Unequal opportunities in the knowledge economy

A social network analysis of formal and informal networks

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Abstract
A new capitalistic era known as the knowledge economy has emerged since the middle of the 20th century, identified by ‘knowledge-based work’ and ‘immaterial labor’ generating innovation in leading-edge sectors, and recognized as a driver for economic change and future growth. As a spatial consequence, the importance of regions as economic entities has increased. Where regions often are dependent on innovative activities to generate competitive advantage and prospect. To promote a socially inclusive regional economic development, scholars stress the significance of addressing issues of gender, particularity in male-dominated occupations such as knowledge-intensive industries, where masculine cultures tend to be deeply rooted. However, the regional learning and innovation literature is criticized for being firm-centric, gender-blind and ignoring the wider existence of the knowledge worker, thus reproducing patterns of gender constraints such as barriers of equal advancements, discriminatory practices and social exclusion. This thesis aims to address these ignored issues by conducting a social network analysis on formal and informal network within firms in the knowledge economy, and examine how individual characteristic might affect a workers position within these networks. A case study of Umeå ICT-industry was carried out where intra-firm social networks were analyzed of 16 firms and 204 workers. The result from the analysis indicates that female knowledge worker tends to be socially excluded within the informal network of these firms, while at the same time more dependent on a well-connected social position to be able to advance to a more influential position within firm’s formal networks. These findings support earlier claims that there is a need to incorporate a gender perspective into future research agendas as well as regional economic policymaking.
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1 Introduction

During the last century, the socio-economic landscape has transitioned from a male-dominated Fordism production era to post-Fordism era, now widely accepted as the ‘new’ knowledge economy (McDowell, 1991; Yeung, 2018). This new capitalistic era is identified by ‘knowledge-based work’ and ‘immaterial labor’ generating innovation in leading-edge sectors, thus, a driver for economic change and future growth (Lundvall & Johnson, 1994; Cooke, 2001; Perrons, 2007). The transition to the knowledge economy meant that new forms of waged work based on flexibility, mobility, emotional intelligence, personal performance, networking, and creativity, and a growing share of females in the waged labor force (McDowell & Dyson, 2011). This growing share of females and the new forms of waged work has led to a general perception that the typical knowledge worker are viewed as being liberated from constraints of categorical inequalities based on class and gender (McDowell & Dyson, 2011). However, multiple studies shows that there is a segregation of female and male associated occupations (Feldman et al., 2007) which is according McDowell (1999) is related to social expectation of gender. Females are concentrated into certain sectors and occupation, they tend to be positioned in the bottom end of the occupational hierarchy, and females as a group earn less than males (McDowell, 1999). McDowell and Dyson (2011) and James (2017) point out that the number of scholars addressing labor market inequalities in the in mainstream social theory, including, economics, sociology and geography has not been impressive. By not addressing issues of gender, especially in a male dominated sectors such as knowledge intensive ones, there is a risk of reproducing patterns of gender inequalities and constraints, such as barriers of equal advancements, discriminatory practices and social exclusion (Rees, 2000; Gray & James, 2007; James, 2017). Furthermore, by ignoring labor market inequalities it is difficult to promote a socially inclusive regional economic development (Rees, 2000).

