Relatedness put in place
On the effects of proximity on firm performance

Lisa Östbring
Acknowledgements

In the process of writing a doctoral thesis one navigates through countless spectra of emotions, which are more or less familiar to oneself in the beginning of the process. There are great expectations and hope, but also the occasional feeling of despair. There is great freedom and flexibility, but also hard work and pressure. There is the joy of having efforts confirmed and appreciated through acceptance to a journal, but there is also the feeling of belittling that accompanies rejection. There is the fear of public speaking and doubt in one’s ability to convey information the first time one enters into a classroom as a teacher instead of as a student. There is also the wonderful sensation of being an authority in a subject matter and having the responsibility and ability to encourage, guide, engage and motivate students into learning slightly more than they thought possible.

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1. Introduction

This thesis considers the effects of learning on firm performance. It specifically examines how various forms of proximity between agents (individuals) influence the competitiveness of firms. The emphasis is on the role played by the individuals, their knowledge and their collective ability to learn and generate novelty within the firm. The thesis rests on the assumption that learning, knowledge and innovation are central not only to firm competitiveness, but also to the discipline of economic geography.

During recent decades, knowledge, learning and innovation have gained increased attention as the main drivers of the economy. Today, it is commonly argued that the importance of knowledge for sustained firm competitiveness supersedes that of capital. Early contributions by economists highlighted the role of human capital and technological change as promoters of economic growth (Arrow 1962; Romer 1990; Solow 1956). In their studies of an increasingly globalized world, economic geographers have developed this idea further. Knowledge and human capital are now often considered the most localized and most important of all production factors. The accessibility of information and goods, for both consumers and producers, has changed patterns of production and consumption and made place “slippery” in many respects (Dicken 2007; Markusen 1996). The locational advantage of firms is no longer mainly determined by proximity to physical input factors or markets or geographically differentiated wages (von Thünen 1966; Weber 1929). Instead, it is increasingly access to knowledge that has become crucial to firm survival and competitiveness. The escalated competition brought about by globalization has increased the rate and frequency of processes of creative destruction (Schumpeter 1942), in which only the most innovative firms in an industry survive. Therefore the success of a firm is highly dependent on its available knowledge resources. It is through these resources that external knowledge is absorbed and internal knowledge combined and applied in new ways to generate novelty.

The prominent role of knowledge in the production of goods and services has given rise to concepts like the knowledge society (Bell 1973), the learning economy (Lundvall and Johnson 1994) and the knowledge-based economy (David and Foray 1995). Two of these concepts, the learning economy and the knowledge-based economy, are often used synonymously, but when they were first introduced their meanings differed. David and Foray (1995) described the knowledge-based economy as relying on science and technological knowledge, mainly in science-driven high-tech sectors. Lundvall and Johnson (1994) described a learning economy in which all sectors seemed to rely on learning more than on any other input factor for their development and competitiveness. It is the perspective of a learning economy in which all industries can generate economically valuable knowledge that is adopted in
the present thesis. The success of a firm is no longer determined by the distance to physical input factors, which through globalizing processes have become increasingly ubiquitous (Maskell and Malmberg 1999b), but rather by the accessibility of relevant knowledge. Even though information accessibility is at an all-time high, knowledge is more specialized and localized than ever (Howells 2012; Maskell and Malmberg 1999a). Every place in the space economy fosters its own unique combination of formal and informal institutions and knowledge, which to a large extent is the result of past economic, political and social structures (Massey 1984). The socialization of knowledge makes it localized because social depth is not easily transferred over the great physical distances that globalization has brought about. In economic geography (Morgan 2004) and in theories of the firm (Nonaka et al. 2000), it is argue that social depth is crucial in transforming information into knowledge. This has motivated an upsurge of theoretical and empirical contributions on non-physical forms of proximity between agents that could alleviate the need for physical proximity in the generation of trust and knowledge (Almeida et al. 2002; Boschma 2005; Boschma et al. 2009; Grabher 2002a; Lam 1997; Torre and Gilly 2000; Torre and Rallet 2005). It is in this body of literature that the thesis is embedded.

Traditionally, economic geographers have studied the relationship between geographical agglomerations and knowledge production. The primary focus has been on the role of geography in facilitating external relations between firms. For example, localised learning refers to interactive learning processes that are stimulated by localised capabilities and the ability to interact easily with other actors in one’s physical proximity (Malmberg and Maskell 2002; Maskell and Malmberg 1999a). Similar perspectives on knowledge creation through external relations are emphasized in theories of learning regions (Morgan 1997), innovative milieux (Maillat and Lecoq 1992), industrial districts (Piore and Sabel 1984) and clusters (Porter 1990). All these different perspectives emphasise the economically desirable characteristics of co-location, such as competitiveness and high growth. Yet another strand of literature focused on the generation of knowledge is that concerned with national and regional innovation systems (Asheim and Gertler 2005; Asheim et al. 2011; Cooke 2001; Lundvall 1992). These perspectives include institutions and relationships between various forms of actors within a geographically delimited territory in their analyses of innovation processes. A commonality between all these theories is the focus on knowledge externalities as important sources of novelty. The role of external knowledge for firms is neither denied nor disregarded, but it is not the focus of the thesis. Firms cannot rely exclusively on external knowledge for their innovativeness, nor can they absorb all available knowledge. It is the in-house composition of knowledge that determines the absorptive capacity of the firm (Cohen and Levinthal 1990) and the combinative capabilities (Kogut and Zander 1992).
Whereas absorptive capacity represents the ability to recognize and absorb external knowledge, the combinative capabilities of the firm are determined by employees’ ability to learn from each other and combine their knowledge in new ways. It is these internal abilities of the firm to learn and innovate that are under scrutiny in the thesis. This is because the economy is ultimately made up of individuals in different networks and structures and the firm is the primary organizing unit of interactive learning processes. Penrose (1959) acknowledged that the distinction between firm and market is administration, which occurs in firms but not in markets. Furthermore, Boschma (2004) discusses and questions whether and how regions can be competitive, as learning and innovation occur in or between firms that are constituted by individuals. Brenner and Broekel (2011) examine to what extent the innovation performance of regions can be measured. They present a number of indicators of how the region, given that it is a coherent unit, may stimulate or contribute to firm innovativeness, thus acknowledging that innovation processes take place within and between firms by combining individuals’ knowledge in new ways.

In the current economic geography literature, and in economics and innovation studies, the beneficial role of relatedness for economic growth is highlighted for regions, firms and plants (Boschma et al. 2014; Eriksson and Lindgren 2009; Neffke et al. 2008). The relatedness, whether it be co-located firms in related industries (Boschma and Iammarino 2009; Neffke et al. 2012), firms diversifying into activities that are related to their main activity (Tanriverdi and Venkatraman 2005) or a labour pool of related competences (Boschma et al. 2009), presumably offers the greatest potential for successful innovation. The reason is that added knowledge and technology that are related to existing knowledge and technology in a plant are similar enough to be absorbed easily, while at the same time different enough to generate ideas for novel applications. A firm may have all the physical capital to produce a related good that renders the cost of diversification low. Similarly, a firm in a locality with a high number of related industries and firms reaps efficiency gains (externalities) both from knowledge spill overs and from supporting structures aimed at promoting the regional knowledge in a specific field (see, e.g., the regional innovation systems literature; Cooke 2001).

In theories of the role of relatedness in the labour pool, whether it concerns the in-house competences in a firm or labour mobility studies, the link between relatedness and competitiveness is less clear cut than in theories of the benefits of related agglomeration or firms expanding into related activities. Cognitive relatedness in the labour pool facilitates effective individual and group learning, i.e., knowledge growth. In the case of labour mobility, it presumably also ensures effective integration of new employees in firm activities. The idea that relatedness represents a cognitive distance, which is neither too long nor too short, stems from the literature on proximity
dimensions (Boschma 2005; Kirat and Lung 1999; Torre and Gilly 2000; Torre and Rallet 2005). The literature on (mainly) non-physical proximity dimensions states that there should be cognitive relatedness between agents for effective learning to occur. But there are also other dimensions (social, organizational, institutional and geographical) that potentially can reduce the demand for cognitive relatedness through their socializing functions. Short distances in these dimensions reduce uncertainty and promote trust and understanding between individuals. It is suggested in the present thesis that individuals can come to be associated in such a manner that they can learn from each other, and advance firm knowledge, despite a long distance between (heterogeneity of) their formal knowledge.

1.1 Contribution and aim

As discussed in the introductory section, knowledge is considered the most important resource in the production of goods and services in the learning economy. There is nothing controversial in claiming that processes of learning and innovation are essential to firm competitiveness in all sectors. For example, Hipp et al. (2000), Miles (2005) and Tether et al. (2001) have studied learning and innovation processes in service industries, whereas Acha and Brusoni (2003) and Tunzelmann and Acha (2005) have studied innovation processes in low- and medium-tech industries. It is through learning that knowledge is obtained and applied to potentially generate novelty. But whereas the role of knowledge production and spill over effects has been thoroughly discussed in economic geography (Heimeriks and Boschma 2013; Neffke et al. 2011), few studies have dealt with the ability of firms to absorb existing knowledge (Howells 2002). In the present thesis, the primary study object is the plant and its employees, i.e., the labour force. In the micro-perspective, the focus is on the interactive learning processes and absorptive capacities of firms and plants. It is through the employees that the firm consumes and absorbs knowledge, and by examining the knowledge variety in plants, the present thesis hopes to contribute to our understanding of the role of the labour force in firm competitiveness.

Apart from absorbing external knowledge through monitoring and co-operations with other actors, firms can also acquire knowledge by hiring new individuals. In such instances, one or a few individuals are brought into the firm, which constitutes a specific socio-technical context. In this context, the new employees are expected to communicate their knowledge, whereas existing employees are expected to absorb, learn and apply the new knowledge. The effect that labour force knowledge has on competitiveness and firm performance is primarily determined by the collective ability of employees to learn and apply the new knowledge. Therefore, analyses of the relational character of knowledge and learning should take multiple proximity dimensions and thus types of relations into account. Torre and Gilly (2000)
suggest that despite the frequent discussions of the beneficial role of proximity in economic geography, the exact workings of proximity remain a black box. This is a black box in urgent need of opening; if the concept is to be more than a theoretical notion, it needs to be analytically relevant and empirically applicable. Both Boschma (2005) and Torre and Gilly (2000) discuss the probable interconnectedness and overlap effects between different forms of physical and non-physical proximity. Nevertheless, most existing empirical work on proximity dimensions and knowledge flows (i.e., labour flows) within and between firms analyse one form of non-physical proximity (see, e.g., Boschma et al. 2009; Timmermans and Boschma 2013; Eriksson 2011). These studies have shown slightly diverging results, which may be attributed to the interconnectedness of multiple forms of proximity. The potentially variable impact of formal knowledge variety on plant performance, due to differences in other types of proximity, is the primary focus of the present thesis. Furthermore, the thesis also considers the in-house composition of knowledge, not only the relationship between inflowing knowledge (labour) and existing knowledge. By so doing, the relative importance of high levels of human capital can be contrasted with the influence of knowledge relatedness (variety). Boschma et al. (2009) found high levels of knowledge relatedness to be more important to firm performance than having high levels of human capital. But without the integration of human capital and knowledge variety into the same analytical model, the relationship between the two forms of knowledge and their unique and combined influence on firm performance cannot be properly addressed.

Our understanding of the shifting role of the labour force, from physical labour to knowledge resources, is still limited. Therefore, starting from the literature on proximity dimensions and relatedness, the aim of the present thesis is to examine how different forms of proximity in the labour force influence the competitiveness of firms in the learning economy. The point of departure is the understanding that the proximity dimensions afford trust and reduce uncertainty between individuals. These are aspects that promote interactive learning processes.

There are multiple claims that processes of knowledge production and learning differ in different sectors. Pavitt (1984) introduced a taxonomy of drivers of technical change in different sectors that has been extensively used ever since. Furthermore, Strambach (2013) claims that knowledge and innovative behaviour accumulate at the level of the industry, the firm, and the region, whereas Malerba (2006) points to the differentiated innovation processes in different sectors. But most empirical studies of labour force knowledge as a promoter of growth have either studied the entire economy (e.g., Boschma et al. 2009) or just one sector (e.g., Bienkowska 2007). This leaves either very broad generalizations about the workings of knowledge throughout the economy, or thorough descriptions of the particular. In the
thesis, the different conditions under which the labour force interacts and applies its knowledge are examined. Each plant in the economy comprises a unique context that is reproduced by the participants and their knowledge and abilities, and by cognitive and physical structures within the plant (Nootenboom 2009). By scrutinizing the interplay between local micro-diversity (i.e., the skills and knowledge of the local labour force) and overarching structures (e.g., firm routines or technological regimes), an integration of micro- and meso-level mechanisms is achieved, which allows for a rich analysis of the role of knowledge in promoting competitiveness for firms and plants. Through this integration of the role of the labour force and its knowledge, on the one hand, and structures in the form of firm routines and production technologies, on the other, it is acknowledged that both parts affect the potential for innovation. It is shown that labour force composition and knowledge are essential parts of firm competitiveness, but only if the surrounding structures offer ways of applying knowledge that is circulating.

In the thesis, knowledge is analysed at the level of the plant and combined with factors that are believed to affect the innovative power of learning in firms. These factors are embedded in the local context and industry setup. Moreover, the labour force is formed by real-life individuals that react differently to the same situations due to their different abilities, knowledge and experiences. Therefore, the efficacy of labour force knowledge in enhancing firm performance is not only contingent on the sum of the employees’ formal knowledge. Learning processes are social processes and similarities in past work experiences and institutional environment influence the ease and success of interactive learning processes. Factors that are assumed to influence the innovativeness of firms are explored in three empirical studies. Each of them pursues a different aspect of learning and knowledge application in firms. The three papers have different foci: the effects of cognitive and geographical proximity on learning in plants in different sectors, the effects of cognitive, organizational and geographical proximity on learning at the plant level and the effects of various forms of cognitive proximity on learning in plants. At the same time, they share the umbrella theme of the labour force as a (mainly localized) knowledge resource and potential promoter of economic growth.

