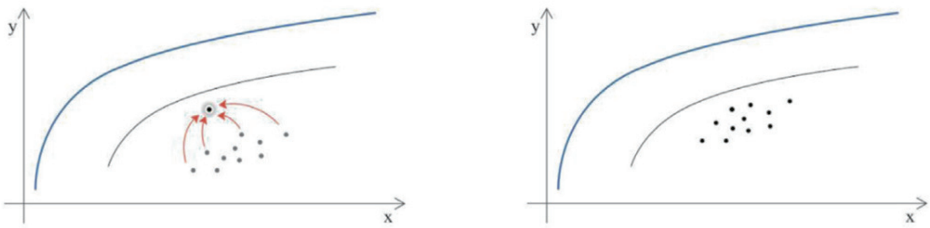
The same mechanism can be applied to industrial level. According to Lee et al. (2017), Figure 5-2 shows the movement of production function and technical efficiency through the cycle of innovation (exploration) and imitation (exploitation). When few innovative firms innovate as a result of exploration (1-(a) in Figure 5-2), sudden technical inefficiency increases because of upward movement of production function (1-(b) in Figure 5-2). However, through imitating activities by other firms, the technical efficiency of the industry increases ultimately (2-(a), (b) in Figure 5-2). Exploitation decreases technical inefficiency, however, it is the exploration which moves the production function upward.



(a) Innovation and upward movement of the production function

(b) Upward movement of the production function and decrement of average efficiency

1. Innovation and decrement of average efficiency



(a) Imitation

(b) Increment of average efficiency

2. Imitation and increment of average efficiency

Figure 5-2. Cycle of innovation and imitation

Source: Lee et al. (2017), p.1507

Recently, the region's combinatorial knowledge dynamics and economic diversification have started to attract attentions in terms of relatedness and related variety (Boschma et al., 2014; Boschma, 2017; Grillitsch & Trippl, 2014; Kogler, 2017; Tödtling & Grillitsch, 2015). With regard to economic diversification process, recombination of knowledge representing internal dynamics of regional knowledge structure becomes a key source (Quatraro, 2016). Based on these concerns, this study aims to investigate the effects of knowledge recombination type on productivity gain at the regional level.

5.3 Methodology and data

5.3.1 Methods

In order to understand the relationship between knowledge recombination type and productivity, the overall analysis is conducted in three stages. First, regional knowledge space is constructed with PATSTAT from EPO for 1980 to 2014. The knowledge space is depicted by a technology class co-occurrence matrix (Kogler et al., 2013; Kogler et al., 2017). With the knowledge space, Figure 5-3 illustrates the scheme of calculating regional capacity in exploration and exploitation of region *R* at period *T*. In left side of the figure, two indexing matrices derived from cumulated knowledge space of EU until the period of *T-1* represent which combinations are completely new or not, respectively. For instance, there are four new recombinant spaces where the two technologies had never co-occurred until the period of *T-1* (combinations between A-D, B-E, C-D, and C-E). Those four spaces are coded 1 in the new combination matrix for the completely new recombination compared to the cumulated knowledge space in EU at the previous period. The same method is applied to existing recombination.

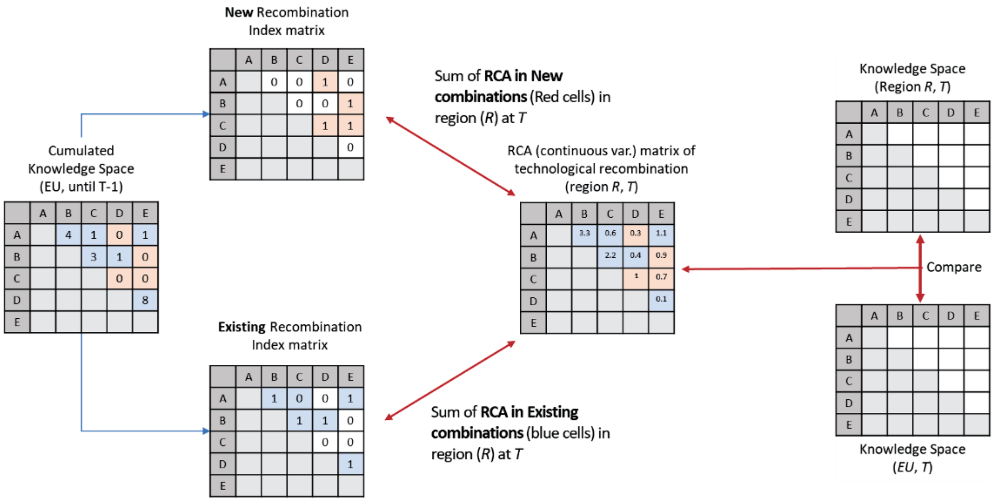


Figure 5-3. Calculation of regional capacity in knowledge combination

Here, relative comparative advantage (RCA) of technology classes for each type is measured to evaluate regional capacity in exploration and exploitation of knowledge. The concept of RCA in technological recombination space used in this paper is specified in Eq. (2), where $s_{i,j,R}$ and $s_{i,j,EU}$ represent the number of co-occurs of technology i and j in region R and EU, respectively in order to take into account of the regions R's recombination capacity compared to the whole EU.

$$RR(RCA\ in\ Recombination)_{ij} = \frac{s_{i,j,R} / \sum_i \sum_j s_{i,j,R}}{s_{i,j,EU} / \sum_i \sum_j s_{i,j,EU}} \qquad \text{Eq. (2)}$$

Then, region R's new recombination capacity (*Exploration*) and existing recombination capacity (*Exploitation*) during the period T are calculated as Eq. (3) and (4), respectively, where $IS_{p,R,T}$ refers to region R's inventor share of patents listing technology i at period T.

$$Exploration_{R,T} = \frac{\sum_i \sum_j RR\ in\ New\ Recombination_{i,j,R,T}}{\sum_p IS_{p,R,T}} \qquad \text{Eq. (3)}$$

$$Exploitation_{R,T} = \frac{\sum_i \sum_j RR\ in\ Existing\ Recombination_{i,j,R,T}}{\sum_p IS_{p,R,T}} \qquad \text{Eq. (4)}$$