Understanding the dynamics of regional economic development in this new knowledge economy is therefore essential for promoting a socially inclusive regional economic development agenda (Perrons, 2001). Explaining uneven spatial development is, and has been, a central question for economic geographers over the last decades. These scholars have tried enhanced the understanding of the socio-cultural mechanism affecting regional economic development, and to understand how conditions for economic competitiveness is generated. Findings from the regional learning and innovation literature explains that concepts like innovative milieux (Camagni, 1991) industrial districts (Becattini et al., 2009), cluster (Porter, 1996) regional innovation system (Cooke, 2001) and learning regions (Asheim, 1996) all recognize geographical proximity as drivers for knowledge creation and innovation (Boschma & Ter Wal, 2007). These spatial agglomerations are suggested to generate knowledge externalities, such as interactive learning, inter-firm spillover, and high-quality labor market matching which is claimed to enhance firm performance (Duranton & Puga, 2004). However, the notion of externalities is abstract and empirically hard to prove, instead, a socio-economic framework has developed that emphasize on the importance of networks and the social interaction within them. These scholars argue that it is not per se the geographical proximity or the density of these localities that enhance the creation of knowledge, it is instead the characteristics and the structure of the social network of that particular region (Huggins & Thompson, 2014; Eriksson & Lengyel, 2019). And that the social interactions within these networks are attributed to the process of facilitating regional learning, economic development, and in the long run, growth (Boschma & Frenken, 2010). Even though the importance of networks has gained more attention recently, there is still little known
about the underlying mechanism that drives these social interactions (Huggins & Thompson, 2014). The level knowledge a labor force possess is recognized as a key factor in explaining regional advantage (Glaeser, 2000; Asheim et al., 2011; Florida, 2014). Despite this awareness of the individual worker, the analytical focus in these studies more often targets the firm and seldom the worker (Audretsch & Feldman, 2004a; Bathelt & Cohendet, 2014). The few studies where the worker is under the lens, they are treated as a passive input to knowledge production, similar to capital (James, 2008). This firm-centric way of conceptualizing labor reduces the worker only to their value (Harvey, 2006a). Instead of treating the worker as a social agent capable of making decisions, the worker is reduced to their skillset; therefore the person behind this ‘atomized agent’ is made invisible (Herod, 2003a). This way of ignoring the worker is major blind spot in the regional learning and innovation literature that deserves more scholarly attention. A second blind spot of this literature is the analytical blindness of gender. Here the scholars often assumes a male innovator and at the same time treat highly skilled workers as a homogenous. Thus, gender issues are rarely addressed (Blake & Hanson, 2005; James, 2017). A third blind spot is the lack of analytically abstracting wage labor from domestic labor. The often idealized worker is a young and carefree male with blurred lines between his social life and his work life, a narrow norm which is far from being representative (Rees, 2000; Perrons, 2001). These three blind spots in the contemporary regional learning and innovation literature are problematic for two reasons, among others. First, the female worker’s voice becomes subordinated in the light of a persistent gender unequal industry. Second, by ignoring gender, any constraints that hinder female workers from engaging in knowledge creating activates are left unaddressed, and these constraints are likely to be reproduced (Gray & James, 2007). It is essential to address both questions of regional economic development and economic restructuring from a people’s perspective and as well as investigate any constraints embedded in the social interaction between economic actors.

In order to address inequalities within a labor market, scholars suggest that there is a need to understand the mechanisms of inclusion and exclusion at the workplace, which are often embedded in daily work practices, such as, informal chats, work-unrelated social activities, and influential figures who helps the next generation of employees (Feldman et al., 2007; England, 2017). These daily work practices generate ties of cooperation, liability, and trust, that gives access to information, shared organizational values, and practices. These practices create and preserve social networks within workplaces, which inevitably might result in reproductions of constraints and inequalities (Granovetter, 1995; Gray & James, 2007). Scholars often link these practices to either formal networks or informal networks, where the first is attributed to cooperation and work-related activities, and second is whom you socialize and trust amongst your co-workers (Borgatti et al., 2018). By empirically investigating both the structure and characteristics of social interaction within workers formal and informal network, it is possible to get a deeper understanding about the dynamics of the knowledge labor force (Ter-Wal & Boschma, 2009; James, 2017; Bathelt & Glückler, 2018). Therefore, studying and identifying an actor’s position within firm’s social networks can help to point out constraints and opportunities that workers will encounter, and thus, contribute to unpacking the person behind the worker (James, 2017; Bathelt & Glückler, 2018; Borgatti et al., 2018).