1.2 Outline of the thesis

The thesis comprises three empirical papers, a theoretical framing and discussion and remarks on methodological considerations and delimitations. In this introductory section, Section 1, the overarching aim of the thesis and the three papers is introduced. The following section, Section 2, places the empirical papers (referred to as Paper I to III) in the theoretical context to which the thesis aims to contribute. By taking an evolutionary perspective on knowledge production and reproduction, the context-dependent nature of
learning and competitiveness is highlighted. The role of the individuals and the potential benefits of being embedded (Granovetter 1985) in different contexts for learning processes are discussed. There is also a short discussion of the presumed hindering or enabling meso-level structures associated with learning and knowledge application in specific sectors. Furthermore, the underlying theoretical implications of the proximity dimensions framework (Boschma 2005; Torre and Gilly 2000) are considered. It is argues that the relational (non-physical) aspects of the proximity dimensions are of greater importance to learning processes on the micro-level of interpersonal knowledge exchange. In Section 3, methodological considerations are discussed, mainly those concerned with operationalization of theoretical concepts. Section 4 offers summaries of the empirical papers and in Section 5 the main findings and conclusions of the papers are discussed. In this section there is also an introduction of potential future research based on the findings in the thesis. A short Swedish summary is provided in Section 6.

2. Theoretical research context

This section presents a general theoretical background for the thesis. It does not reflect the theoretical frameworks for the different papers, which can be found in the initial part of each paper. Instead it provides a description of the theoretical context to which it aims to contribute. It starts with a short overview of the changing role of proximity in theories in economic geography. It then moves on to specifically present the evolutionary perspective on growth, and the role of physical and non-physical proximity in interactive learning and knowledge production for firms. The point of departure is the understanding that contemporary capitalist society is substantially shaped by knowledge and skills. These properties of society reinforce the role of individuals in theories of economic growth. It also points to the importance of micro-level analysis (the level of the firm or plant) as complements to meso- or macro-level analyses of sectors, networks, regions and nations in understanding the uneven spatial development of successful economic activities.

2.1. Setting the scene: From agglomeration externalities to proximity

Already in 1890, Marshall (1890) acknowledged that there was something “in the air” in agglomerations that seemed to stimulate the competitiveness of firms. Proximity is thus not a new idea in economic geography, but for a long time it was mainly physical proximity to numerous external auxiliary functions that was thought to be important to firm competitiveness. The benefits of high concentrations of agents and firms have been repeatedly highlighted in the agglomerations literature. Proximity to competitors, sub-
contractors, clients, large markets and a specialized labour pool have all been considered locational advantages for firms, dating back to von Thünen (1966 (English version of the 1826 publication *Der Isolierte Staat*)) and Marshall (1890) and their predecessors. After the Second World War, Fordist mass production was gradually replaced with leaner forms of production. This was mainly a result of technological advancements occurring at an increasingly rapid pace, which allowed for consumer influence and custom-made products. On a global scale, the technological advancements meant substantial improvements of, initially, the physical infrastructure and, later on, the digital infrastructure (Dicken 2007), which gave the impression that ‘distance was dead’ (Cairncross 1997). The role of science and technology in the advancements of the global networks that emerged steered the foci of economic geography research toward specific geographical agglomerations and clusters, namely those of highly competitive and successful high-tech industries (Cooke 2004; Frenkel 2001; Klepper 2010; Saxenian 1994; Sternberg 1996).

With the focus on high-tech regions came an inflated interest in knowledge and people as resources, rather than just physical labour. In the literature, there was increased mention of the embodiment of knowledge. With such a socialized competence view came reflections on how human capital, knowledge workers and talents formed the local environment (Florida 2002; Lucas 1988; Romer 1990; Scott 2004). This was described as occurring not only indirectly, through their place of work, but also through their lifestyle preferences. The role of individuals in shaping the local environment was put forward by economic geographers as being twofold: partly as being part of the labour force and as such –, small units of cognitive abilities – collectively shaping the innovativeness of firms, and partly as being cultural and social beings that were part of communities and networks that reproduced not only knowledge, but also values and norms (Bathelt and Glückler 2005; 2013; Farole et al. 2010; Storper and Scott 2009; Storper and Venables 2004). Silicon Valley is probably one of the most researched regions with regard to the relationship between technological innovativeness and social and institutional structures (see, e.g., Saxenian 1994; Kenney and von Burg 1999). The recognition of workers as embodying knowledge and knowledge production as occurring in a cumulative fashion in a specific socio-technical context (Strambach and Klement 2012) offered further insights into the variable outcomes of seemingly similar knowledge inputs in economic processes in different spatial contexts (Gertler 2003; Leiponen and Drejer 2007).

The benefits of geographical proximity, as discussed in the agglomerations literature, came to concern the structures and networks, in a region, that supported or sustained high levels of technical innovation rates. Institutional and social perspectives on differentiated regional growth introduced non-
physical forms of proximity between actors. As mentioned in the introduction, geographical proximity – or co-location – facilitates and stimulates interaction between actors (Knoben 2009). In theories of the learning region, geographical proximity facilitates collaborations based on trust between actors (Morgan 1997), and in the industrial districts literature the role of collaborations between small- and medium-sized firms is stressed (Piore and Sabel 1984). The importance of geographical proximity in the innovative milieu literature is based on the facilitated relations between knowledge producing actors (Maillat and Lecoq 1992). The role of geographical proximity in cluster theory highlights proximity to competitors and partners (Porter 1990). Eriksson (2011) found an inverse relationship between the positive effects of related variety and distance of origin of labour inflow, indicating the importance of place-specific institutions in understanding variety in production technology. Similarly, Rigby and Essletzbichler (2006) and Haltiwanger et al. (1999) found great spatial differences in production techniques within the same manufacturing industries. The difficulty in imitating and learning from other firms in the same sector but from different regions preserves the heterogeneity between firms and demonstrates a place dependence of knowledge that is due to specific social and institutional characteristics.

There is a voluminous body of literature on place-specific institutions and firms as structures that affect, and are affected by, the behaviour of micro-agents. The reciprocal relationship allows a collective past to influence the perceived probability of success associated with different actions (see, e.g., Amin and Cohendet 2005; Bathelt and Glückler 2013; Farole et al. 2010; Maskell 2001). These structures are integrated into individuals’ cognitive abilities, partly as past experiences and partly as current practices.

### 2.2. An evolutionary framework

The seminal work of Nelson and Winter (1982), on the evolutionary perspective, has had a major impact on the promotion of evolutionary theory in economics. According to Nelson (1995), evolutionary theory in any discipline discusses the same three key principles: they explain the temporal development of something, they consider random elements that generate variation, and they emphasize the existence of inertial forces that provide continuity among entities. In evolutionary economics, the three main mechanisms that influence the outcome of economic activities are: the routines, the search for new and better routines and the selection environment. Evolutionary economics is quite different from neoclassical economics in its rejection of the economy as a closed system. Furthermore, it argues that technological change should be the primary focus of economic analysis. There is great emphasis on novelty and change in evolutionary economics, which is in contrast to traditional equilibrium theory. In
evolutionary economics, decreasing returns due to price competition is a secondary phenomenon in comparison to innovation processes and the search for novelty and Schumpeterian rents (Boschma and Frenken 2006).

Following theories of evolutionary economics, an evolutionary economic geography framework has recently been developed (Boschma and Frenken 2006; 2009; Boschma and Martin 2007; 2010). The concept of evolution was not altogether absent in geography and economic geography prior to this work (see, e.g., Martin 2000; Massey 1984; Rigby and Essetzbichler 1997), but the intention of the framework is a clearly defined theory of economic development in economic geography. The ambition with the framework is a theory complemented with research methodology and a research agenda. In evolutionary economic geography, firm routines and their development over time are core attributes in the competitiveness of firms. The overarching aim of evolutionary economic geography is thus to analyse the changing spatial distribution of routines and the resulting impact on the distribution of economic activity.

Within an evolutionary framework, analyses of economic processes can be carried out on multiple levels (Boschma and Frenken 2006). At the macro-level, the development of sectors and networks can be analysed within spatial systems, such as cities, regions or nations, and their structural and dynamic prerequisites compared in a global system. At the meso-level, evolutionary economic geography highlights the spatial development of sectors and networks and the analysis of relations of competition and complementarity. Finally, at the micro-level, the firm and its routines are under scrutiny. The development of the firm and the effects of variety on the competitiveness of the firm are highlighted as important research topics. At all levels of analysis, the fundamental assumption is that structures (institutions, routines, etc.) lead to the accumulation of knowledge and capabilities, in firms, sectors, networks and regions, which can be steered in different directions through a combinatorial dynamic driven by the interactions of agents (Strambach and Klement 2012; Strambach 2013). The present thesis focuses exclusively on the micro-level of analysis and learning processes that occur as the result of internal variety, at the level of the plant. The reproduction and adaption of firm routines occur within the firm and its plants as responses to market changes. The accumulated knowledge in a plant determines the efficacy of knowledge absorption and adaption. Therefore, studying the in-house composition of knowledge and abilities is a crucial step in understanding the variable ability of firms to adapt and consequently remain competitive.

2.3. Knowledge in the learning economy

The territorial accumulation of knowledge occurs on multiple scales and has many names, for example varieties of capitalism (Hall and Soskice 2001), regional innovation systems (Cooke 2001) and localized learning (Maskell and
Malmberg 1999). The spatial accumulation of knowledge in structures and people suggests that there is a place-specific characteristic of knowledge and how it is produced, reproduced and ultimately applied (Lam 1997; Rigby and Essletzbichler 2006; Storper 1997). Knowledge accumulates in regions due to the interactions of social and technological networks that have developed over time (Leiponen and Drejer 2007; Rigby and Essletzbichler 1997). Knowledge can thus be seen as a structuring component throughout society. On the individual level, people make increasingly reflexive decisions about their everyday life and practices based on their knowledge (Giddens 1990). On the systems level, knowledge has come to be an essential part in explaining how the economy works (Bell 1973; Lundvall and Johnson 1994). But firm routines, the industry and its technological regime and the local labour market all influence the choices and outcomes of knowledge applications. The path-dependency of knowledge generates non-physical proximity between individuals belonging to the same firm, industry and labour market. Thus, knowledge does not only have to be technologically relevant to be conversed and applied within the firm. It also has to be understood and communicated throughout the specific firm in a specific region. This thesis scrutinizes the micro-diversity of labour force knowledge and links it to macro-structures in an attempt to better understand the contingent nature of learning and innovation.

The concept of the learning economy (Lundvall and Johnson 1994) did not only introduce knowledge and processes of learning as key factors in innovation and firm competitiveness. It also pointed to the role of knowledge in all sectors, not only in the traditionally R&D-intensive sectors, but also for firms in, for example, the service industry. Barras (1986; 1990) argues that the rise of ICT (Information and Communication Technology) led to an industrial revolution in the service sector. The use of ICT allowed firms in the service sector to improve their efficiency and quality and develop new services at a faster pace than had previously been possible. In the learning economy, the acquisition, creation and implementation of knowledge are the key factors in explaining competitive advantage, as firms must continuously innovate to not lose market shares (Nonaka 1994; Lawson and Lorenz 1999). Under such circumstances, it is not only the learning that is important, but also the ability to apply knowledge to productive practice.

The embodiment of knowledge in people makes it a unique resource. Because people are embedded in local contexts, their knowledge is not only personal, but also localized and contextual. Therefore, the effects of sharing bits of knowledge vary between interactions due to different interpretations (Nonaka et al. 2000). These interpretations are based on personal experiences (Polanyi 1962; March 2010), understanding of the firm routines (Nooteboom 2009) and technological knowledge of the specific industry (Pavitt 1998). But innovations within firms are not just the result of the combined abilities of all
employees to absorb, converse and apply knowledge. There are also external factors that always, but variably, affect the formation of a context and influence the propensity for knowledge application and innovation. These factors are the industry in which an activity is carried out (see, e.g., Pavitt [1984] on the determinants for sectoral technological trajectories) and the firm in which the activity takes place (see, e.g., Dosi et al. [2008] on firm routines as a selection mechanism for knowledge absorption). Whereas place-specific institutions (i.e., Gertler 2003; Maskell and Malmberg 1999a) contribute to the formation and production of knowledge, there are factors associated with firm and industry that do not only steer the knowledge view within the firm, but also affect the firm’s capacity to implement the ideas of individual employees. Individuals, firms, sectors and regions are all shaped by past events and experiences. The configuration and development of economic activities in specific places are evolutionary and path-dependent on multiple levels.

In contemporary economic geography, descriptions of knowledge have come to include relational and social aspects. For instance, Howells (2002) describes knowledge as a socially constructed process, whereas Amin and Cohendet (2005) define it as a process and practice rather than a possession. Lam (2000) considers knowledge to exist between individuals rather than within them. Thus, knowledge is a resource in itself, but it also impacts how the firm uses other resources. Knowledge is therefore a major differentiating factor for firm competitiveness, because the ability of firms to procure, converse and apply knowledge varies. In addition to that, knowledge is also a volatile resource due to its embodiment in people. If a person decides to change jobs, the firm risks losing crucial bits of knowledge (Howells 2012). Due to the dependence on knowledge, and implicitly on the labour force or even single individuals, throughout the capitalist economy, the importance of micro-level analysis of labour force characteristics and collective learning processes cannot be stressed enough. The present thesis aspires to uncover some of the complexity associated with learning, innovation and economic growth within firms.

Although knowledge and learning have only recently begun to attract the attention of economic geographers, the economy has always depended on knowledge (Hudson 2009). The complexity of knowledge and learning, and the later association with innovation, has generated a vast body of literature, ranging from psychology and cognitive science (Vygotsky 1962) to sociology, organizational studies (Cohen and Levinthal 1990; Lam 2000) and economics (Harrison et al. 2001; Penrose 1959). Whereas philosophy largely views knowledge and learning as internal processes within the individual, sociology sees learning as an interactive process between two or more individuals. In economics, Penrose (1959) regarded the varying ability of firms to administrate similar production factors to be the main differentiating factor
in firm growth. The notions introduced by Penrose have been further developed in economics, and knowledge has come to be regarded as the main resource or capability of the firm in the knowledge-based theory of the firm (Grant 1996a).