Second, technical efficiency (TE) is measured with stochastic frontier analysis (SFA) for regional productivity. As the distance between the frontier production function and regional technology level decreases, then TE of the region increases. This study adopts Battese and Coelli (1995)'s SFA model and measures TE to capture the change in efficiency over time as follows:

$$Y_{R,T} = f(\boldsymbol{X}_{R,T}; \boldsymbol{\beta})e^{v_{R,T}-u_{R,T}} \qquad \text{Eq. (5)}$$

where $Y_{R,T}$ is the observed amount of output of region R at year T, $\boldsymbol{X}_{R,T}$ is a vector of region R's input set in period T, f is the production function, $\boldsymbol{\beta}$ is a vector of unknown parameters to be estimated, $v_{R,T}$ is an independent and identically distributed random variable that follows a normal distribution of regression equation, and $u_{R,T}$ refers to the inefficiency of the region R from the frontier production function. To reflect the fact that inefficiency is always above zero, $u_{R,T}$ is non-negative and follows a half-normal distribution.

For the production function *f*, this paper uses trans-log production function to take account of complicated interactions between inputs instead of Cobb-Douglas production function, because Cobb-Douglas production function assumes output as a log-linear combination of inputs, which is too simplified. Thus, Eq. (5) can be rewritten as Eq. (6), using random effects time-varying production model and trans-log production function:

$$lnY_{R,T} = \beta_0 + \sum_{m=1}^{3} \beta_m lnx_{mRT} + \sum_{m=1}^{3} \sum_{\substack{k=1, \\ k \geq m}}^{3} \beta_{mk} lnx_{mRT} lnx_{kRT} + v_{R,T} - u_{R,T} \qquad \text{Eq. (6)}$$

where $Y_{R,T}$ is the output of region *R* at year *T*, x_{1RT} indicates the size of capital of region *R* at year *T*, x_{2RT} indicates the size of cost of region *R* at year *T*, and x_{3RT} indicates the size of labor pool of region *R* at year *T*. Gross value added (GVA), gross fixed capital (GFC), compensation of employees, and number of employees were used for each variable.

Then, the technical efficiency is calculated as in Eq. (7):

$$TE_{R,T} = e^{-u_{R,T}} = \frac{Y_{R,T}}{f(\boldsymbol{X}_{R,T};\boldsymbol{\beta})e^{v_{R,T}}} \qquad \text{Eq. (7)}$$

Lastly, multiple regressions are conducted with TE and growth rate of TE with random intercept and random coefficients model as Eq. (8) and Eq. (9), where $\boldsymbol{X}_{R,T}$ includes measurement of economy scale (GDP per capita), knowledge stock (number of patents per capita), and controls for periodic effect.

$$TE_{R,(T+1)} = f(Exploration_{R,T}, Exploitation_{R,T}, \boldsymbol{X}_{R,T};\ \boldsymbol{\alpha}_{[\boldsymbol{R}]\boldsymbol{j}}, \boldsymbol{\beta}_{[\boldsymbol{R}]\boldsymbol{j}}) \quad \text{Eq. (8)}$$

$$\Delta TE_{R,(T+1)} = f(Exploration_{R,T}, Exploitation_{R,T}, TE_{R,T}, \boldsymbol{X}_{R,T};\ \boldsymbol{\alpha}_{[\boldsymbol{R}]\boldsymbol{j}}, \boldsymbol{\beta}_{[\boldsymbol{R}]\boldsymbol{j}}) \quad \text{Eq. (9)}$$

Here, six models are regressed as shown in Table 5-1. Control variables ($\boldsymbol{X}_{R,T}$) are all included in the six regressions, and exploration, exploitation, interaction term of exploitation and exploitation, and ratio of exploration variable are added for the analysis.

Table 5-1. Regression models

Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Controls	Controls	Controls	Controls	Controls	Controls
	Exploitation		Exploration	Exploration	
		Exploration	Exploitation	Exploitation	
				Exploration × Exploitation	
					Exploration ratio

5.3.2 Data

The whole analysis above requires two types of data set: one is patent data which can be identified by technological fields and where the technologies were invented, and the other one is regional socio-economic data. The patent data is from European Patent Office (EPO)'s PATSTAT as it contains all patents applied to EPO and their detailed information on year of application, inventors, assignees, technological fields, and citations. In this study, technological fields are split by using Cooperative patent classification (CPC) codes at the four digit level. The advantage of using CPC is that it contains new categories under section Y of new technological developments and crossover technologies (Leydesdorff et al., 2017). Also, technologies are separated by NUTS 2 regions based on the patents' information on inventors' residency address.

Moreover, socio-economic data is acquired from Eurostat and Cambridge Econometrics for SFA analysis and control variable. Control variables used in this research includes GDP per capita, patents per capita, and fixed time effects. The GDP and patents variable are then divided into three groups each, thus including two dummy variables for each in analysis models, respectively. Also, the time variables are included as dummy variables.

For the purpose of this study, our analytic sample is created as follows. First, the sample is restricted to those patents of which the filing year for the first application was in between 1980 and 2014. Then, the period is grouped into five years for the analysis. Secondly, the sample includes only observations that have all values in variables in use. Thirdly, the analysis uses standardized value for exploration and exploitation. Descriptive statistics of variables for the regression models are reported in Table 5-2.

Table 5-2. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
TE	1277	0.6553	0.1096	0.314	0.997
⊿TE	1277	0.0185	0.0044	0.0002	0.025
Exploration	1277	0.1044	0.0595	0	0.7869
Exploitation	1277	1.0654	0.5668	0.1935	6.2371
Exploration ratio	1277	0.096	0.042	0	0.2639
GDP per capita	1277	0.0231	0.0117	0.0026	0.1591
Patents per capita	1277	0.4249	0.492	0.0022	4.1698

5.4 Results

5.4.1 Regional recombination capacity

With technology class co-occurrence matrices for regions for every five years, the average exploitation and average exploration are calculated for measuring regions' recombination capacity. Figure 5-4 shows the regions' recombination capacity for exploration and exploitation. The x-axis and y-axis represent average exploration and average exploitation, respectively, and patent share of regions is also illustrated. The scatter plot shows that exploitation and exploration have a positive linear relationship. Further, despite of their relatively smaller share in number of patents, regions such as Munster, Hamburg, and Schwaben showed their strength in both exploration and exploitation. Regions from Germany tend to have high capabilities in knowledge recombination according to this analysis.