1.1 Aim and Research question

In the attempt to explain regional economic development as well as provide policy advice, the innovation and regional learning literature has, up to this point, more or less ignored the role of the worker, issues of gender and work-life balance. Motivated by these shortcomings, this thesis tries to bring a new perspective into this literature by addressing these long-time ignored problems. The aim of the thesis is to investigate possible constraints experienced by the female knowledge worker. By conducting a social network analysis and examine the interactions between
knowledge workers in a formal and informal network of workplaces in the knowledge economy, this thesis will, hopefully, contribute to a deeper understanding of how constraints and opportunities within the knowledge economy operate.

To fulfill the aim, the following research questions will be addressed.

- Who are the individuals occupying an influential position in firms formal network, do they have any common attributes?
- Are there any recognizable constraints or opportunities from the positional and structural features of the formal and the informal networks of the knowledge economy?

The aim will be fulfilled by conducting a social network analysis of the Umeå ICT industry. Examining the ICT-industry is relevant because it is one of the fastest growing and leading-edge industry with the knowledge economy today (Frykors & Klofsten, 2011; James, 2017). This thesis will, therefore, view the dynamics ICT-industry as representative of the of the entire knowledge economy. According to the OECD definition, ICT means Information and Communication Technology and refers to the combination of manufacturing and services industries that treat, transform and show data and information electronically (Pilat et al., 2003). The case of Umeå is a particularly relevant case because this region is one of Europe’s most innovative regions and attracts students, researchers, entrepreneurs, talents, and investors from all parts of the world. Umeå’s ICT-industry has rapidly expanded over the last decades and is known for its many influential tech companies with innovations that solve major societal problems (Uminova 2019). This case study will address the uncertainties of how the personal attributes might affect the structure and composition of intra-firm networks (Colombo et al., 2011; Phelps et al., 2012; Bathelt & Glückler, 2018). No study to date has examined the Umeå’s regions ICT-industry through a workers perspective using social network analysis. The social network analysis will be conducted using primary survey-data and will explore how connectional and positional features shaping the dynamics of interactions between workers in the knowledge economy. And by using employer and employee matched micro-data and descriptive statistics, the evolution of the Umeå’s ICT-industry between 1996 and 2016 will be examined, and used as an analytical base for the social network analysis. The goal of the thesis is to contribute to the current gaps in economic geography literature by deepening the understanding of how workers opportunities and constraints are embedded within social networks of rapidly growing knowledge-intensive industries.
2 Theory and framework
This section will introduce the theoretical framework of this thesis. It starts by explaining the importance of place and space within the socio-economic landscape. And later, describes the fundamentals of the relational economic geography framework, as well as positioning my thesis in relation to this framework.

2.1 Perspectives on place and space
Explaining uneven spatial development - the role of space and location in economic development, and how economic landscapes change over time is reoccurring central theme in economic geography research (Lovering, 1999). The conceptualization of space, for example, how a region is defined is hence a fundamental research issue for geographers. Despite recent years effort of defining and theorizing spatial units, there is no agreement amongst scholar for how space should be treated in economic geography research (Garretsen & Martin, 2010). Where one region ends and where the other begins is therefore not entirely clear. Spatial units, like regions are seldom coherent or continuous, but instead characterized by the economic, social, cultural and spatial irregularities (Bathelt & Glückler, 2018).

Part of the issue when conducting spatial research derives from three common ways of conceptualizing space, absolute, relative and relational space. Absolute space is fixed, where socio-economic activities and events are happening inside a spatial frame, which is bounded by territories such as states, and administrative areas (Harvey, 1990). The notion of relative space is associated with Einstein relative theory and non-Euclidean geometries (Garretsen & Martin, 2010). Harvey (2006b) states that space is relative in a double sense, multiple geometries that can represent a spatial frame, and this spatial frame depends heavily on what is being relativized and by whom. For instance, by focusing on networks or transactional spaces, mappings of relative space often extend continuities found in the absolute concept of space, for example exceeding administrative borders. The relational conception of space states that there is no space or time outside the process that defines them. Space is embedded in the process, where the process defines its spatial frame (Harvey, 2006b). Harvey (2006b) stresses the fact that both the relative and the relational views of space is impossible to understand space without considering the aspect of time. This because external factors which influence the process gets internalized in the process over time. Therefore, an event at a point in time cannot simply be understood by what exists in the point, instead, it depends on everything else going on around it. Economic geographers like Harvey (2006b) and Massey (1999) argue that an absolute definition of space can be used to delimit a region, the but this region may have a smaller meaning in functioning economic terms. If instead, the aim is to understand uneven spatial development the relative and the relational concept of space are crucial, where the spatial unit become defined by the process that being investigated (Bathelt & Glückler, 2003; Garretsen & Martin, 2010).