Howells (2012) goes back to reinvestigate Michael Polanyi’s work on tacit knowledge and knowledge flows to determine the appropriateness of the rather flexible use of the concept in economic geography. He theorizes that knowledge cannot flow freely, only information can. Instead, the embodiment of knowledge in people requires human interaction for learning to occur. As mentioned in the introduction, information becomes knowledge only when it is meaningful to the receiver (Nonaka et al. 2000). Meaning is created from associating information with what one already knows and has experienced (March 2010; Polanyi 1962). If past experiences help individuals interpret information and situations, the implication is that processes of understanding are tacit. Therefore, processes of knowledge creation and learning are always, but varyingly, tacit and thus socially embedded (Morgan 2004) and cumulative (Strambach 2013). In his early work, Polanyi (1962; 1966) put forth the idea that knowledge exists in a wide spectrum (not a dichotomy) ranging from wholly tacit to wholly explicit knowledge. But because the understanding and application of knowledge are based on personal and collective experience, which affects perception and anticipation, there is no such thing as completely explicit knowledge – it is always subjective and contextual.

In economic geography, Bathelt and Glückler (2003) deal with this subjectivity in terms of a relational perspective on knowledge, in particular, and resources, in general: Knowledge is in the eye of the beholder and the socio-technical context determines how knowledge advancements are best achieved. March (2010) also acknowledges the subjectivity of knowledge by discussing employees’ experiences as useful but imperfect teachers in dealing with situations at the current place of work. The success of communication between two individuals, thus, depends as much on past experiences and awareness of practices associated with a specific industry and firm as it does on their formal knowledge. The contextual and relational aspect of knowledge was introduced in economics and the resource-based view of the firm in the late fifties by Penrose (1959). She claimed that the main differentiating factor for firms with apparent similarities in input factors was their capability to combine existing resources in different ways. A few decades later, the same phenomenon but on a different scale – the local environment or the region – was picked up by economic geographers. Theories of localised capabilities (Maskell and Malmberg 1999a) and learning regions (Morgan 1997) are a few contributions that consider the socially embedded and relational character on knowledge economic geography. The socializing and structuring of knowledge occurs within firms as well as within regions. It is therefore
reasonable to assume that knowledge and the effects of learning in firms and regions cannot be understood in isolation, but rather in combination with socializing structures, such as technological trajectories and formal and informal networks. Individuals in a certain place produce and reproduce capabilities through their formal competences and interpretations of values, norms and goals.

2.4. Sector and firm as structures of knowledge

One form of macro-structure is the technology used within a sector or specific industry. The possibility that different production technologies offer structurally different opportunities for learning and innovation has been somewhat overlooked in studies on knowledge dissemination within and between firms. Pavitt (1998) stated that the specificity of input factors in various sectors renders them differently equipped to integrate inflows of skills and knowledge into plant routines. The reason is differences in technological regimes and routines (Dosi 1982; Nelson and Winter 1982), which generate unequal absorptive capacities (Cohen and Levinthal 1990; Nooteboom et al. 2007) and partly explain asymmetric industrial development (Patel and Pavitt 1997). Because the technological trajectories of firms vary, their propensity to act on and respond to new knowledge differs with regard to how well the information is understood and can be used within the plant. According to Pavitt (1984), learning processes are sector-specific and dependent on the firm’s principal activity and the knowledge inputs.

Knowledge has a cumulative aspect to it, which can be explained by strong firm routines and rigid structures, but cumulativeness may also arise from a dependence on machinery and physical capital in other forms (Dosi 1982; Patel and Pavitt 1997; Pavitt 1998). Thus, firms that rely heavily on their physical capital may exhibit high levels of path-dependence partly because of knowledge accumulation in physical capital. This kind of knowledge accumulation lowers the probability of innovation through labour (i.e., knowledge) inflow. It also impedes the ability to absorb and utilize external knowledge. Lagerholm (2007) showed that within mature industries (i.e., manufacturing in the Swedish context), process innovation is mainly the result of supplier innovation rather than in-house innovation. Thus, substantial knowledge advancements are brought to the plant via investments in new machinery rather than through knowledge contributions by in-house or in-flowing staff. In labour-intensive sectors, on the other hand, both process and product innovations are mainly the result of in-house knowledge applications, and the sheer number of innovative opportunities is thus greater than in capital-intensive sectors. Therefore, the variety (relatedness) of knowledge in industries that are dependent on their labour rather than their
physical capital will be characterised by a larger number of potential applications of that knowledge.

Within firms, knowledge is administrated and structured in accordance with the knowledge view and firm goals (Nonaka et al. 2000). The firm can, thus, be perceived as an administrative unit (Penrose 1959) of individuals that creates cohesion through its routines. It also influences the knowledge view of its employees through these structures. When Nelson and Winter (1982) originally presented their evolutionary theory of the firm, they perceived routines as the capabilities of the firm and as the genes of the firm. This implied that routines could both have gene-like generative qualities and be manifested as firm behaviour. The ambiguity of the concept has persisted and the interpretations and use of the concept are manifold, but there is consensus on the context-dependence and regularity aspects of routines (Cohen et al. 1996; Dosi et al. 2008). Context-dependence and regularity suggest that routines create a form of proximity (intra-organizational proximity) between agents within the same firm and subsequently steer their view on knowledge usability and applicability. This will be further discussed in the section on proximity.

Within the conceptual evolutionary economics literature, routines are often conceived of as the latent genes of the firm, synonymous with macro-level social and cognitive maps of how to interpret problems and context, manifested through firm behaviour. Whereas Pentland (1995) and Pentland and Reuter (1994) liken routines to grammar, where a routine is not one pattern but a set of possible patterns, Miner et al. (2008) consider organizational routines to be the foundation of organizational learning because routines function as organizational memory. These perspectives agree on the role of routines as the rules, social and physical structures and cognitive scripts and abilities of organizational members. These organizational restraints create path dependence on the firm level, in both the knowledge view and attitudes toward external knowledge. Routines at the micro-level are often concerned with the individual’s explicit task and position within a routine process and the performance of that task (Becker 2004). Most empirical research has been carried out as case studies at the micro-level (e.g., Becker and Zirpoli 2008; Feldman 2000, 2003; Weick and Roberts 1993), where specified routines have constituted tangible and measurable processes from which inference has been drawn about their interconnectedness, their adaptable and/or stable nature and the role of individual agency.

The dichotomy between micro- and macro-views of routines is misleading due to the interdependent relationship between the two. Routines take place in a context that makes explicit routines partly tacit through individuals’ interpretation of “how things are done” within in firm. In the everyday workings of routines, individual members use their understanding of the macro-level routine to adjust their performance at the micro-level in response
to circumstances and outcomes (Feldman 2000, 2003). In order for a routine to be efficient, there need to be strong and continuous connections and interactions between the different agents partaking in the process (Feldman and Rafaeli 2002). The connections should preferably generate extensive knowledge of the links between distributed activities within the organization (Weick and Roberts 1993). This can be expressed as a high level of contextual understanding, which presumably leads to extensive knowledge about the individual’s and others’ role in the firm. Furthermore, organizational members are aware of latent structures and “how things are done” in the firm, which potentially allows rapid application of internal ideas.

2.5. Proximity and relatedness

In the present thesis, the analysis of learning and innovation processes emphasizes the relations between individuals rather than using a full systems approach. There is no doubt that the relations between individuals are embedded in greater systems and that external knowledge input is necessary for firms to sustain competitiveness (see, e.g., Bathelt et al. [2004], Grabher [2002b; 2004] and Maskell et al. [2006] on the importance of inter-organizational projects for firm innovativeness). However, by only focusing on relational aspects of individual attributes in the labour force and thus abstracting from a number of influences, an increased analytical clarity is achieved. MacKinnon et al. (2002) argue that in order for learning to be a relevant factor in explaining the spatial distribution of activities, the role of knowledge needs to be carefully grounded empirically. By focusing on individual knowledge and interactive learning within plants, the thesis attempts to isolate the effect that learning has on plant performance. This section presents the proximity dimensions framework. It also discusses the role the proximity dimensions for interpersonal learning play on the micro-level of the plant.

The Russian developmental psychologist Vygotsky (1962) claimed that learning occurs through interaction between internal cognitive processes and the context. He introduced the idea that a person can gain a certain amount of knowledge on her own through internal processes, but that through interaction with others (helpers or instructors) there is potential for further knowledge advancements. He called this potential further learning that could be achieved through interactions the Zone of Proximal Development (ZPD). In order to promote someone else’s learning, there must be pieces of shared interests or mutual focal points from which to depart, otherwise communication will fail. In reference to recent contributions within economic geography, Vygotsky’s theory relates to the growing body of literature on cognitive proximity and other forms of non-physical (relational) proximity. When the distance between agents, in one or several of these non-physical proximity dimensions, is just right, related –, learning is facilitated and
innovation more likely to occur than if there are long distances between the
dimensions (Boschma 2005; Harrison et al. 2001; Song et al. 2003; Torre and
Rallet 2005). Referring back to Vygotsky (1962), long distances in all
proximity dimensions cause a void between individuals that complicates
communication and learning. On the regional level, a short distance in
multiple proximity dimensions between firms may lead to a regional lock-in.
This is a scenario in which understanding and agreement between agents are
high, but equally high is the risk of myopia (Maskell and Malmberg 2007) and
an inability to identify new relevant technological knowledge (Boschma 2005;
Visser and Boschma 2004). The present thesis considers that the same
phenomenon is likely to occur on the interpersonal level of the plant.

Theories of non-physical types of proximity between firms were originally
introduced by the French Proximity Dynamics Group (Kirat and Lung 1999;
Torre and Gilly 2000; Torre and Rallet 2005). They distinguish between two
dimensions of proximity: the physical dimension, which is geographical
proximity, and the non-physical dimension, which is organizational
proximity. Their theory illustrates how interactive knowledge creation and
innovation processes are shaped by a relationship between relational factors
and physical distance. It is further argued that the relevance of the different
proximities changes in different stages of the innovation process. In their
framework, geographical proximity refers to physical distance in a twofold
manner: first: firstly, as perceived by individuals and thus partly socially
constructed, and second, as a separation of activities and relations in space.
The organizational dimension, on the other hand, refers to a relational
distance that affects the ability to coordinate actions. This dimension is
constructed in accordance with two related logics. First, similarity in firm
routines, which are partly built on shared beliefs and high degrees of tacit
knowledge, offer the same reference space and shared understanding of
structures and knowledge view. This is a perspective also taken by Blanc and
Sierra (1999). Second, firms that are close in organizational terms belong to
the same networks and have interactions of various forms. In the present
thesis, where labour force knowledge and relatedness between individuals are
under scrutiny, the former definition of organizational proximity is adopted.
The logic here is that individuals will benefit from having a shared
understanding of structures and knowledge view in their knowledge
interactions. A short organizational distance between individuals ensures
overlapping, or ideally identical, reference spaces. This proximity, or
familiarity, represents an institutional micro-context that will reduce
uncertainty and promote trust between individuals. Trust is a key factor in the
transfer of highly tacit knowledge and thus in interactive learning.

Multiple proximity models have been developed (e.g., Blanc and Sierra
1999; Kirat and Lung 1999; Zeller 2004) since the initial work of the Proximity
Dynamics Group. The most detailed account of the analytical relationship
between proximity and innovation is provided by Boschma (2005). In his model, Boschma presents five proximity dimensions: geographical, organizational, cognitive, institutional and social proximity. *Geographical proximity* is defined as both absolute and relative distance, and the impact on, and relationship with, the other proximity dimensions is underlined. Boschma’s (2005) definition of organizational proximity differs from that of Torre and Gilly (2000) in its focus on control of relations and hierarchy. In his model, *organizational proximity* refers to the coordination and control of intra- and inter-organizational relations. Organizational proximity is achieved when firms are connected through coordinated channels and activities, and this proximity reduces uncertainty and the risk of opportunism. This description of organizational proximity is better suited to examination of inter-firm learning processes and innovation. This is because it is associated with the accessibility and power relations between firms that determine how organizational networks are shaped.

*The cognitive proximity* dimension, as presented by Boschma (2005), deals with differences and similarities in the capabilities of economic agents. Antonelli (2000) and Howells (2012) have argued that knowledge is distributed among different firms and industries. Firms learn and create knowledge by combining existing pieces of complementary knowledge in new ways (Nootenboom 2000). In order for firms to absorb external knowledge (Cohen and Levinthal 1990) and combine it with internal knowledge, the external knowledge must be similar enough – related – to the existing knowledge to be recognized as valuable (Boschma and Lambooy 1999). The cognitive distance should not be too long, nor should it be too short, because short distances do not offer any learning potential. *The institutional proximity* dimension refers to the degree of similarity in values, norms, rules and laws between economic agents. It is, thus, regarded as being dependent on both informal and formal structures. Boschma (2005) discusses the close and intertwined relationship between institutional proximity and geographical proximity. In the present thesis, they are regarded as representations of the same phenomenon, namely similarity in norms, values and understanding of formal and informal rules. Because the labour force and labour flows are examined, the physical distance between firms influences the probability that a person will change employer from one firm to another. But the distance also represents an institutional similarity, or difference, that affects the understanding of norms and practices among individuals and may therefore influence the level of trust between individuals. As mentioned previously, trust is thought to be necessary for the transfer of highly tacit knowledge. Lastly, *the social proximity* dimension, as presented by Boschma (2005), is associated with social ties between individuals resulting from friendship and kinship. Thus, the social dimension is the only dimension that, in its original form, specifically focuses on the micro-level of inter-individual
relationships. This proximity dimension is not further examined in the thesis, but the other dimensions are considered on the micro-level of interpersonal distances within the plant. The rationale for the micro-perspective is that, in order to understand how firms learn, we need to examine the knowledge that constitutes the firm and its absorptive capacity. Following Torre and Gilly (2000) and MacKinnon et al. (2002), the thesis attempts to empirically ground the concept of knowledge by further opening the black box of proximity relations in relation to knowledge transfer and learning.