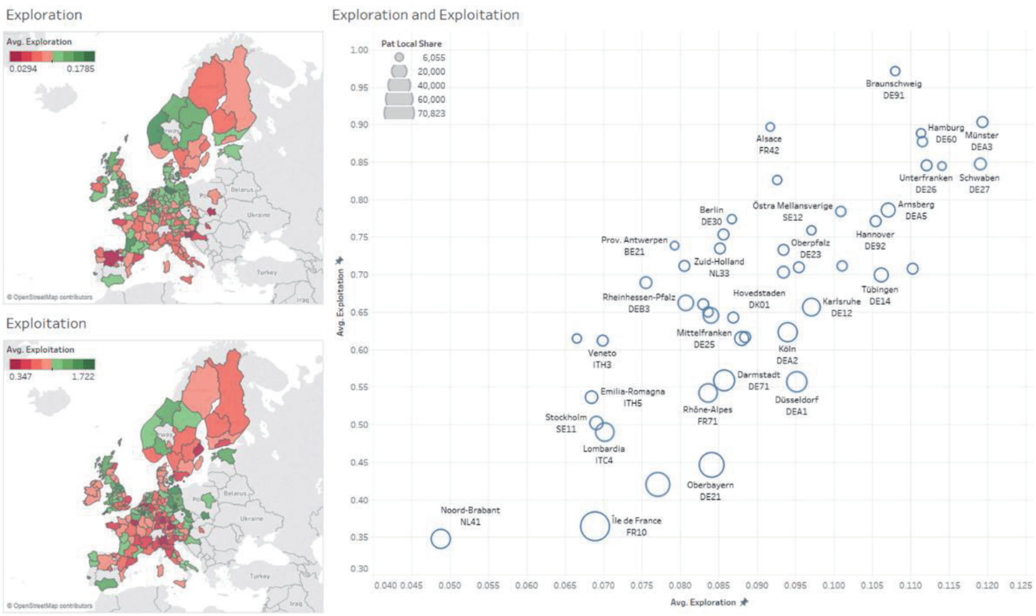


Figure 5-4. Regional recombination capacity and patenting

The trend of exploration and exploitation activities in European regions are depicted in Figure 5-5. Unlike continuous increase in exploitation, exploration displays fluctuations during the period.

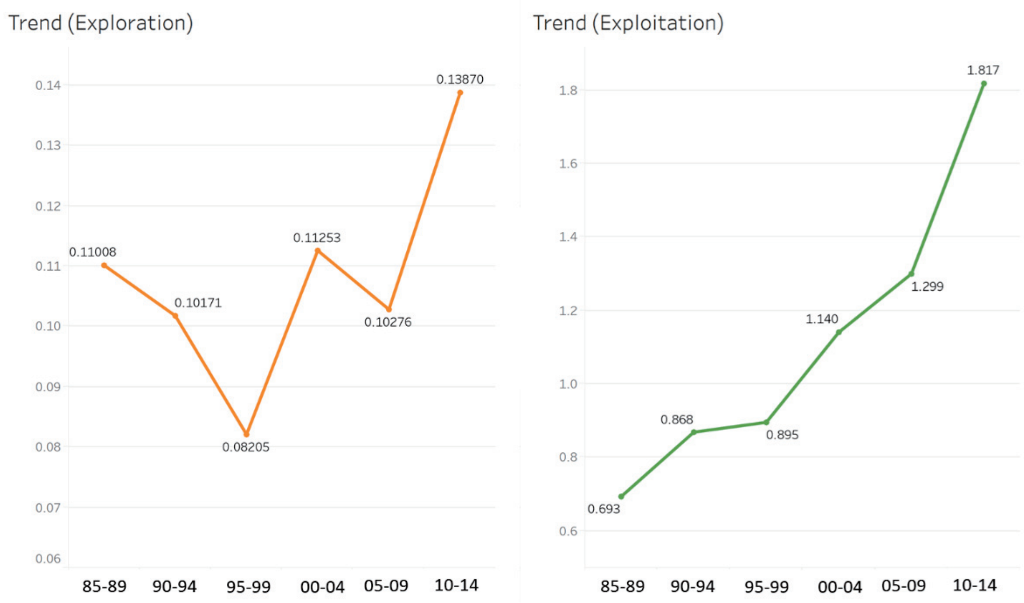


Figure 5-5. Trends in regional recombination capacity

5.4.2 Regional productivity

The stochastic frontier function is estimated and then TE for each region over the years is calculated. Figure 5-6 shows the highest 35 regions and the lowest 35 regions in rank of average TE. The 'Blue Banana' shape which indicates main economic development and innovation centers in Europe (Hospers, 2003) also appears on the map in the left side of Figure 5-6.