2.2 Relational economic geography
Sprung from the relational concept of space (Harvey, 2006b) a somewhat new approach within in the field of economic geography called relational economic geography has recently emerged. Within the field of geography, there has been a tendency of separation between economic and cultural orientations as well as a divide between qualitative and quantitative approaches. This separation has happened alongside a convergence of research interest in disciplines such as regional economies, economic sociology, and business and management studies (Bathelt & Glückler, 2018). These different disciplines all share a common interest in addressing issues of unequal distribution and economic development, i.e., the processes that drive economic actions
and how their spatial outcomes interact. The aim of this approach is to support a cross-disciplinary involvement by focusing on a broader social perspective, including economic, social, cultural, institutional and political dimensions when studying economic actions (Yeung, 2005b; Bathelt, 2011).

In more classical regional science, space is often viewed as a container or absolute, where a region might have place specific characteristics but are not affected by external economic activities. Thus, economic activity can be abstracted from the spatial dimension, which in policy conclusion often means that regions should lower their cost to stimulate growth (Bathelt & Glückler, 2003). This way of doing research neglects the fact that regions are socially constructed entities, defined by their particular economic, social, cultural, and political setting, settings under which people in firms and organization interacts (Maskell & Malmberg, 1995). In contrast, the relational approach assumes that the economic landscape is indeed relationally constructed and that economic activities is taking place within networks and structures of social interaction, where the outcome is influenced and not determined by prior acts (Martynovich & Henning, 2018)ons (Bathelt, 2011). For instance, instead of conducting statistical spatial analyses to investigate economic phenomena and its outcomes the relational approach studies the specific context of the location and the linkages/relationship between the corresponding actors, affecting the phenomena (Clark & Tracey, 2004).

Relational economic geography evolves around the principles of context, path dependencies, and contingency of economic activities and interactions, and how they manifest into spatial structures and linkages (Bathelt & Glückler, 2018). First, economic interaction is by nature always contextual (Malmberg & Maskell, 2002) and it is, therefore, crucial to understand the context; how the linkages and the interactions between the producer and user works, the constraints and opportunities provided by place-specific institutional and political landscapes (Bathelt & Glückler, 2018). Second, economic actors base their decision on previous activities and pre-existing structures. Hence, the path dependencies of a context is essential. Despite the importance path dependencies, the pre-existing structures of an economy does not determine the outcome of the economic decisions, rather the opposite. Third, the contingency principle underlines this fact - specialization and differentiation are fundamental behaviors to stay competitive, which makes the outcome of economic decision-making unpredictable (Sayer, 2000). For example, similar firms who are providing the same services and are located in the same region might address previous economic outcomes in different ways, how they target their customers will therefore differ and so their result. This is why economic decisions are contingent by nature (Delgado et al., 2016; Bathelt & Glückler, 2018).