Each proximity dimension offers a way to construct shared values between individuals and potentially also a shared basis for communication and learning. In the proximity dimensions framework suggested by Blanc and Sierra (1999), they identify a dimension that they call relational proximity: “Relational proximity accounts for the existence of non-economic relationships among individuals in the form of a common working ethos, a common language and culture, good mutual knowledge, mutual trust, mutually respected norms of behaviour” (Blanc and Sierra 1999:197). In the present thesis, all of the above-discussed proximity dimensions fit under the description of relational proximity, suggested by Blanc and Sierra (1999). This relational characteristic implies that what two individuals lack in mutual formal knowledge may be compensated for by mutual norms and codes of conduct or a background in similar organizational contexts. Whereas Boschma (2005) argues that cognitive relatedness is a necessary but not necessarily sufficient prerequisite for learning to occur between firms, it is argued here that, on the interpersonal level, relatedness in any one of the proximity dimensions may be sufficient for learning to occur. The reason for this goes back to Vygotsky’s ZPD and the need for a connection between individuals in order for them to communicate efficiently, begin to trust one another and subsequently learn from each other. The temporal aspect is also crucial to the distinction between intra- and inter-firm learning. Within the firm or plant, individuals remain for extended periods of time and inflows of labour are regarded as, more or less, permanent additions to the labour force. In inter-firm learning, numerous relations are temporary. Therefore, there is a greater need for cognitive relatedness, which allows for efficient communication of the unique knowledge that each project participant can contribute. In the case of mergers and acquisitions, it is unlikely that two firms with completely different core competences will merge. In such cases, similarity or relatedness in the organizational or institutional dimension can facilitate or impede learning processes (Boschma 2005) initiated by relatedness in the cognitive dimension.

Regardless of the level of analysis, there is still great uncertainty about whether or not the proximity dimensions are of equal importance to learning and innovation. Moreover, few previous empirical studies have examined to what extent proximity in one dimension can replace, or compensate for, a long
distance in another dimension. The theoretical literature on proximity
dimensions and relatedness between agents offers plausible interpretations of
the relational characteristics of knowledge. But many of the suggestions made
in the literature have yet to be empirically tested and grounded. The effects of
cognitive and geographical proximity on learning and innovation have been
the most theorized and empirically tested on both the interpersonal and
interfering level. On the interpersonal level, Boschma et al. (2009) found that
cognitively related in-house competences as well as cognitively related labour
inflow positively impacted plant performance. They further identified
interdependence between the cognitive and the geographical/institutional
dimension. Cognitively unrelated inflow that originated from the same local
labour market positively influenced plant performance. This is interpreted as
indicating that cognitive relatedness is not always a necessary condition for
interpersonal learning to occur. It is rather the combined influences of
multiple types of proximity/distance between individuals that determine the
learning potential. On the other hand, Neffke and Henning (2013) created a
measure of relatedness between industries, based on labour flows between
them. Their results indicate that firms are more likely to diversify into
activities to which they have pre-existing ties through their labour force than
into activities that diverge substantially from their core activities.
Furthermore, Neffke et al. (2011) showed that evolution of the regional
industrial setup is strongly path-dependent. They demonstrated that
industries that are related to pre-existing industries are more likely to enter a
region than those that are not.

In studies on labour mobility, the cognitive dimension is commonly
measured as relational differences in formal education, sector belonging,
occupation similarity or intensity of previous knowledge exchange between
actors (Boschma et al. 2009; Neffke and Henning 2013; Timmermans and
Boschma 2013). There is coherence in the view that, for fruitful
communication to occur, knowledge and skill should be neither too similar
nor too different. Therefore, bringing together people with related skills and
knowledge is the most efficient way to promote learning. In such instances,
people are able to understand one another while simultaneously drawing on
each other’s knowledge to advance their own knowledge, as suggested by
Vygotsky (1962). But the indicators for cognitive relatedness do not consider
the plethora of factors that influence individuals’ cognitive abilities. Merely a
fraction of an individual’s skills and abilities are measured with each of the
different techniques of estimating cognitive relatedness. This is mainly due to
methodological and empirical restraints and limitations and leads to sub-
divisions of cognitive relatedness. This is fine, as there is no way to include all
factors that influence individual ability, mainly because of the subjectivity of
knowledge and learning and partly because there are no registers and micro-
data that include such levels of detail. But a greater awareness of the
multifaceted ways of achieving cognitive relatedness, in particular, and relatedness in other dimensions, in general, is important.

As in most empirical work, Paper I and II in the present thesis included and analysed, analyse one aspect of cognitive relatedness. Because different studies use different definitions of cognitive relatedness, there is a risk of over- or under-estimating the effects of relatedness on firm/plant performance. This is due to the exclusion of other factors that also influence the abilities and skills of the agents under study. One such other factor is organizational proximity that arises from similarity in firm routines. With regard to the notion that firm routines are fundamental in creating organizational proximity, there are several researchers who claim that knowledge within a firm is distributed rather than dispersed, meaning that everyone knows some information, but no one knows all of it (Becker 2004; Cohen and Bacdayan 1994; Feldman and Rafaeli 2002; Nonaka et al 2000; Lam 2000; Weick and Roberts 1993). This unique context creates isolating mechanisms that hinder not only external imitation of firm capabilities, but also internal articulation of what these capabilities are exactly. The tacit nature of firm routines generates intra-organizational proximity and possibly also a social proximity that together create trust between individuals. This trust potentially allows them to discuss ideas over wider cognitive spectra than would otherwise have been possible.

Due to the relational and contextual nature of knowledge and the varying degree of tacitness, knowledge is difficult to transfer and develop. Labour mobility is thus the most efficient channel for dissemination of highly tacit knowledge, but presumably also for dissemination of less tacit knowledge (Szulanski 1996). Many have studied the transfer of embodied knowledge by examining the effects of labour mobility on performance and innovation (see, e.g., Agrawal et al. 2006; Almeida and Kogut 1999; Boschma et al. 2009; Breschi and Lissoni 2009; Maliranta et al. 2009; Song et al. 2003; Timmermans and Boschma 2013). Whereas Almeida and Kogut (1999) showed that the mobility of engineers influenced local transfers of knowledge, Power and Lundmark (2004) found labour mobility among key persons to be the driving force behind the upgrading of skills within ICT clusters. Breschi and Lissoni (2009) built on the results of Almeida and Kogut (1999) and put forward the idea that labour mobility is the main conductor of local knowledge transfer, superior to formal networks and social ties. Lacetera et al. (2004) were able to quantify the effect that inflowing high-ability individuals can have on their colleagues, thus showing that single individuals can impact the knowledge of the entire workforce.

When knowledge is put in a new context, there is potential for completely new applications of that knowledge, due to the new employee’s interpretation of what is needed as well as the “old” employees’ understanding of the new knowledge. Strambach and Klement (2011) argue that there is a combinatorial
knowledge dynamic at the micro-level of the firm. This works, in combination with the cumulative knowledge dynamics inherent in the socio-technical context of the region, to generate novelty (innovation). By bringing a specific skill-set from one context to another, the individual potentially contributes to the generation of new combinations of existing knowledge as well as to the creation of entirely new knowledge (Asheim and Coenen 2005; Nonaka et al. 2000; Pinch and Henry 1999). But there is still uncertainty, not only about the learning capability of the employees, but also about the external circumstances (i.e., factors external to the individuals partaking in the knowledge exchange) under which knowledge is most likely to be successfully applied within a plant. The present thesis incorporates theories of sector- and firm-specific structures into the description of the relationship between physical and non-physical proximity and interactive learning in firms.

3. Methodological comments

The thesis is based on quantitative modelling of socio-economic processes within and between plants. Methodology is closely related to the philosophy of science, as different methods are used to capture different aspects of the social world. The scientific methods employed in the thesis are shaped by critical realism (Bhaskar 1978). The collective learning processes associated with the knowledge composition within a plant are considered to be contextual and cumulative and manifested in changes in plant productivity. The view on learning as a process and practice driven by the variety of accessible knowledge fits well into an evolutionary perspective on the accumulation of knowledge and the growth of the economy, as discussed earlier in the thesis. The evolutionary perspective has many common traits with a critical realist ontology. Castellacci (2006) puts forth a view on reality as complex, differentiated and structured, as a system that is open and continuously changing and transforming, and as a world characterized by great uncertainty.

In critical realism, the world exists independent of human awareness (Sayer 1981). Furthermore, the world exists in three domains: the real, the actual and the empirical (Collier 1994). The real domain contains all physical objects, but also mechanisms and structures associated with the objects and combinations of objects. Thus, it acknowledges the existence of non-physical objects and processes in society. In the actual domain, events occur irrespective of whether humans register them or not. In much social science production, mechanisms in the real world are used to explain the development of events in the actual world. Finally, the empirical domain represents the events that are experienced by humans (Collier 1994).

Social science, in general, and evolutionary economic geography, in particular, study phenomena in the empirical domain (the spatial distribution
of economic activities), the ambition being to understand the mechanisms that underlie these phenomena (institutional settings, social networks, embodied knowledge, etc.). Similar to the evolutionary perspective on economic growth, critical realism regards science as constantly evolving. Theories of the deeper domains are produced and reproduced based on their plausibility in the empirical world. There is likely not one absolute truth in social science, but there are explanations that are more plausible than others, based on observations in the empirical world. Thus, constantly checking for sources of error in the empirical setup and building on previous research are essential elements in validating the theoretical claims made about structures and mechanisms in the real domain (Collier 1994). Scientific explanations of events offer theoretical descriptions of the mechanisms that caused them. By empirically testing knowledge relations and innovations in firms, fragments of the real world can be captured that, in turn, can inform us about probable causal mechanisms. These causal mechanisms, found in both humans and structures, can improve our understanding of pieces of the real world. By combining insights from numerous theoretical descriptions, a synthesized understanding of the functioning of the real world may be achieved (Lawson 1997).

3.1. The data

The empirical analyses in the three papers are based on data from the ASTRID database at the Department of Geography and Economic History at Umeå University. The database integrates several administrative registers maintained by Statistics Sweden (SCB) and offers detailed, geo-referenced, longitudinally linked information about all individuals, plants and firms in Sweden. By integrating registers, it is possible to connect attributes to people, and people to plants and firms with attributes of their own. The longitudinal aspect of the database enables analyses of changes in work force composition within individual plants, as well as recording of individuals’ past work experiences with regard to plant, industry, and firm. Because it includes recorded coordinates for all buildings, residences and plants, the database has a high spatial resolution. This enables analyses of mobility patterns and agglomeration activities. The data in ASTRID are measured and encoded on a yearly basis, and the values of the variables in the database reflect the situation at a specific point in time. Thus, it is not possible to see whether a person has had multiple employments in a year. But by comparing personal wage and social benefits, it is possible to determine whether a person has been employed and unemployed during the same year. The analytical unit in all the empirical papers is the plant. A plant is traditionally associated with manufacturing, but in the database and in this thesis it a workplace. This workplace can be of any size and belong to any industry. The plant represents a physical building or part of a building that is administrated by a firm. A firm can have multiple
plants, which all have their unique plant identification number (CFAR), but share the same organizational identification number (OrgID). Individuals are associated with plants, not with divisions or subunits within a plant. Therefore, it is not possible to determine whether a person has changed jobs or positions within a plant, but intra-firm mobility between plants can be detected. Mobility is captured as a change in plant identification number and change in plant coordinates for individuals in the database, and consequently internal mobility (intra-plant mobility) is concealed in the data, not just in the analyses conducted in the thesis but in the structure of the database in general. The intra-firm mobility between plants is recorded as a change in plant identification number within the same firm identification number.

The Swedish labour market is characterized by fairly high job mobility rates, which correspond to those in several other north European countries, e.g., Denmark, Finland and the Netherlands (EUROFOUND 2006). Between 1988 and 2012, 68 percent of all employees who ended their employment did so to change jobs, not due to retirement or layoffs triggering unemployment (Andersson et al. 2014). Thus, job change is the dominant type of labour flow on the Swedish labour market. Furthermore, job mobility is more prevalent in some segments of the labour market than in others. Highly educated individuals show higher job change rates than do the less educated. Men change jobs more often than women do, younger individuals more often than older people and highly paid individuals more often than those in the lower wage segments (Jansson 1997; Widerstedt 1998). In the analyses of job mobility (Paper I and II), only mobility related to job change is considered. Thus, transition from unemployment to work is excluded from the analyses, whereas change of workplace is included.

The empirical analyses are based on data covering the period between 2000 and 2010. Paper I uses data from the period 2002-2005, whereas the analysis in Paper II is based on data from 2003-2008. Paper III examines data from the period 2000-2010. Thus, the results in Paper II and III could, theoretically, be affected by the financial crisis that struck the labour market in 2008 and 2009 (Öhman 2010). But the Swedish labour markets and financial markets were relatively mildly impacted by the global crisis. Between the middle of 2008 and the end of 2009, 120,000 people lost their jobs. This can be compared to the crisis in the early 1990s during which 600,000 people lost their jobs (Öhman 2010). During troughs, job mobility decreases (Andersson and Tegsjö 2006), but in Paper II all job changes were recorded between 2003 and 2006, and only plant performance was recorded up until 2008. In Paper III the empirical analysis is based on the in-house composition of knowledge in knowledge-intensive business services (KIBS). Thus the flows are implicitly considered in the yearly estimations of in-house knowledge variety. The performance of the plants may have been negatively impacted by the recession, which may have led to an underestimation of the impact of
different forms of knowledge variety on performance. But the empirical setups in the two papers have mitigated the risk of any severe underestimation. In Paper II a longitudinal panel was estimated, and in Paper III pooled OLS regressions with observations over a ten-year period and yearly dummies to control for time-specific heterogeneity were calculated.

In Papers I and II the focus is on labour mobility and its impact on plant performance. The models used in these papers do not control for the exit of labour from the plants, only the entry. Thus, in some cases the inflow of labour replaces exiting employees, whereas in other cases the inflowing labour is a new addition to an expanding plant. There are a few central concepts in the papers that are discussed in greater detail below in an attempt to visualize the transformation of theoretical concepts into quantitative variables.