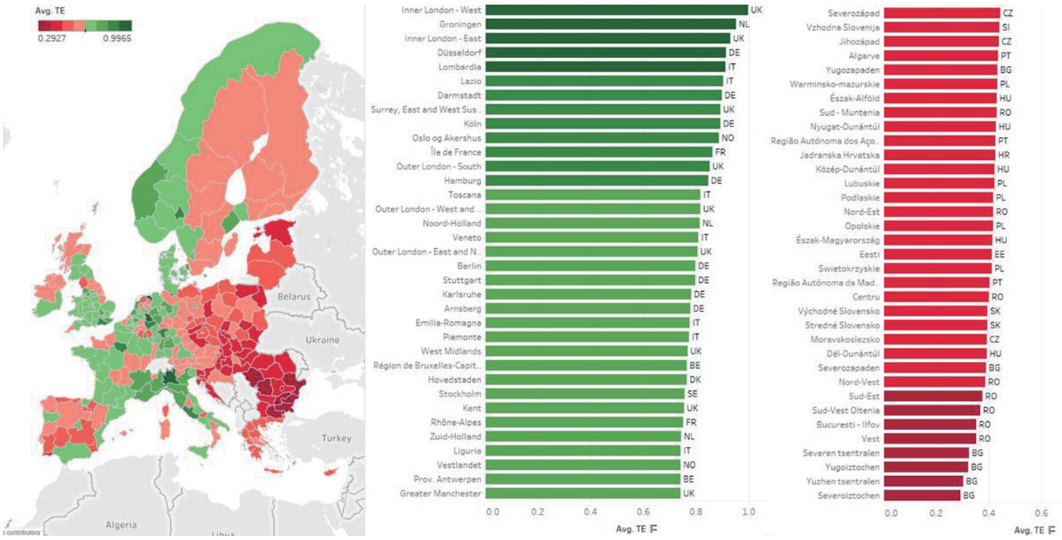


Figure 5-6. Regional productivity

5.4.3 Regional recombination and productivity

Table 5-3 reports result of the regression of recombination capacity and TE. In all models, economy scale (growth of GDP per capita), knowledge stock (growth of patents per capita), and periodic effect are included. According to the results, while exploitation has no statistically significant effect on TE (Model 3-5), exploration has a positive association with TE (Model 2). Besides, ratio of exploration also positively affects TE (Model 6). Especially, the ratio of exploration is significant at a 0.1% significance level in the model ($\beta=0.004$, $p<0.001$).

Table 5-3. Results of TE

TE	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
GDP pct						
1	0.005***	0.005***	0.004***	0.004***	0.004***	0.003***
2	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
Patent pct						
1	0.002*	0.002*	0.002*	0.001*	0.001*	0.001
2	0.002	0.002	0.002	0.001	0.001	-0.000
Time						
1	0.016***	0.016***	0.016***	0.017***	0.017***	0.019***
2	0.032***	0.032***	0.032***	0.032***	0.032***	0.036***
3	0.049***	0.049***	0.048***	0.049***	0.049***	0.054***
4	0.066***	0.066***	0.065***	0.066***	0.066***	0.071***
$Exploration$		0.001*		0.001	0.001	
$Exploitation$			0.000	-0.000	-0.000	
$Exploration \times Exploitation$					-0.000	
Ratio of $Exploration$						0.004***
constant	0.610***	0.610***	0.610***	0.610***	0.610***	0.603***

*p<.05, **p<0.01, ***p<0.001

Table 5-4. Results of ⊿TE

ΔTE	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
TE	-0.029***	-0.028***	0.030***	-0.029***	-0.029***	-0.025***
GDP pct						
1	-0.000	-0.000	-0.000	-0.000	-0.000***	-0.000
2	-0.000***	-0.000***	-0.000***	-0.000***	-0.000**	-0.000***
Patent pct						
1	0.000	0.000	0.000	0.000	0.000	0.000
2	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
Time						
1	-0.000***	-0.000***	-0.000***	-0.000***	-0.001***	-0.000***
2	-0.000***	-0.000***	-0.000***	-0.000***	-0.001***	-0.000***
3	-0.000***	-0.000***	-0.000***	-0.000***	-0.002***	-0.001***
4	-0.001***	-0.001***	-0.001***	-0.001***	-0.003***	-0.001***
$Exploration$		0.000*		0.000**	0.000	
$Exploitation$			0.000	-0.000	-0.000	
$Exploration \times Exploitation$					-0.000	
Ratio of $Exploration$						0.000**
constant	0.037***	0.037***	0.038***	0.038***	0.020***	0.035***

*p<.05, **p<0.01, ***p<0.001

Table 5-4 reports result of the regression of recombination capacity and growth rate of TE (ΔTE). The result shows that exploration and ratio of exploration have a positive and significant effect on ΔTE as well (Model 2, 4, 6). Thus, the two results consistently represent that exploration and ratio of exploration are linked with the increase of productivity. However, exploitation and interaction term of exploration and exploration have no significant effects.

5.5 Discussion and conclusion

Using regional recombination capacity calculated from technology class co-occurrence matrices and estimated technical efficiencies from SFA, this study analyzed the effect of recombination capacity on productivity gain across European NUTS 2 level regions. To do this, TE and growth rate of TE were regressed on exploration and exploitation capacity, and control variables including economy scale, knowledge stock, and periodic effects.

The results in Table 5-3 and Table 5-4 showed that new recombination, which is, explorative activities had positive and significant influence on productivity gains while exploitation of knowledge had no significance. In other words, regions who have strength and focus in exploration of knowledge tend to gain greater productivity and faster growth in terms of productivity. Thus, to achieve regional growth through enhancing productivity, explorative search needs to be implemented.

This paper contributes, first, by considering regional recombinant capacity in the process of innovation and productivity gain driven from knowledge structure. Previous studies have noticed the importance of knowledge structure and its effect on innovation in the region, however they have failed to consider how new knowledge is created upon the structure and how it affects innovation and productivity growth. This paper, however, raised discussion from knowledge management field which was usually done on firm level to regional level with estimation of regional knowledge capacity and technical efficiencies of regions.

Secondly, this study proposes policy implications. According to the results, albeit reconfiguration of existing knowledge costs less and secures returns to effort, completely new recombination is the factor that leads to productivity growth. Thus, explanatory search on new knowledge is required to enhance productivity growth. Now in such regions with favorable socioeconomic contexts and high innovative capacity, collaborative or collective learning should be facilitated for explorative search of knowledge.

This paper has some limitations that the analysis applied dichotomous structure on regional knowledge recombination, and the dependent variable, productivity gain, is limited to technical efficiency. Also, main diagonal of knowledge structure could not be considered because of technical issues.

Thus, future research can apply more specified classification on knowledge recombination and sectors, for example, new, low-related, and high-related recombination in manufacturing or service sectors, and variables such as total factor productivity or technical progress can be applied. Further, if more detailed use of information of patents data becomes possible in the future, more precise knowledge space of regions can be constructed. Finally, as exploration appears to be significant for productivity performance, knowledge spillovers transferred between regions can be investigated.

Chapter 6. Conclusion

6.1 Overall summary

This thesis adopts an evolutionary and systematic integrated view to investigate regional innovation and growth patterns, focusing on learning processes in regions with different levels of innovation potential.

The growing attention to regional level innovation and development arose from the recognition of the importance of geographical space in innovation processes and economic growth. Due to the advantages of regional examination, theories such as evolutionary economic geography and regional innovation systems have been developed to work on regional innovations and economic growth. Those studies contributed to the design and implementation of regional innovation policies.

However, one-size-fits-all problems remain a factor in regional policies despite significant differences between regions in terms of their socioeconomic contexts, innovative capabilities, and understandings regarding technology. Therefore, based on the review of literature on regional development theories and policies, this thesis investigates regional innovation and growth patterns of regions with different levels of technological capabilities and knowledge to determine the feasibility of regional development policies and sustainable long-term growth. Accordingly, three different uses of knowledge, absorption, diffusion, and generation of knowledge, in terms of regional innovation and growth in distinct regions, are depicted in three studies.

The first study in Chapter 3 proposes a framework for initiating community-level innovation in a lagging region of developing countries. Lagging regions with little or no technological capability or knowledge merely adapt to external knowledge, which can be easily realized from appropriate technology cases. Appropriate technology aims to provide local and context appropriate technology considering the needs and capacity of recipients for resilience and persistence; however, in reality many regions fail to absorb external technology and knowledge. From these concerns, the article argues for a comprehensive approach by establishing a theoretical background of appropriate technologies. Subsequently, the concept of grassroots innovation, a community-level bottom-up and socially inclusive innovation for sustainability, is introduced. While appropriate technology has been developed for developing countries, grassroots innovation has been discussed in the urban context of developed countries.

The study identifies the links between appropriate technology and grassroots innovation to suggest potentials for integration of the concepts. Then it redefines core common constructs within the framework: context, driving force, niche, organizational form, and resource base. Based on a qualitative case study of appropriate technology in Laos, the results show that social niche (community-level activities) plays a significant role in improving the use of technology by generating a local knowledge transfer mechanism through social learnings. Additionally, it is required to adopt the comprehensive approach with the framework of the five constructs, and important keywords for each construct are suggested.

Secondly, the study in Chapter 4 draws attention to regional innovation and growth patterns in intermediate regions in Korea. Because clusters are considered to promote greater innovation and growth by facilitating intra-regional knowledge spillovers, they have been popular among regional policy makers. In this regard, Korean local governments have also pursued a cluster-based policy for regional development. However, clusters are oversupplied without an objective examination of conditions and demands for the regions. The existence of clusters does not guarantee regional networks and subsequent economic growth. Therefore, this study examines the effects of clustering on regional economic performance along with socioeconomic and knowledge capacity factors from a systematic perspective.

By applying PCA methods and panel regression models with GLS estimation on composite factors and individual variables, this study conducts both static and dynamic analyses with 59 regions in Korea for the period between 2010 and 2016. The results suggest that favorable socioeconomic contexts are prerequisites to foster innovation and growth by clusters. In addition, cluster-based policy may have smaller effects than expected, because R&D capacity turned out to have a stronger and longer effect on economic performance. Lastly, specific elements such as percentage of working age population, number of private education institutions, number of students per faculty, number of university faculty, and number of SCI per university faculty was found to be significant for regional economies. In addition, in terms of clustering indexes, agglomeration density and diversity of clusters are found to be effective on regional growth in regions in Korea.

Finally, the third study in Chapter 5 investigates regional capacity in knowledge recombination and its impact on regional productivity of regions in Europe. As knowledge is accumulated, knowledge diversity and novel recombination of knowledge become new drivers for economic growth and especially for sustainable long-term regional development in advanced regions. However, questions on the relationship between the recombination capacity and productivity at a regional level has remained unanswered. In this regard, this study specifies regional type in technological recombination into exploration and exploitation and measures their effects on regional productivity in NUTS 2 level European regions from 1980 to 2014. Exploration stands for completely new recombination of knowledge, and exploitation means already existing recombination of knowledge.

For the analysis, first, knowledge space of a region is constructed based on technology class co-occurrence matrices with patent data retrieved from EPO's PATSTAT, and a region's relative comparative advantage for each recombination type is calculated. Then, technical efficiency is estimated with stochastic frontier analysis model using random effects time-varying production model and trans-log production function with socioeconomic data. Lastly, the relationship of regional recombination types and technical efficiency is regressed while controlling for economic scale, knowledge stock, and periodic effects using random coefficient models. The results indicate that explorative recombination has positive and significant influence on productivity gains in European regions, while exploitative recombination has no significant influence.

6.2 Policy implications and contributions

Overall, this thesis provides different regional development policy implications stage by stage from evolutionary and systematic perspectives.

In Chapter 3, the study emphasizes the importance of nurturing local knowledge transfer mechanisms within a social niche for lagging regions to adapt to external knowledge for sustainable regional development. In other words, when technology is transferred to regions where they possess little or no technological capabilities and knowledge, knowledge transfer should accompany technology transfer. Especially for the case of appropriate technology, many projects have failed to sustain because most of them were conducted in a temporary and shot-term manner in practice. Instead, policy makers and practitioners should encourage and develop grassroots niches so that recipients of technology can maintain and improve in using technologies, which can be defined as grassroots innovation. Moreover, appropriate technology practices should thoroughly consider contexts, driving forces, organizational forms of participants, and resource base to induce further innovation dynamics and capabilities beyond the solution of basic needs.