3.1 Measuring knowledge and ability

This section deals with the concept of knowledge and ability and to what extent knowledge can be assessed through quantitative methods. The central role of knowledge in the learning economy has been emphasized throughout the thesis. The European Commission states that: "...the key aspect of human capital has to do with the knowledge and skills embodied in people and accumulated through schooling, training and experience that are useful in the production of goods, services and further knowledge" (De la Fuente and Ciccone, European Commission 2002, p7). Formal measures, such as academic degrees and occupation titles, offer guiding information about the theoretical and practical scope of parts of an individual’s knowledge. Relating back to the critical realist ontology, an individual’s formal knowledge (education, occupation or industry experience) is a signal (Spence 1973) in the empirical domain, which allows the researcher to make informed assumptions about a portion of the individual’s ability. Arrow (1973) introduced the idea of the educational system as a filter through which the most able students pass, whereas the less capable individuals are caught in the filter and prevented from further knowledge advancements. In Spence’s (1973) article on job market signalling, academic degrees are signals to employers about the ability of the individual to perform. Over the years, the individuals change and adapt their signals with increased experience and additional work titles. Thus, formal measures of knowledge are conscious efforts on the part of the labour force to signal not only ability, but also acquired knowledge to employers.

Factors that are believed to socialize knowledge and affect learning are, to some extent, accounted for through the integration of proximity dimensions other than the cognitive dimension into the analytical models. But the main focus of the papers is on the relationship between formal knowledge variety and plant performance. Educational background is used to estimate relatedness in knowledge between individuals in Paper III. Educational background and industry experience are used as measures of knowledge in
Paper I and occupational title is used in Paper II. Whereas educational background represents formal theoretical knowledge, industry experience informs us of how the individual’s knowledge has been practically applied. Occupation title considers both the applied knowledge through the work tasks and the individual’s qualification for those tasks (educational background). These three formal measures describe parts of the individual’s total knowledge that is codified and actively acquired. They accurately represent knowledge that the individuals have obtained, but they do not represent all the knowledge that the individuals possess. The formal measures of knowledge tell us little about the social and tacit components of knowledge (Grabher 1993; Polanyi 1962). In Paper III aspects of the social character of knowledge are touched upon through the integration of individuals’ past experiences. These past experiences have influenced and shaped employee knowledge beyond the information in the strictly formal records. By tracing employees’ former co-workers an image of the context in which they have been active emerges, which allows for an analysis of the relative similarity of previous work experiences in the current labour force within a plant. It is suggested here that this is a way to approach the tacit dimension of knowledge and ability in a quantitative manner. Past work experience informs us about how formal knowledge has been applied. It also offers insights into the knowledge networks of individuals. The networks indicate what parts of the individual’s own formal knowledge may have been accentuated and developed further as a result of these interactions.

In contrast to Becker’s (1964) human capital theory, in which he claims that individuals weigh the costs and benefits of investments in higher education, the Swedish context offers few costs associated with higher education because education is free. The possibility for student loans and social and economic benefits for students are the same for the entire Swedish population. The general educational level in the population is high, and the individual reward (income) of additional years of schooling is below average in the European Union (Björklund et al. 2000; Eliasson 2006). The European Commission found the average return on each year of schooling to be a 6.5 percent increase in personal income in the European Union (De la Fuente and Ciccone 2002).

3.2 Estimating proximity in the labour force

In this section the characteristics of the labour force and the various forms of proximity that are estimated in the papers are presented and discussed. Throughout the empirical papers (Papers I-III) various forms of proximity dimensions are referred to and their effects on interactive learning are discussed. A short distance in any of the dimensions implies similarity between agents. Boschma (2005) argues that similarity reduces uncertainty between actors. Actors can be firms, organizations and governmental institutions, but also individuals. Whereas Boschma (2005) mainly discusses
the role of the various forms of proximity on the inter-firm level, the present thesis examines the role of proximity in interactive learning processes on the inter-individual level within plants. The plant is an administrative unit of inclusion in the sense that it generates cohesion between its members (employees). This is achieved through a common understanding of firm routines and the technological trajectory of the specific industry in a given region. From this rationale it follows that individuals who enter the plant, as newly employed labour, may diverge from the existing staff. Apart from differing in formal knowledge, new employees may also have different experiences of firm routines and institutional settings that originate from a different firm in a different region. The efficiency of absorption of individual knowledge into plant knowledge is affected by the degree of similarity between the inflowing labour and the existing in-house labour. In the remainder of this section, the operationalization of geographical, cognitive and organizational proximity is elaborated upon and discussed.

Geographical proximity is estimated between inflowing labour and the existing in-house labour in Paper I and Paper II. The inflowing labour is categorized as being either intra-regional or inter-regional with regard to local labour markets. Thus, the inflows are considered proximate (similar) or distant (different or unrelated) in a dichotomous manner. The rationale for this division is that the geographical proximity dimension is closely related to, not to say intertwined with, the institutional proximity dimension (Boschma 2005; Farole et al. 2010; Rallet and Torre 1999). In the regional innovation systems literature, the varieties in regional (or local) institutional settings are emphasized in the competitiveness of firms and industries (Asheim and Gertler 2005). This aspect of institutional proximity may be of little importance to interpersonal learning processes, but belonging to a community and enjoying insider advantages within one’s own labour market are aspects of the geographical proximity dimension that are considered in the thesis. Inter-regional labour mobility represents a scenario in which the individual enters into a new community from a context that the new co-workers know nothing or little about. Using the same logic, it is argued that intra-regional labour flows preserve the insider advantages and remain within the same institutional environment or community. The familiarity associated with intra-regional labour flows presumably reduces uncertainty and generates trust between the in-house labour and the inflowing labour.

The non-physical proximity dimension of cognitive proximity is estimated in various ways in the papers. The reason for this is to show that different types of knowledge can generate cognitive relatedness between individuals, through which they can learn from each other. In Paper I the in-house knowledge composition is calculated as an entropy measure of variety (as suggested by Frenken et al. 2007). The estimations of relatedness in the in-house labour force are based on educational background, whereas the relationship between
the inflowing labour and the existing in-house labour is based on industry codes (as done by Boschma et al. 2009). It is assumed that a knowledge inflow from related industries is efficiently absorbed while simultaneously contributing new pieces of knowledge that can be combined with the existing knowledge in new ways. In *Paper II*, entropy measures based on occupation are used to determine the degree of relatedness in the in-house labour force. The same entropy calculations as in *Paper I* are used to determine the degree of similarity, relatedness and unrelatedness in the in-house composition of knowledge. Occupation is a slightly more refined measure of knowledge than educational background, as it reflects both work tasks and individual qualifications. The relatedness between the inflowing knowledge and the existing knowledge in *Paper II* is estimated using the same relational entropy measures that Boschma and Iammarino (2009) used when determining the relative similarity of trade linkages and the regional industrial setup. The inflowing labour and its occupation titles are compared to the occupational distribution within the plant. By so doing, the levels of similarity, relatedness and unrelatedness are determined between the inflowing labour and the existing labour.

In *Paper III*, in-house knowledge variety is estimated in three different ways. This is done to demonstrate that cognitive relatedness can be achieved in more than one way. Individuals’ experiences shape their cognitive abilities (March 2010), and it is argued in *Paper III* that, in an evolutionary framework, the knowledge of the labour force should be regarded as evolving over time and, thus, as being influenced by past events. Just as firms, industries and regions are affected by their past history, so are the micro-agents, the individuals, which constitute the labour force. The first measure of cognitive relatedness is an entropy measure of formal education variety, exactly like the in-house estimations in *Paper I*. The degree of similarity, relatedness and unrelatedness in formal education in the labour force are followed by an experience measure of variety. The similarity in industry experience is estimated in the in-house labour force. This type of knowledge represents applied knowledge. For each employee a fifteen-year backlog is retrieved from the database that allows us to see what industries the individual has worked in, during the past fifteen years. The industry experiences of all employees at the plant are combined in an “experience pool”. From this pool of industry experiences, the degree of similarity, relatedness and unrelatedness in labour force industry experience are determined. The third measure of cognitive proximity is a measure of similarity in knowledge networks in the in-house labour force. This type of knowledge represents variations in experiences in practices and epistemic communities within the current place of work. Similar to the industry experience measure, the knowledge network is calculated from a pool of knowledge exposures that each employee has been subject to during the past fifteen years. The educational background of every person who has
worked with the individual under study is recorded and added to the pool of knowledge exposures at the plant. The same entropy measures, as for the other two types of cognitive proximity, are used to estimate the degree of similarity, relatedness and unrelatedness in knowledge exposure. The rationale for estimating cognitive proximity in three separate ways is to demonstrate that knowledge relatedness can be achieved in multiple ways. Thus, a labour force that is characterized by high levels of unrelatedness in one of these measures may be related through another type of cognitive relatedness.

Organizational proximity is estimated in Paper III in a similar fashion to geographical proximity, as explained above. Individuals are regarded as being either organizationally proximate or organizationally distant in a dichotomous manner. Intra-organizational labour inflows are individuals changing plants within the same firm. These flows represent proximity in the organizational dimension. The inter-organizational flows are individuals originating from another plant and firm. These flows are organizationally distant. Organizational proximity is considered to generate a mutual understanding of “how things are done” and a coherent knowledge view and awareness of firm norms and values. These aspects create combined institutional and social cohesion within the micro-context of the firm. On the interpersonal level, this is presumed to reduce uncertainty and contribute to efficient communication. Inter-organizational labour flows originate from other micro-institutional environments that may differ significantly from the new context. Therefore, these flows need to familiarize themselves with the new structures and internal networks and their initial interactions with the existing in-house labour will entail more uncertainty.

### 3.3 Measurement of innovativeness

Before proceeding to the measurement of successful learning processes at the plant, the relationship between knowledge and innovation is considered. According to Pavitt (2005), innovation processes contain three overlapping sub-processes: production of knowledge, conversion of knowledge into physical and non-physical artefacts and the matching of these artefacts to market needs and demands. Thus, all innovation processes depend on the acquisition, creation and application of knowledge. This knowledge is disseminated on the market and conversed within the firm or plant (Nonaka 1994). It is important to keep in mind that knowledge creation and acquisition do not occur at one specific point in time during the innovation process, but rather throughout the entire process. This has been both empirically demonstrated (see Butzin and Widmaier [2012] on innovation biographies) and theoretically argued (e.g., Kline and Rosenberg [1986] critique the linear model of innovation [Bush 1945]).
On a related note, the reverse product cycle (RPC) introduced by Barras (1986; 1990) in the service industry also enters into traditional manufacturing. RPC constitutes three successive phases: improve efficiency, improve quality and, lastly, new services. The order of these stages is opposite to that of the product cycle model for manufacturing introduced by Abernathy and Utterback (1978). But approximately 35 years after the introduction of the product cycle model, the reach of capitalism and the increasing pace of Schumpeterian creative destruction have impacted the product cycle in manufacturing. The cost associated with improving the quality of existing products and the efficiency of production processes are substantially lower than they are in relation to developing new products. Therefore, improving quality, improving efficiency, finding new markets, creating services around existing products and making incremental changes to existing products are viable options that generate noticeable results within a foreseeable future. This development, one of increased global competition, indicates that collective learning processes, which generate incremental innovations within plants, not only can but do occur in all sectors. But to pinpoint exactly how and when essential bits of knowledge are exchanged or recombined is impossible using quantitative methodology, and also beyond the scope of the present thesis. Instead, the thesis rests on the assumption that learning occurs in all sectors, and that it can be detected in the performance of plants due to the predominance of innovations that increase efficiency.

To estimate and evaluate the potential increase in efficiency due to collective learning processes, plant performance is specified as labour productivity at the level of the plant in Paper I, II and III. The database does not contain information on productivity, so performance is instead measured as value added per employee. But the database only contains information about value added for firms, not their respective plants. For firms with only one plant this is unproblematic, but for multiplant firms the database ascribes the value added of the entire firm to all of its plants. This is dealt with in Paper I, Paper II and Paper III by distributing value added to plants in accordance with their wage quota. By ascribing value added to plants based on their wage quota, both the education and experiences of the employees are considered (Wictorin 2007). As discussed in a previous section, individuals signal their knowledge and ability (Spence 1973) and the employer is ensured of their ability through the filtering function of higher education (Arrow 1973). High-ability individuals are efficient (Becker 1962), which is recognized by the employer, who awards them with higher salaries. High efficiency is a mixture of innate ability, specific knowledge related to educational degree and generic knowledge in communicating, learning and synthesizing knowledge inputs. Following this logic, it is reasonable to allocate value added in proportion to wage quota. In Papers II and III, value added was also proportionally allocated to plants with regard to the share of firm employment (as done by
Martin et al. 2011). This approach is perceived as being more egalitarian, because every employee is valued as being equally important to the firm. This was done as a robustness check, and the allocated value added remained the same in Paper III. The reason for this may be found in the sample of firms in Paper III, which only consists of KIBS. Unlike a manufacturing firm with multiple plants with different functions, firms in KIBS will most likely have similar functions and human capital levels at all their plants. In Paper II the models were estimated with the alternative productivity measure, and the trends in the models did not change. The procedure for allocating value added is therefore deemed fit for the purpose of the papers.

4. Paper summaries

4.1. Paper I: Labour mobility and plant performance: On the (dis)similarity between labour- and capital-intensive sectors for knowledge diffusion and productivity

The first paper, Paper I, analyses the differences between capital- and labour-intensive sectors with regard to the impact of workforce knowledge composition and labour mobility on plant performance. As discussed in the theoretical background, knowledge relatedness between individuals is assumed to be beneficial to knowledge absorption and learning. But the conditions under which new knowledge can be applied and generate novelty presumably vary between different industries and firms. In the literature on proximity and relatedness, especially papers focusing on individuals and labour flows, knowledge transfer and learning are often treated as if they occur in isolation, detached from any surrounding context. This disregard of the time-place fusion in which every action is carried leaves the analyses incomplete and at risk of over- or underestimating the effects of knowledge and relatedness on plant performance. The aim of the paper is to bridge a perceived gap between micro- and macro-level theories of knowledge generation and innovation in the space economy and thereby to nuance the debate on non-physical proximity and the labour force as a knowledge resource. Whereas there is one strand of literature advocating the benefits of complementarities and relatedness for plant performance (Boschma et al. 2009), there is another strand discussing the different prerequisites for innovation in different technological regimes (Castellacci 2008; Pavitt 1984). These strands are neither contradictory nor opposing, but they rather exist in parallel and should be combined if one wishes to model the context in which individuals interact and learn to promote innovation and productivity. Through the integration of these theories in conjunction with theories of the effects of labour mobility, the paper shows that learning and innovation do not occur in isolation. Everything takes place in a context determined partly by the individuals involved, but also by the main technology used by the firm.

For the empirical part of the paper, geo-referenced longitudinal employer-employee micro-data are used. All firms in Sweden are categorized as being either capital-intensive or labour-intensive. The effects of labour flows
between plants, within and between labour markets, are then analysed for capital-intensive and labour-intensive sectors, respectively. The sample contains all plants in Sweden with 10 employees or more that have had a labour inflow in 2003 and value-added for both 2003 and 2005. The analysis is carried out using weighted least square (WLS) regression analysis. An additional variance analysis (ANOVA) is performed to determine the relative effect of each of the co-explaining factors on plant performance.

The aim of the paper is achieved by testing the effects of in-house constellation of knowledge on productivity, of type of knowledge inflow on productivity and of geographic origin of the inflow on productivity. By so doing, the effects of cognitive and geographical proximity in the labour force on plant performance are tested in the labour-intensive sectors and the capital-intensive sectors, respectively. The assumption is that the labour-intensive sectors will show overall higher effects of labour inflow on plant performance than will the capital-intensive sectors, which rely heavily on the efficiency of their physical capital (machinery) and supplier ingenuity for their productivity.

The results presented in Paper I show that knowledge type (similar, related or unrelated) and knowledge origin (local or non-local) have different effects on plant performance in the two sectors. A high degree of related knowledge in the in-house workforce positively impacts plant performance in both sectors, but the relative effect (when compared to other explanatory factors) is larger in the labour-intensive sectors. The analysis of labour inflow indicates that knowledge in the capital-intensive sectors is localized – only intra-regional labour flows give rise to increased plant productivity. In the labour-intensive sectors, the geographic and cognitive dimensions complement one another; similar knowledge needs to be non-local in order to be beneficial to plant performance, and unrelated knowledge mainly contributes to plant productivity growth when it originates from inside the region. The findings presented in the paper indicate that there are substantial differences between the capital-intensive sectors and the labour-intensive sectors. With regard to the analyses of in-house skill portfolio, related variety has considerably more influence on firm performance within the labour-intensive sectors.

The overall weak effects of knowledge on performance in the capital-intensive sectors may be attributed to high levels of cumulativeness of knowledge stored in the physical capital.

4.2. Paper II: Labor mobility and organizational proximity: Routines as supporting mechanisms for variety, skill integration and productivity

In Paper II the context-dependent nature of knowledge is further scrutinized through examination of the role of firm routines (proxied as intra-organizational proximity) in learning and innovation. The aim of the paper is to contextualize labour force knowledge by focusing on the socializing and structuring nature of firm routines, the goal being to offer new insights into theories of knowledge as a resource, in general, and theories of knowledge
transfer via labour mobility, in particular. The impact of knowledge inflow, which is assumed to have an innovative effect, is measured as changes in per capita productivity at the plant. By operationalizing familiarity with firm routines as intra-firm labour flows, and contrasting them to unfamiliarity with firm routines, operationalized as extra-firm labour flows, knowledge transfer is studied in light of not only cognitive and geographic proximity, but also organizational proximity.

Paper I showed that there are differences in the effects of related knowledge inflow in capital- and labour-intensive sectors, respectively. This supports the hypothesis that learning and innovation depend on more than just the relatedness of formal knowledge between the partaking individuals. The probability of successful application of new knowledge is also contingent on the firm’s routines, which steer the knowledge view and shape patterns and processes of communication within the firm. Whereas studies in economic geography have shown the importance of having a related knowledge base within a plant, as well as related knowledge entering the plant (Boschma et al. 2009; Eriksson 2011; Timmermans and Boschma 2013), the literature in organization studies indicates that firm routines constrain and/or enable learning through the rules, social and physical structures and cognitive scripts and abilities of organizational members (Dosi et al. 2008; Miner et al. 2008; Nelson and Winter 1982; Pentland and Reuter 1994). The firm can be perceived as a social community specialized in the generation and transfer of knowledge. In the present paper, familiarity with firm routines is perceived to generate intra-organizational proximity between organizational members. This gives internal labour flows the advantage of a shared context with the in-house staff. Internal labour flows thus have the benefit of a shared social and cognitive map and knowledge of firm goals with the in-house staff. This advantage presumably offers a shared basis of understanding and eases communication, which alleviates the need for related formal knowledge in order for learning to occur.

The analysis employs longitudinal micro-data from the ASTRID database at the Department of Geography and Economic History at Umeå University. For the empirical estimations, the Arellano-Bond dynamic panel generalized method of moments (GMM) is applied. The analysis is based on 8,633 internal job moves and 9,418 external job moves to 33 plants and four firms, offering a total of 99 observations, in Sweden between the years 2003 and 2006. Together with a group of co-explaining factors, the effects of cognitively differentiated intra- and inter-firm labour flows on plant performance are determined. The effects of the inflow variables are estimated at three points in time: the same year as the inflow occurs, the year after and two years after; this is done because internal flows are believed to be integrated more rapidly and produce, more or less, instant productivity gains.

The results indicate that the theoretically positive relationship between cognitively related labour flows and plant performance is not unaffected by the inclusion of an organizational proximity dimension in the analysis. Cognitively related knowledge inflow positively impacts productivity when it
originates in another firm and thus is organizationally unrelated. The positive effect on productivity is delayed, theoretically due to the longer time needed for absorption and conversion when the cognitive dimension is the only shared dimension. Cognitively related intra-firm labour flows (individuals changing plants within the same firm) are familiar with firm routines and thus organizationally similar (a short distance in the organizational dimension). This combination of similarity in the organizational dimension and relatedness in the cognitive dimension generates too much similarity for any innovative learning to occur. The findings suggest that cognitively related labour flows are primarily economically beneficial between firms. In such cases, cognitive relatedness is enriched by sets of firm-specific norms and routines associated with the previous employer that allow for rich combinations of knowledge at the new plant.

When a third proximity dimension is added to the models, namely geographical proximity, the effects of cognitively related inflows are positively reinforced in the extra-regional model. This indicates that relatedness in the cognitive dimension is mainly necessary when there are no other socializing proximities present, i.e., organizational or geographical proximity. In the absence of organizational and geographical proximity, cognitive relatedness is necessary and sufficient to generate effective learning and application of knowledge. These results imply that a cognitively related labour inflow originating from afar (firm and place) contains a greater variation, associated with the past place and firm, than does intra-firm or intra-regional inflows of cognitively related knowledge. Throughout most of the analysis there is a positive relationship between cognitively unrelated flows and plant performance in the intra-firm models. These flows are organizationally proximate and absorbed instantly and efficiently, generating productivity growth for the plant over consecutive time periods. The proximity in the organizational dimension allows for unrelated knowledge to be combined and applied in a familiar setting. When the inflow is still organizationally proximate but geographically distant, the positive effects of cognitive unrelatedness disappear. This indicates that distance (unrelatedness) in two dimensions, of which one is the cognitive dimension, cannot be overcome by proximity (similarity) in the organizational dimension.

Another outcome of Paper II is the framing of the intrinsic nature of the proximity dimensions with regard to learning and knowledge transfer in the labour force. Without any hierarchical ranking of their relative importance, it has been shown that multiple proximities exist that can promote learning and affect plant performance. The effect of the cognitive dimension can be reduced or amplified by the distance in other dimensions. In the paper, a combination of organizational and geographic proximity was shown to generate a state in which cognitively similar and related knowledge inflows either were detrimental or insignificant for productivity. It is concluded that cognitive relatedness is not a necessary condition for learning to occur in the labour force.
4.3. **Paper III: Relatedness through experience: On the importance of collected worker experiences for plant performance**

In *Paper III* the role of labour force experience in learning and innovation in firms is examined. In contrast to the two previous papers, *Paper III* does not explicitly study labour mobility, instead in-house competences are observed over time. The formal cognitive abilities of employees, as expressed by their education, are supplemented with cognitive abilities in the form of employees’ previous work experiences. These experiences are divided into industry experience and past knowledge exposure associated with previous workplaces. Theory clearly states that experience is an elemental part of individuals’ interpretative abilities (Polanyi 1962; March 2010) and should thus be considered when analysing the in-house innovative potential. Past experiences are essential in forming individuals’ abilities to seize ideas, communicate them and transform them into productive practice. Therefore, in the present paper, the cognitive proximity dimension is divided into three forms of knowledge, each with its own variety and distance. The experience variables represent socialized cognitive abilities that have been used in processes and practices at plants. Furthermore, interaction terms are constructed and their impact estimated in order to determine the potential overlap effects of different forms of cognitive proximity. By analysing the interaction effects, *Paper III* not only shows that the combined effects of different forms of proximity differ from the independent effects, but it also shows that the impact of one form of knowledge on plant performance is conditional on the level of another knowledge variable.

The reason for *Paper III* is the vast interest in knowledge as a valuable resource for firm performance. This interest has gradually shifted focus from the accumulation of human capital to the inflow and accumulation of related and complementary knowledge, as the most important determinants of knowledge transfer, learning and innovation (Boschma 2005; Harrison et al. 2001; Nooteboom et al. 2007; Tanriverdi and Venkatraman 2005). *Paper III* builds on the theory that a shared practice can be achieved through related cognitive abilities between individuals (Boschma 2005), represented as past work experiences. Shared practice is manifested in an understanding of how things are done, familiarity with firm goals, coherence in knowledge view and a good ability to communicate. It is further suggested, in the paper, that relatedness in formal knowledge between employees facilitates communication, whereas relatedness in industry experience and knowledge exposure offers a plethora of possible applications of formal knowledge and understandings of multiple practices. Therefore it is assumed that cognitive relatedness within the firm can be achieved in different ways by highlighting different aspects of employees’ total cognitive abilities.

The empirical analysis, a weighted pooled OLS regression with year-, industry- and region-fixed effects, is based on geo-referenced longitudinal matched employer-employee data. In the study, the abilities and experiences of employees in knowledge-intensive business services (KIBS) are analysed
for firms in Sweden between 2000 and 2010. Firms in KIBS depend on their employees’ ability to learn and apply knowledge for their performance, as they mainly engage in consultancy activities and research in various knowledge fields. Thus, the micro-diversity within plants is more thoroughly scrutinized in the present study than in the previous ones because the employees are, more or less, the only resource for many of these firms. In addition to the examination of staffs’ formal abilities, a 15-year backlog of industry experience and past knowledge exposure for every current employee is created and analysed to determine the degree of relatedness in industry experience and knowledge exposure.

The results show that high human capital ratios positively impact plant performance. Considering that these firms mainly produce and sell knowledge, the results are not surprising. The resource of knowledge presumably promotes not only technological development, but also economic growth in both firms and regions in all industries. Thus, high human capital ratios represent the knowledge that has accumulated in a place over time. In this instance, the place is a firm, or rather a plant. But when the level of human capital is put in the same model as the various forms of knowledge variety, a substantially more nuanced picture of the workings of knowledge on plant performance emerges. It is shown that the effects of the different forms of knowledge composition variables on plant performance are conditional on the level of human capital at the plant. That is to say that the effect of, e.g., high levels of similarity in formal knowledge on plant performance varies as a function of level of human capital. This is something that previous theories of proximity dynamics have put forward, but been unable to empirically test. The results further indicate that the effects of the negative relationship associated with high levels of similar or unrelated formal knowledge on learning are abated as the level of human capital increases at the plant. High levels of similar formal knowledge and human capital even generate productive learning processes in plants in KIBS. In previous studies on the impact of labour force knowledge on plant performance, the different forms of knowledge have been tested separately. By combining them and creating interaction terms, Paper III is able to more accurately represent the actual conditions for learning and innovation at a plant. Not only are the different forms of knowledge combined and tested simultaneously, but the multiple ways of accomplishing and measuring cognitive relatedness are also recognized. In most existing empirical work, high levels of similar knowledge have negatively impacted plant performance. But by combining multiple forms of knowledge and estimating their relationship with performance simultaneously, this study has been able to show that the impact of similar knowledge is conditional on the human capital ratio at the plant. The conditional relationship between human capital levels and the cognitive relatedness of the labour force have not been empirically tested previously.
Instead most studies have chosen to include either human capital or cognitive relatedness in the labour force when estimating the effects of interactive learning on plant performance.

5. Concluding discussion: Relatedness put in place

The present thesis set out to examine the relationship between different types of proximity in the labour force and the competitiveness of firms. The rationale for the micro-level focus is the assumption that interactive learning processes within plants occur under different conditions than inter-firm learning processes. Therefore, the relationship between interactive learning and the proximity dimensions is assumed to differ from that for inter-firm learning. Moreover, it is suggested that the functioning of the proximity dimensions varies between technological and organizational contexts. The workings of knowledge dynamics at the micro-level of the plant have been scrutinized in three empirical papers. The empirical findings indicate that the proximity dimensions are interconnected and that cognitive distance in the labour force is not the only factor that determines the efficiency of interactive learning processes. The geographical and organizational distances between inflowing labour and in-house labour also influence the potential for interactive learning. A third factor that impacts the effect of learning on performance is the degree of dependence on physical capital associated with sector belonging. It is demonstrated that capital-intensive sectors benefit substantially more from having a local labour inflow than a cognitively related inflow. Furthermore, it is established that relatedness is not necessary for interactive learning to occur, neither in the cognitive dimension nor in any of the other dimensions examined. Instead, it is the combined distances of multiple proximity dimensions that determine the degree of interpersonal learning.