Second, the study in Chapter 4 provides several political and practical implications for intermediate regions where they are not eligible for intra-regional knowledge diffusion. The findings highlight, first, the importance of favorable socio-economic contexts to foster greater returns on regional innovation and growth by clusters. Current cluster-based policy in Korea depicts ‘people follow jobs,’ however, the results confirm ‘jobs follow people.’ In this regard, local governments should carry out an objective examination on regional demands and conditions in advance, and policies to create favorable residential environment and competent education systems should be developed to attract residents and employees in the regions

Also, policy makers should refrain from exclusively focusing on cluster-based policy, but should develop stable R&D investment policy at the same time to strengthen the innovation capacity of individual economic actors in the region. When focusing on clusters, selection on types and fields of clusters should be based on preliminary examination of demands and skills of labor pool, and policies should be differentiated among different types of clusters. Other practical implications include; development of vocational education systems for employees and focus on strengthening quality of regional universities instead of size and numbers.

The last study in Chapter 5 proposes the importance of explorative knowledge recombination capacity to generate new knowledge for long-term economic growth in regions with a high level of knowledge accumulation. Although exploration has high costs and risks, generation of new knowledge with novel knowledge recombination brings productivity growth. This can be coupled with the discussion of relatedness or related variety of knowledge base and economic diversification of the regions. By confirming that explorative combinatorial knowledge dynamics is significant, means for collaborative and collective learning for explorative search of knowledge within a region should be explored.

In accordance with the findings and implications of the studies in this thesis, regional innovation and development policies should consider evolutions of learning processes and accumulation of knowledge. The three studies not only suggest implications for each region, but the three stages depicted in a row also illustrates a dynamic and self-transforming process of a region according to the three functional dimensions of knowledge, leading to a sustainable transition and long-term growth.

In addition, the thesis provides insights to consider package-based policies composed of learning, innovation, and social system for regional growth. Namely, learning process or internal development of knowledge, modes of innovation, and supporting social system should go together in regional policy making. For example, intermediate regions in Korea often struggle with a continual decrease in population and jobs, as illustrated in Chapter 4. To cope with this problem, local governments enforce cluster-based policy in a 'people follow jobs' manner. However, as the opposite is demonstrated by the analysis, a package-based approach is required to facilitate learning in regional innovative networks supported by adequate social system. Local universities and local clusters or firms can collaborate systematically to develop academic curriculum and on-site vocational training programs that match industrial demands and regional demands. Consequently, by attracting a workforce with adequate skills and firms, regions can benefit from greater returns from clustering effects.

6.3 Limitations and future research

This study has some limitations that can be addressed with future research. In the first study, the framework and the constructs were suggested based on a successful case of an appropriate technology project. Due to the explanatory nature of the study, the single case was illustrated thoroughly rather than aggregating several cases with simple analysis. Thus, further qualitative research in diverse technology fields and types of appropriate technology is necessary to confirm the advantage of application of grassroots innovations to developing countries. Also, negative aspects which can be derived from failure cases could not be considered in this study. Therefore, it is necessary to expand the scope of the study to reach some failure cases to figure out critical points and lessons for further research.

The second study estimates the effect of clusters on regional economic performance with social factors and capacity factors. Although it aims to investigate the whole story in a broad sense, the study has limitations in that it cannot explain in detail how clusters affect regional growth. The three composite factors, social, capacity, and clustering, could give a big picture by investigating interdependencies between them; however, the study does not deal with how and what types of clusters have impacts on regional economy. Therefore, for future research, a study can classify clusters according to, for example, their typical type of industry and estimate their effects. Moreover, this article targeted si·gun level regions in Korea for the analysis. Yet, there was limited access to data of variables such as R&D expenditure. The data on R&D expenditure or R&D human resources are only provided at a national level and do level regions in Korea, however, the analysis was conducted on a more segmented level. Due to limited use, the study used substitute variables and tried to validate the use by conducting an additional analysis with patent application data. However, since R&D expenditure is the direct indicator of investment in R&D, future work can be done when the R&D expenditure data at si·gun level can be accessed. In addition, the analysis could not include the role of intermediate organizations into consideration, despite their importance in intra-regional spillovers. If quantitative data can be identified and collected regarding intermediate organizations that foster regional innovations, the variable can be added.

Finally, the third study has some limitations where the analysis applied two types of regional knowledge recombination, exploration and exploitation. Rather than this dichotomous structure, more specified classification on knowledge recombination can provide detailed results and implications. Also, if sectors or technology classes are divided, different patterns of knowledge recombination in each sector can be discussed. Lastly, as the study found out that exploration is crucial to productivity gain, thus, future research can be expanded to inter-industry and inter-regional knowledge spillovers.

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Appendix 1: Sources for case study

[1] List of interviewees and discussions

Interviewees		Selected discussions
KOICA officials	Former country director of KOICA Laos Office	• Sector policy of the partner country (Laos) • International bidding procedure • Monitoring of the project and adjustments in evaluation • Efficiency of cooperation and communication among project actors
	Former deputy country director of KOICA Laos office	
PMC	President of Global Community Development Research Institute	• Outputs and achievements of the project • Costs and time spent on the project • Structure of implementation • Communication with local villagers
CM	Former technician of Dongho	• Outputs and achievements of the project • Costs and time spent on the project • Structure of implementation Communication with local villagers
End-of-project evaluator	Vice president of Yooshin Engineering	• Outputs and achievements of the project • Check-up list for operation and management after the end • Consideration that need to be taken into account during the ex-post evaluation
Vientiane Province	Vice governor of Vientiane Province (former director general of planning and investment)	• Selection process for the beneficiary village and the construction company • Management of the dam and canal • Project plan for the construction of the dam and canal • Plans to ensure sustainability

	Three interviewees including Vice chief of the Vientiane Provincial Agriculture and Forestry Office	• Participation in the planning and implementation phases • Data on the irrigated area after the completion of the project • Operational status of the dam and canal • Achievements of the project, etc.
Meun District Agriculture Department	Director general of agriculture department and two staffers	• Participation in the planning and implementation phases • Data of irrigated area after the completion of the project • Operational status of the dam and canal • Achievements of the project, etc.
Namhee village	Namhee village chief and 18 people	• Data of agricultural land and irrigated area before and after the project • operational status of the dam and canal • operation status of the water user group
Other donor agencies in Laos	Senior natural resources and agriculture specialist of ADB	• ADB's irrigation projects and their features • Lessons learned from previous irrigation projects
	Total two interviewees including representative of agriculture and rural development of JICA	• JICA's policy direction on water projects • JICA's direction and features of irrigation projects • Main considerations for building irrigation facilities