The next section is structured around a discussion of the key findings in the papers and their implications for interactive learning in firms. The subsequent section discusses the findings in relation to the analytical framework of the proximity dimensions and evolutionary economic geography. It focuses on how we can understand firm competitiveness through analysis of the labour force. Moreover, the relationship between the findings and the spatial development of economic activities is outlined. The last section offers suggestions for future research.

5.1 Findings

When the three papers are considered together, five main findings emerge. First, as theoretically suggested by Boschma (2005) and Torre and Gilly (2000), the proximity dimensions are interrelated and can influence one another. It is evident that the geographical dimension influences the impact
of the cognitive dimension on plant performance. The observed relationship is captured in Paper I and Paper II and is supported by previous empirical findings by Boschma et al. (2009) and Eriksson (2011). It is also shown that the organizational dimension influences the cognitive dimension. The interdependence is manifested through the variable impact on plant performance that a given distance in one dimension has, depending on what other type of proximity is accounted for in the model. Put differently, a short distance in one dimension may require a long distance in another dimension in order for interactive learning to take place.

In Paper I and Paper II it is demonstrated that inflows of unrelated formal knowledge positively impact plant performance if they are also geographically proximate. This can be explained by the interrelationship of cumulative and combinatorial knowledge dynamics (Strambach 2013; Strambach and Klement 2012), which allows for heterogeneous knowledge to be combined in a context where there is accumulation (similarity) in another dimension. Proximity in the geographical dimension indicates a mutual understanding of norms and values associated with a community (Farole et al. 2010) and also a shared appreciation of, and involvement in, the localized capabilities (Maskell and Malmberg 1999a). This finding demonstrates nicely how local labour market flows reproduce and develop the localized capabilities by allowing for combinations of unrelated pieces of knowledge through the accumulation of place-specific values and norms.

Proximity in the organizational dimension, which here is estimated as intra-organizational proximity, is assumed to generate a coherent knowledge view in the labour force. Moreover, intra-organizational proximity ensures a shared understanding of the structures and procedures within the firm that reduces uncertainty about the role of others (Weick and Roberts 1993). The interdependence of the different proximity dimensions is found in all three papers1 (Paper I, II and III). These findings suggest a twofold relational and social aspect of knowledge interactions. Interactive learning occurs between individuals who possess knowledge and work in specific socio-technical contexts. Their knowledge can be quite similar, but it can also be completely unrelated. The degree or relatedness determines how well knowledge is understood and appreciated in knowledge interactions. This relational distance determines the efficiency of communication and learning in groups, and varies between any two individuals. This is the first relational aspect of knowledge interactions. Concurrently, employees at a plant are also connected through dimensions other than the cognitive2 dimension. Depending on the

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1 Paper III examines different types of cognitive proximity, rather than different proximity dimensions. But the same pattern is detected, where the influence of one knowledge type on plant performance depends on what other type of knowledge is accounted for in the model.

2 E.g., the organizational, the geographical/institutional or the social dimension. The social dimension is not examined in the thesis.
distance in these other dimensions, learning can be either facilitated or complicated. This is the other aspect of the relational character of the proximity dimensions.

The second finding demonstrates that the proximity dimensions have conditional effects on learning and innovation in firms. The empirical findings of the interdependence of the proximity dimensions in Paper I and Paper II are further established and elaborated upon in Paper III, where it is established that the impact of a given distance in one dimension varies with the distance in another dimension. Whereas such relations have been theoretically discussed in the literature (e.g., Boschma 2005), they have not been demonstrated empirically before. The conditional effects are called overlap effects. These overlap effects can either enhance the initial impact of either variable – a positive overlap effect – or they can mitigate the initial impact – a negative overlap effect. The empirical findings show that the impact of high levels of in-house similarity in formal knowledge is conditional on the level of in-house similarity in past knowledge exposures. High levels of similarity in knowledge exposure substantially reduce the negative impact of similarity in formal knowledge to the extent that high levels in both variables positively impact plant performance. These findings could help explain the slightly diverging results of previous studies on the effects of knowledge variety on plant and firm performance.

Third, it is not only the proximity dimensions that are interrelated, but the impact of the cognitive dimension on interactive learning is contingent on the human capital ratio at the plant. The findings in Paper III demonstrate that it is the combination of knowledge variety and human capital ratio at the plant that determines the competitiveness of the plant. Previous studies have argued that it is not human capital per se that influences the performance of plants, but rather the degree of relatedness in the in-house labour force (Boschma et al. 2009). However, the present findings suggest that the impact of knowledge variety on plant performance is conditional on the level of human capital at the plant. Other empirical studies have refrained from estimating the impact of knowledge variety and human capital ratio in the same model. But in Paper III the parallel impacts of knowledge variety and human capital ratio are estimated together with their conditional impacts on plant performance. It is argued that human capital represents ability, whereas knowledge variety symbolizes specialized expert knowledge.

It is theoretically suggested that high levels of human capital represent high generic abilities to communicate, learn and synthesize. It also signals high individual abilities (Spence 1973) that are guaranteed through the successful completion of higher education resulting in a diploma (Arrow 1973). According to Becker (1964), the high abilities of highly educated individuals render them more efficient in their execution of different tasks compared to those without higher education. The degree of knowledge variety within a
plant, on the other hand, informs us of the potential for combining different pieces of specialized knowledge into new knowledge. *Paper III* shows that the impact of similar, related and unrelated formal knowledge (educational background of the employees) is conditional on the level of human capital. The negative impact on plant performance associated with high levels of similar or unrelated knowledge is mitigated by high levels of human capital. This suggests that interactive learning processes cannot be properly understood and estimated if attention is not paid to both the generic abilities of the labour force and the combined variety of their specialized knowledge. Furthermore, as discussed above human capital represents an ability, presumably an innate ability, whereas formal knowledge expresses the individual’s area of expertise. Productive interactive learning processes within plants are influenced by both the abilities of the labour force and the knowledge variety present in the plant.

The fourth finding shows that there are differences between sectors that generate variable outcomes of learning processes. This implies that the workings of the proximity dynamics also vary between sectors, not only between different levels of analysis. In *Paper I* the role of knowledge variety in interactive learning in capital-intensive sectors and labour-intensive sectors, is examined. In line with previous empirical studies (Haltiwanger et al. 1999; Leiponen and Drejer 2007; Rigby and Essletzbichler 1997), the results illustrate a strong dependence on localized capabilities in the capital-intensive sectors, where only local labour inflows positively influence plant performance. The regional variations in production technology reinforce and develop the localized capabilities, by allowing local inflows of unrelated knowledge to be absorbed into the plant. Furthermore, it is established that the overall impact of both in-house knowledge variety and inflowing knowledge variety is smaller in the capital-intensive sectors than in the labour-intensive sectors. The implications are that there are structural differences between capital-intensive and labour-intensive sectors. This may be explained, at least partially, by the dependence on physical capital (machinery), which is produced externally, in the capital-intensive sectors. This dependence reduces the number of innovative opportunities, because process innovations are mainly the result of supplier innovations (Lagerholm 2007). Moreover, the physical capital used in the production of goods may restrict the potential to apply new knowledge, generated from interactive learning processes. The possibility to apply knowledge is presumed to completely depend on firm routines and the technologies used within the firm. This is a step that is often disregarded in economic geography, where interactive learning processes, in and between firms, are treated as generating equally applicable knowledge regardless of the sectoral and organizational context. Both the technology used in an industry and the firm routines within a specific firm can be viewed as structures that either hinder or promote
effective absorption of inflowing knowledge and the possibility to apply new knowledge.

Lastly, the findings suggest that cognitive relatedness is not necessary for interactive learning to occur on the micro-level of the plant. *Paper I* demonstrated that the combination of either geographical proximity and cognitive distance or geographical distance and cognitive proximity generated significantly stronger positive impacts on plant performance than cognitive relatedness did. In *Paper II* organizational and geographical proximity allowed for unrelated knowledge to be efficiently absorbed and applied in the plant. Within plants, interactions take place between individuals on a daily basis. Under such circumstances, it is more important to share a short distance in one dimension, than it is to be cognitively related. This implies that trust and social structure are more important to learning than is sharing formal pieces of knowledge. This is in contrast to the agglomerations literature and the RIS literature. With regard to externalities and knowledge spill overs between co-located firms, Neffke et al. (2012) demonstrated that a related industry setup in the region substantially increases the survival rate of plants. Similarly, Boschma and Iammarino (2009) show that technological relatedness in the regional industry base positively impacts export rates. The presumed reasons for the positive effects of a related local industry setup or RIS are explained by supporting structures and knowledge accessibility (Trippl 2011).

In cases of mergers and acquisitions or temporary projects between firms, relatedness is a necessary condition for the joint ventures to be initiated and for innovation to occur. The temporal character of such case and the potential lack of any other proximity necessitate cognitive relatedness (Boschma 2005). This is in contrast to the inter-individual level and labour mobility. In such scenarios, one or a few individuals enter a context in which they are to stay for an indefinite period of time. They need to be “accepted” by the receiving group – the in-house labour force – and any type of proximity relation will speed up, and ease, the integration of the inflow. Once accepted, the individual will be able to communicate more distant pieces of knowledge, with regard to the existing in-house composition. Thus, on the interpersonal level all proximity dimensions seem to have mainly a socializing function, including the cognitive dimension, whereas for cooperation between firms, relatedness in the cognitive dimension is probably the reason why the joint project came to be in the first place, and the other proximity dimensions can hinder or promote the learning and innovation processes. The present results indicate that the workings and effects of proximity dynamics are different at different levels of analysis.
5.2. Discussion

The above findings show that in order to explain the uneven spatial development of economic activities it is crucial to understand how knowledge is produced and reproduced in firms. Since learning and innovation occur in plants and firms rather than regions we need to understand the interplay between internal processes and the external environment. In the present thesis it has been demonstrated that sector belonging, firm routines, and the knowledge resources in the firm interact to generate unique conditions for interactive learning and innovation. Firms and regions reproduce increasingly specialized knowledge in order to sustain a competitive advantage (Howells 2012), while utilizing the accumulated knowledge resources in the firm and region. A micro-perspective on knowledge offers significant empirical evidence that distributed knowledge production is an essential element in the learning economy. This means that knowledge is becoming increasingly spatially fragmented, due to the local or regional reproduction of knowledge. One major reason for this is the labour force and its relative fixity in space that makes it a mainly local resource. Labour force knowledge is fostered in a socio-technical context in which formal knowledge and skills are integrated with social and institutional structures that affect the view on knowledge and knowledge application (e.g., Maskell and Malmberg 1999a; Morgan 2004; Storper and Venables 2004; Strambach and Klement 2012).

The findings further suggest that for learning to occur on the interpersonal level, it is more important to share a bond than to be cognitively related. The interrelationship between proximity and distance that has been suggested here is in contrast to much of the existing empirical literature on proximity dynamics (e.g., Boschma et al. 2009). It is found that relatedness in the cognitive dimension is not unambiguously positive for interactive learning and innovativeness. Having similarity in one dimension and unrelatedness in the cognitive dimension has a significantly stronger impact on interactive learning than simply having relatedness in the cognitive dimension. It therefore seems as if the combined distance of several proximity dimensions should be taken into account when estimating the innovative power of a firm or industry. The empirically demonstrated interdependence of different types of proximities may help to explain the somewhat diverging empirical results of the relationship between firm performance and knowledge variety in the labour force. The findings also offer support for the notion of a relational economy (Bathelt and Glückler 2003; Torre and Gilly 2000) in which economic actors are unequally able to combine their knowledge and skills with the knowledge and skills of other actors, depending on their level of association.

The micro-foundation of innovation and economic performance is knowledge transferred between individuals. The findings indicate that innovation emerges as a result of cumulative and combinatorial knowledge dynamics. Whereas Crevoisier and Jeannerat (2009) argue that the cumulative aspect of knowledge in firms and regions is losing importance, it
is argued here, and in line with Strambach (2013), that the cumulative and combinatorial knowledge dynamics interact in the generation of novelty. It is the cumulative aspect of knowledge that has driven the theoretically motivated need for cognitive relatedness in all empirical work on learning so far. There have been two parallel logics to explain the need for cognitive relatedness in inter-firm and interpersonal learning. First, on the inter-firm level, firms are unlikely to diversify into activities that are completely unrelated to the existing competences (Harrison et al. 2001). The efficiency of such mergers, acquisitions, alliances and projects is too low to be economically justified (Rumelt 1974). Second, knowledge in a firm has accumulated over time and any additional contribution to the existing stock needs to be cognitively related in order to be recognized as relevant (Cohen and Levinthal 1990; Nooteboom 2009). But, instead of just focussing on cognitive relatedness as a bridge between accumulated knowledge and new knowledge, the present thesis has demonstrated that similarity in the organizational or the geographical/institutional dimension allows unrelated knowledge to be integrated into production processes. It has been shown, for instance, that organizationally proximate individuals successfully generate novelty by combining their unrelated formal knowledge (Paper II). Moreover, unrelated formal knowledge originating from the same institutional context (i.e., being intra-regional) contributed to the upgrading of skills in the capital-intensive sectors in Paper I. Thus, it is argued that the accumulation of social capital and firm-specific knowledge occurs on the level of the individual. This accumulation represents a certain degree of familiarity with firm routines and norms and values in a region that are shared with other individuals in the same context. This similarity represents a short relational distance between individuals that generates cohesion and reduces uncertainty on the interpersonal level. If there is similarity in any one of the dimensions, unrelated knowledge can be integrated into firm practices.