Source: KOICA(2016a), p.20-21

[2] Rating result of the project

Criteria	Contents	Ratings
Relevance	Consistency of development strategies of Laos	4
	Adequacy of project's design and implementation	2
	Ownership of the beneficiaries	4
	Average	3.3
Efficiency	Efficiency of expenditure	2
	Efficiency of project period	3
	Achievement compared to input resources	2
	Average	2.3
Effectiveness & Impact	Achievement of planned outputs and objectives	3
	Positive/negative impacts on socioeconomic contexts	4
	Average	3.5
Sustainability	Sustainability of manpower, institutions, and budget	2
	Sustainability of maintenance system	3
	Average	2.5
	Total	11.6

Source: KOICA(2016a), p. iii

Appendix 2: Model test statistics

[1] Multicollinearity (VIF)

variable	VIF	1/VIF
Total pop	4.02	0.248583
Social	2.96	0.263410
Capacity	3.81	0.337871
Clustering	1.14	0.879515
Mean VIF	2.98	

[2] Heteroskedasticity (Breusch-Pagan test)

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
        Ho: Constant variance
        Variables: fitted values of ln_grdp

        chi2(1)      =     0.19
        Prob > chi2  =   0.6634
```

[3] Autocorrelation (Wooldridge test)

```
Wooldridge test for autocorrelation in panel data
H0: no first order autocorrelation
    F(  1,      58) =    243.106
          Prob > F =      0.0000
```

[4] Stationarity (LLC unit root test)

Ho: Panels contain unit roots	Number of panels = 59
Ha: Panels are stationary	Number of periods = 7
AR parameter: Common	Asymptotics: N/T -> 0
Panel means: Included	
Time trend: Not included	

ADF regressions: 1 lag
LR variance: Bartlett kernel, 6.00 lags average (chosen by LLC)

Levin-Lin-Chu unit-root test for ln_grdp

	Statistic	p-value
Unadjusted t	-10.3238	
Adjusted t*	-9.5764	0.0000

Levin-Lin-Chu unit-root test for Social

	Statistic	p-value
Unadjusted t	-12.9877	
Adjusted t*	-12.0291	0.0000

Levin-Lin-Chu unit-root test for Capacity

	Statistic	p-value
Unadjusted t	-2.5809	
Adjusted t*	-1.2989	0.0970

Levin-Lin-Chu unit-root test for Clustering

	Statistic	p-value
Unadjusted t	-48.5400	
Adjusted t*	-51.0512	0.0000

Levin-Lin-Chu unit-root test for tpop

	Statistic	p-value
Unadjusted t	-10.7964	
Adjusted t*	-10.6624	0.0000

Appendix 3: Additional analysis with patent variable

	1	2	3	4	5	6	7	8	9	10	11	12	13
Constant	13.989***	13.905***	13.799***	13.808***	12.425***	13.875***	14.197***	13.885***	13.914***	13.888***	13.997***	13.924***	13.788***
tpop	3.44e-06***	3.85e-06***	5.48e-06***	4.03e-06***	3.65e-06***	3.91e-06***	4.76e-06***	3.95e-06***	3.67e-06***	3.70e-06***	3.30e-06***	3.32e-06***	3.33e-06***
Social	0.057***								0.062***	0.053***	0.07***	0.112***	0.08***
Capacity	0.123***	0.122***	0.063*	0.028***	0.101***	0.116***	0.076***	0.091***			0.126***	0.134***	0.092***
Clustering	0.034**	0.05***	0.008	0.012	0.018	0.035**	0.002	0.009	0.04***	0.036***			
unemp		0.015											
popdens			-.0001***										
youth				0.858									
wapop					2.323***								
priedu						0.043*							
stupf							-.03***						
univstu								3.99e-06					

patent	0.0001*				
scipf		0.872***			
size			2.44e-06*		
focus				0.424***	
div					0.073***

Appendix 4: Random-effects parameters in random coefficient models

[1] TE

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
lnsl_1_1						
constant	-2.172***	-5.798***	-4.896***	-5.448***	-5.464***	-1.975***
lnsig_e						
constant	-5.126***	-5.182***	-5.227***	-5.372***	-5.368***	-5.494***