Combining unrelated pieces of knowledge is only possible between individuals who share some kind of common ground that enables trust and reduces uncertainty. In line with recent contributions in economic geography (Boschma 2005; Strambach and Klement 2012) and the reasoning underlying the ZPD (Vygotsky 1962), it is argued here that proximity and distance represent accumulation and combination and that interactive learning in the labour force is facilitated by close proximity in any one dimension. Furthermore, the findings in this thesis support the view that micro-agents (i.e., individuals in the present thesis) are embedded in (Granovetter 1985) and inseparable from the structures that surround them. Physical and cognitive structures influence and are influenced by the actions of micro-agents. Whereas structures (institutions, technology and firm routines) offer possibilities and impose restraints on agents, they are also interpreted every time an agent attempts to act accordingly. As time passes, the structures are incrementally changed and adapted by the individuals that live and work under them. The local environment generates relational proximity between agents through formal and informal networks (Storper 1997). This proximity
reproduces and rejuvenates localized capabilities by enabling the combination of heterogeneous pieces of knowledge in firms through local unrelated labour inflow. Thus, time and place can be perceived as the paramount dimensions that shape the micro-dynamics of knowledge generation and innovation.

The notion presented by Feldman and Kogler (2010), that places are not equal and are defined by evolutionary processes, is empirically corroborated in the present thesis. An important element in the evolution of economic activities is the accumulated knowledge embodied in the labour force in a region (Maskell and Malmberg 1999a). The impact that labour force knowledge has on plant performance is substantial, multifaceted, differentiated, and demonstrated through multiple relational measures of knowledge and ability throughout the empirical papers. The findings in the thesis support the claim by Storper and Scott (2009) that the productivity of resources and skills depend on selective geographical matching processes. It has been shown that the proximity dimensions are interdependent and it has also been demonstrated that physical and cognitive structures are interconnected with the proximity dimensions. These interdependencies lead to path-dependent trajectories for firms and regions. These trajectories will offer different absorptive capacities and innovative behaviours throughout the economic landscape (Storper and Scott 2009).

The contextual and relational aspects of learning has been demonstrated in the papers and emphasised throughout the thesis. The findings of the relational character of knowledge offer significant support for the notion presented by Bathelt and Glückler (2003) that economic actors are situated in contexts of social and institutional relations. According to the knowledge and competence-based theory of the firm (Kogut and Zander 1992; Teece et al. 1997), knowledge accumulation in firms is mainly driven by firm routines and organizational practices. These are based on localized learning processes that have emerged over time in specific institutional and technological contexts, of which the labour force is a vital part. The specificity of these localized learning processes helps explain why the behaviour and knowledge of successful firms cannot easily be replicated or transferred to other contexts (Szulanski 1996; Teece 2010). The existence of localized capabilities is also demonstrated through the variable impact of knowledge inflow depending on the geographical (institutional) origin of the labour inflow. It would seem that geography is not dead (Cairncross 1997) and space is not neutral with regard to the development and competitiveness of economic activities.
5.3. Directions for future research

The present findings suggest that the conditions for learning and knowledge application vary throughout the economic landscape. Therefore, interactive learning processes and innovation should be examined within the context of the firm and its technological trajectory and institutional environment. Future studies on interactive learning and knowledge dynamics should therefore consider the structures that surround the labour force and the knowledge variety that the labour force constitutes. A further division of sectors based on the structures that their technological trajectories dictate could advance our understanding of how knowledge generation is impeded and promoted in different contexts. The reciprocal relationship between structures and agents suggests that the role of knowledge variety in firm competitiveness should be regarded as one part of a greater system. Thus, future research aimed at understanding local conditions for competitiveness and growth could benefit from the integration of meso- and micro-level analyses.

Another interesting direction for future research is to further detangle the interdependencies and conditional influences of the proximity dimensions. In *Paper III* it was shown that different types of cognitive proximity have conditional impacts on plant performance. These findings indicate that conditional effects may also be found between other types of proximity. This would require the development of continuously integrated frameworks where multiple types of proximity are analysed simultaneously. Furthermore, the trend away from appreciating “just” high levels of human capital may be premature due to the conditional effects of human capital and knowledge variety. Thus, future studies on the influence of labour force knowledge on competitiveness should integrate ability (human capital) and knowledge into the analysis. This effect is also likely to vary between different sectors.

Moreover, the present findings indicate that the role of different proximity dimensions may vary at different levels of analysis. For example, cognitive relatedness is not found to be necessary for knowledge generation on the interpersonal level of intra-firm or intra-plant learning. On the other hand, in discussions of inter-firm relations, Boschma (2005) and others argue that cognitive relatedness is a necessary but not sufficient requirement. Further analytical clarity about the workings of the proximity dynamics on different levels of analysis is therefore needed. In relation to that issue, there is a need to continue to develop empirical tools for estimating proximity in the different dimensions on the different analytical levels.

Our understanding of the external mechanisms that impede and/or facilitate learning (i.e., the firm and its routines, the sector and the region) should be further looked into, preferably in an increasingly integrated framework that considers multiple factors that affect learning and the innovative capabilities of firms or regions. The evolutionary framework offers
great opportunities for integrating various levels of study as well as different mechanisms that influence the potential for learning and innovation. Regardless of level of analysis, the passage of time leaves the observed entity or place with events and experiences that impact the ability to adapt to new circumstances in the future. Therefore, differences in the economic performance of firms, sectors and regions should be perceived as varieties of accumulated paths on several interconnected levels. Through more extensive research on each of the above-mentioned mechanisms thought to obstruct and/or promote knowledge transfer, we will eventually come closer to a complete synthesis of how and why differences in innovative capabilities exist.

6. Sammanfattning (Summary in Swedish)

I den här avhandlingen undersöks förutsättningar för lärande och tillämpning av kunskap (innovation) i företag. I ekonomisk geografi och besläktade ämnen har kunskap kommit att betraktas som den viktigaste faktorn för företags och regioners konkurrenskraft. Det beror på att kunskap är lokalt förankrad till skillnad från materiella produktionsfaktorer som kan tillgängliggöras genom transporter över hela världen. Genom socialiseringsprocesser kopplade till såväl platser bransch- och företagsstruktur som deras historia tolkas, används och reproduceras kunskap på olika sätt på olika platser. Det handlar inte huvudsakligen om att varor och tjänster produceras på olika platser utan snarare om att likartade produkter produceras på olika sätt på olika platser. Den lokala kunskapen styr hur användningen av andra resurser (produktionsfaktorer) utformas och det, i sin tur, påverkar framtidiga förutsättningar för förändring och nytänkande i såväl enskilda företag som i regioner.

Innovationskraften - förmågan att förnya produkter, processer, styrning och marknadsföring m.m. - anses avgörande för bibehållna eller utökad produktivitet för företag och regioner. Således blir den tillgängliga kunskapen och förmågan att förnya den av yttersta vikt. Individer representerar olika kunskap, vars kvalitet och kvantitet bedöms och avgörs av sammanhanget de befinner sig i, dvs. av de andra deltagande individerna. Att skaffa sig en konkurrensfördel genom arbetskraften handlar därför inte om att ackumulera expertiseknapskap inom ett område utan snarare om att sammanföra individer med varierad kunskap som kan kommunicera med, och lära av, varandra. På så vis skapas en dynamisk miljö med förutsättningar för fortsatt lärande och förnyelse som i förlängningen kan ge stärkt konkurrenskraft. Individers och gruppers lärande är förvisso en nödvändighet, men är i sig självt otillräckligt för att initiera en innovationskedja. För att kunskapen ska kunna omsättas i praktik krävs en närvaro av fysiska och kognitiva strukturer som tillåter detta. Dessa strukturer varierar mellan såväl branscher som företag och påverkar i
hög grad möjligheten för enskilda individer att tillämpa ny kunskap i produktionen. Det är således inte enbart kunskapsamhällssättningen som är avgörande för företagens produktivitet utan även regional bransch- och företagsspecifika strukturer som påverkar möjligheten att omsätta kunskapen.

Utgångspunkten i den här avhandlingen är arbetskraftens kunskap och den variation i kunskap som finns på arbetsplatser och i deras närmiljö. Arbetskraftens individuella och samlade förmågor utgör grunden för lärande. Således är även de potentiella tillämpningarna (omsättningen av teori i ekonomiskt betydelsefull praktik) av ny kunskap i företag ytterst beroende av arbetskraftens kunskap och förmågor. Men för att implementera kunskap och ge den ett ekonomiskt värde räcker det inte med att kunskapen existerar, utan det måste även i företaget och branschen finnas inkluderande och flexibla strukturer som tillåter enskildas eller gruppers teorier att bli praxis. Mycket av den befintliga forskningen fokuserar antingen på kunskapens betydelse för företagens produktivitet eller på de övergripande strukturernas hindrande alternativt befrämjande egenskaper för innovationskraften. Få studier integrerar de två perspektiven, vilka kan sägas vara olika analysnivåer av samma fenomen, innovationskraft och konkurrenskraft. Att försöka fånga och kartlägga interaktionen, mellan kunskapssamhällssättning och strukturer är denna avhandlings huvudsakliga syfte.

Syftet uppnås genom tre artiklar som använder sig av kvantitativa analysmetoder för att belysa olika aspekter av arbetskraftens kunskap i relation till företagens produktivitet och konkurrenskraft. Samtliga studier utgår från formella mått på arbetskraftens kunskap (t.ex. utbildningsinriktning eller yrkestitel) och den variation av kunskap som finns på arbetsplatsen. Dessa mått relateras sedan till andra strukturer som varierar mellan arbetsplats, så som fysiska strukturer kopplade till sektoriella skillnader, kognitiva strukturer i form av företags skilda rutiner och professionella nätverks effekt på arbetskraftens faktiska förmågor. Analyserna bygger på detaljerad, longitudinell socioekonomisk data ifrån statistikdatabasen ASTRID som finns på institutionen för geografi och ekonomisk historia vid Umeå universitet. ASTRID innehåller data från Statistiska Centralbyrån och information finns på årsbasis om samtliga företag, arbetsplatser och individer i Sverige.

Syftet med den första artikeln, Paper I, är att testa huruvida det finns systematiska skillnader i möjligheten att omsätta kunskap till praktik mellan två stora sektorer i ekonomin, nämligen den kapitalintensiva- och den arbetskraftsintensiva sektorn. Genom att analysera effekten av såväl sammansättningen av kunskap på arbetsplatsen som inflödet av ny arbetskraft till arbetsstället, studeras både kunskapssamhällssättningens betydelse för arbetsplatsens produktivitet och de skilda möjligheterna att integrera inflödande kunskap med befintlig kunskap inom sektorerna.
Artikeln bygger dels på litteratur som diskuterar hur produktionsmetoder och produktionsfaktorer genererar strukturella skillnader i innovationsmöjligheter mellan branscher, och dels på litteratur om arbetskraftsrörlighet och värdet av relaterad kunskap för företags produktivitet. Resultaten i den första artikeln visar att det är gynnsamt för alla arbetsplatsarbetsplatser, oavsett sektor, att ha anställda vars formella kunskaper är besläktade (related) men inte identiska (similar). Den positiva effekten är dock större i arbetskraftsintensiva sektorer än i kapitalintensiva sektorer. Den svaga positiva effekten av inflödande besläktad kunskap i de kapitalintensiva sektorerna antas bero på att kunskap i stor utsträckning ackumuleras i det fysiska kapitalet, vilket är kostsamt att förändra och utveckla. I de arbetskraftsintensiva sektorerna lagras majoriteten av kunskapen i arbetskraften och utbyte och utveckling av idéer och kunskap kan ske genom den dagliga interaktionen.


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tas till såväl formell kunskap som det geografiska (institutionella) ursprunget framträdde en bild där kombinationen av likhet och olikhet i dessa dimensioner genererar ett sammantaget intellektuellt avstånd som gynnar lärande och innovationsförmågan på arbetsplatsen. De samlade resultaten i den första artikeln indikerar att förutsättningarna för absorption och tillämpning av kunskap skiljer sig åt mellan de två stora sektorsgrupperna.


I den tredje artikeln, Paper III, testas effekten av arbetskraftens kunskap i företag inom kunskapsintensiv företagsservice (KIBS). Medan de två första artiklarna fokuserar på effekten av inflöden av arbetskraft på arbetsplatserna så fokuserar denna artikel på den befintliga arbetskraften på en arbetsplats. Till kunskapsintensiv företagsservice räknas bl.a. juristföretag, arkitektkontor, olika IT-tjänster och forskning m.m. Dessa branscher genomsyras av lärande och förändringen då de huvudsakligen säljer expertkunskap och arbetar på uppdragsbasis mot kunder vars behov varierar. Kunskapens och lärandets roll förvändats således vara betydande för företagens konkurrenskraft. Dessa branscher lämpar sig därför extra bra för studier av kunskapsstrukturer, lärande och innovationskraft. Utöver att undersöka vilken effekt den formella kunskapen och dess sammansättning har på innovationskraften i dessa företag så presenteras och testas en teori om att kunskap hos individer kan mätas på fler sätt än som formell utbildning. Genom sina arbetslivserfarenheter kommer människor i kontakt med såväl olika branscher som arbetsplatser vars medarbetare har olika utbildningsbakgrund. Dessa möten och erfarenheter formar individens kunskap och förståelse av hur kunskap kann användas. Både branscherfarenhet

Tidigare branscherfarenhet representerar tillämpad kunskap. Därför är det rimligt att liknande (relaterade) branscherfarenheter hos medarbetarna på en arbetsplats skapa förtrogenhet med multipla tillämpningar av en viss typ av formell kunskap. Likaså vittnar tidigare kunskapsexponering om förmågan att absorbera och kommunicera kunskap. Att medarbetarna har liknandeliknande erfarenheter av kunskapsexponering skapar förtroende för kompetensen genom igenkänning.

av identisk kunskap är villkorad av utbildningsnivån på arbetsplatsen. Detta är något som tidigare forskning inte lyckats visa.


Det tredje bidraget, som har en mer implicit karaktär bygger på slutsatsen att likhet i formell kunskap inte är nödvändig för att lärande ska äga rum mellan individer. Det tycks viktigare, för att lärande ska uppnås, att det finns närhet mellan individerna i någon dimension. Denna närhet skapar förtroende mellan individerna, vilket skapar förutsättningar för att koppla samman olika kunskap. Således är det sammantagna avståndet i flera dimensioner av större betydelse för lärande på en arbetsplats, än vad det är att enbart det kognitiva (kunskaps) avståndet är det rätta. Resultaten i
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