lnsl_1_2						
constant		-2.173***	-2.184***	-4.645***	-4.656***	-2.240***
lnsl_1_3						
constant				-2.192***	-18.450***	
lnsl_1_4						
constant					-2.192***	

[2] ΔTE

ΔTE		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
lnsl_1_1							
	constant	-6.588***	-9.082***	-8.186***	-9.025***	-8.819***	-8.220***
lnsig_e							
	constant	-8.696***	-8.827***	-8.911***	-9.084***	-8.855***	-8.983***
lnsl_1_2							
	constant		-6.546***	-6.627	-8.183***	-9.483***	-6.330***
lnsl_1_3							
	constant				-6.598***	-29.132***	
lnsl_1_4							
	constant					-5.394***	

Abstract (Korean)

기술 변화와 혁신이 국가 경제 성장의 주요 원천으로 강조되는 한편, 혁신 활동에 있어 지리적 공간의 중요성을 인식함에 따라 지역적 차원에서의 혁신과 성장에 대한 논의가 심화되고 있다. 이러한 지역 수준 관점의 상대적 이점에 따라 지역 혁신과 성장에 관한 이론이 발전해왔으며, 그에 상응하는 지역 혁신 및 성장정책이 설계 및 이행되어왔다. 하지만 지역 고유의 개별적인 특성과 혁신역량이 다양하고 이질적임에도 불구하고 이에 대한 깊은 논의는 부재한 채 동질적인(one-size-fits-all) 지역혁신 및 성장 정책이 적용되어 왔다. 따라서 본 연구는 진화적 및 시스템적 관점을 채택하여 서로 다른 수준의 혁신 잠재력을 지닌 지역들을 대상으로 각 지역의 학습 프로세스에 중점을 둔 지역 혁신 및 성장 패턴에 관하여 분석하고자 한다.

이러한 목적 하에서 본 논문은 기술변화 진화이론에서 제시하는 지식에 대한 접근과 효율적 사용을 가능케 하는 세가지 핵심 기능 영역인 새로운 지식의 흡수, 혁신의 확산, 그리고 새로운 지식의 창출, 이 세가지 단계에 주목하고자 한다. 이 주요 세 가지 기능에 초점을 맞춰, 세 가지의 세부 연구내용이 학위논문에 포함되었으며, 개별 세부 연구들은 서로 다른 지식 축적 수준과 다양성을 가진 지역들의 지역혁신체제의 형성과 발전과정에 대한 연구를 담고 있다.

우선 첫 번째 세부 연구에서는 기술력이 거의 없거나 전혀 없는 개발도상국의 지역에서 외부의 지식을 흡수하고 지역사회 차원에서 혁신을 촉발시키기

위해 적용할 수 있는 개념적 틀을 제안하였다. 이를 위해 개발도상국의 적정기술 사례에 풀뿌리 혁신(grassroots innovation) 이론의 개념을 적용하여 질적 사례연구를 수행하였다. 풀뿌리 혁신은 선진국에서만 논의되어온 개념으로, 지속가능성을 위한 사회적 또는 포용적 혁신을 추구하는 커뮤니티 수준의 상향식(bottom-up) 혁신이다. 본 연구는 이러한 풀뿌리 혁신과 개발도상국을 대상으로 하는 적정기술의 유사성 및 연결성을 체계적으로 제시하고, 그를 바탕으로 다섯 가지의 핵심 구성 요소들을 포함한 개념적 틀을 재정의 및 제시하였다. 사례 연구에 따르면 사회적 니치는 로컬 지식 전달 메커니즘이 발현될 수 있도록 하며 이는 지역사회가 더 효율적으로 기술을 사용하는 데에 중요한 역할을 하는 것으로 나타났다.

두 번째 세부 연구의 경우에는 한국의 시군 지역들의 혁신 및 성장 패턴을 규명하고자 하였다. 클러스터들의 경우 집적효과를 통해 더욱 높은 수준의 혁신과 성장을 촉진한다는 측면에서 지역혁신체제 내에서 큰 잠재적 역할을 지닌다. 그에 따라 많은 지역에서 클러스터 정책을 지역 혁신 및 성장정책 수단으로 활용해왔으며, 우리나라의 지방정부들 역시 클러스터 기반 정책을 활발히 추진 중에 있다. 그러나 우리나라의 클러스터 정책은 지역의 상황과 수요에 대한 객관적인 분석이 미비한 채 과잉 공급되어 실효성 없는 정책으로 평가 받고 있다. 따라서 두 번째 세부 연구에서는 사회경제적 요소들과 지식 역량 관련 요소들을 함께 포함하여 시스템적 관점에서 클러스터에 따른 지역 경제성장 효과를 파악하고자 하였다. 이를 위해 클러스터가 존재하는 한국의 모든 시군 지역을 대상으로 PCA 분석과 패널 분석을 시행하였다. 분석 결과 클

러스터를 통해 지역 내 혁신과 성장을 촉진하기 위해서는 사회경제적 환경이 선행되어야 함을 확인하였다. 그리고 우리나라 지역에서는 R&D 역량 제고에 따른 성장효과가 클러스터 효과보다 더 크고 장기적으로 영향을 미침에 따라, 클러스터 기반 정책이 당초 예상했던 것보다 낮은 성과를 가져올 수 있음을 제시하였다. 더불어, 지역 내 활용 가능한 인적자원, 교육 시스템, 연구개발 활동의 질, 클러스터의 집약도 등의 요소들이 한국의 지역 성장을 위해 필수적으로 고려되어야 할 제도적 부문인 것으로 확인하였다.

세 번째 세부 연구는 지식을 새로 재조합하는 능력이 지속가능하고 장기적인 성장을 위한 동인으로 평가됨에 따라, 유럽의 지역들을 대상으로 지역의 지식 재조합 역량이 지역 생산성에 미치는 영향을 파악하고자 하였다. 더 구체적으로, 본 연구는 지식 혹은 기술 재조합의 유형을 탐색(exploration) 유형과 활용(exploitation) 유형으로 나누어 두 가지 유형이 생산성에 미치는 영향을 비교분석 하고자 하였다. 이를 위해 EU NUTS 2 레벨 지역들을 대상으로 특허 데이터를 활용한 기술 구분간 결합 매트릭스의 생성으로 지식 축적 패턴을 분석하고, 확률적 프론티어 모델을 통해 기술 효율성을 계산하였다. 그리고 경제 규모, 지식 축적 정도, 시기 효과등을 조절하여 지역의 지식 재조합 유형과 기술 효율성간의 관계를 회귀하였다. 분석 결과 활용적 재조합은 별다른 영향을 주지 않는 반면, 탐색적 재조합은 지역의 생산성 향상에 긍정적이고 유의미한 영향을 미치는 것으로 나타났다.

위의 논의를 바탕으로 본 학위논문은 서로 다른 지역 수준에 따른 정책적 시사점을 제공할 것으로 기대한다. 첫째, 기술력이 낮은 후발 지역에서는 풀뿌

리 혁신의 개념적 틀을 적용하여 외부 지식, 기술 또는 혁신을 흡수하여 지역의 요구에 대응할 수 있는 기반을 형성하여야 한다. 둘째, 지역 내 지식확산이 효과적으로 이루어지기 위해서는 바람직한 사회경제적 환경이 선행되어야 하고, R&D 역량에 대한 투자가 지속적으로 함께 이루어져야 한다. 셋째, 지식 축적 정도와 지식의 다양성 수준이 높은 지역에서는 새로운 지식의 탐색적 비용과 불확실성이 높음에도 불구하고 새로운 지식 재조합의 역량을 키워야 할 것이다.

주요어 : 지역혁신, 진화경제지리학, 풀뿌리혁신, 클러스터, 지식 재조합
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