2.2.1 Relating the framework to the scope of this thesis

The relational economic geography framework emphasizes the notion that economic activities are embedded in the structure of social interactions. To study these interactions the analytical focus targets processes, such as regional learning, creative interaction, innovation, and inter-organizational communication. Further, this framework uses a geographical lens to investigate these processes, instead of trying to uncover spatial patterns and structures it uses place specific characteristics to understand these interactions (Bathelt & Glückler, 2003). Analyzing and studying interactions between economic agents can be done at multiple levels such as, global, inter-regional, regional, between firms, and within firms. This thesis will conduct a micro analysis, and focus in the relational activities happening within firms, in the specific context of Umeå, Sweden. Intra-firm social networks function to enable access to information and knowledge and to create job opportunities, but at the same time, function to prevent others from gaining access to such privileges (Feldman et al., 2007). By analyzing social and work-related practices within firm’s social network, this thesis hope to better understand inequalities within knowledge
intensive occupations. And, by conceptualizing space as relational through the framework of relational economic geography, it is possible to examine constraints and opportunities that might be embedded within these social networks. Even though space is conceptualized as relational, these interaction are happening within the specific context of Umeå. Thus, guided by the principles of this framework, the regional context and history of Umeå’s ICT-industry will be analyzed, to better understand the dynamics of these interactions within the social network of this industry.

3 Literature review
This section provides an overview of theory and concepts within the field of regional learning and innovation. It will briefly explain regional economic development in the knowledge economy, the role of innovation, as well as identify and theorize research gaps in the within this stream of literature.

3.1 Regional development in the knowledge economy
The shift from conventional industrial manufacturing to the creation of knowledge services is, since the 1970s widely accepted as a new era of capitalistic economic development, often referred to as the knowledge economy (Cooke, 2001). Before reviewing the literature on regional development within the knowledge economy, it is important to outline the nature of knowledge itself. Differentiating between information and knowledge helps clarifies the meaning of the concept. Information is data which is processed and classified into an understandable form, and it is reproducible and explicit because it is unattached to the person. In essence, information answers to a particular question. Knowledge, on the other hand, refers to the theoretical and practical understanding of an entity and the cognitive capability of employing it to a particular practice. Combining information, experience, and intuition generates knowledge, which then is bounded to the individual, and therefore, much harder to reproduce (Gertler, 2003).

In this new economy, innovation is seen as one of the main ways to enhance economic growth so that a region or nation can prosper (Fagerberg et al., 2005; Verspagen, 2009; Lundvall, 2011) where innovation is dependent on the creation, application, and dissemination of knowledge. Interactive learning and cooperation between economic agents in regional networks, are described as a key factor to facilitate innovation (Fagerberg et al., 2005; Verspagen, 2009; Lundvall, 2011). Innovation is also considered crucial for technological development within industries and sectors (Malerba, 2002), and for single firms, it becomes a necessity to renew their business model to maintain their competitive advantage over time, especially in dynamic markets. Schumpeter (1934) described innovation as a new combination of production factors, the introduction of new processes, the opening of new markets, access to intermediaries and new sources of material and re-organization of industries – a definition still frequently used (Alsos et al., 2013).

A geographical consequence of the knowledge economy is the rise of regions as an important center for economic activities (Trippol et al., 2015). These regional industrial complex, regional innovation systems or clusters are characterized by high rates of technological learning and innovative activities and has for the last decades received more and more attention from policymakers and academics (James, 2017). Scholars have been trying to answer questions like; why do some regions perform better than others? How does physical proximity positively affect learning and innovation capacities? And, how does the mechanisms of knowledge spill-over function at different spatial scales? The scholarly aim has been to provide guidance for local and regional policymakers to enhance the economic competitiveness, and to move beyond the ‘critical factors’ of cluster development, to a more nuanced perspective where for instance place specific condition is taken into account (Markusen, 1996; Wolfe & Gertler, 2004; Trippol et al., 2015).
These regional scholars use the work of Alfred Marshall (1920) as a theoretical starting point for their research (Capello & Lenzi, 2018). Marshall (1920) theorized a ‘triad of localization externalities’ that generate economic advantages but reside outside the individual firm so that other closely located firms can benefit from these externalities and increase their competitive advantages. Especially Marshalls notion of the regional ‘industrial atmosphere’ has been revisited and redefined, which states that the local industry cannot be separated from the contextual social norms and tradition – these should be regarded as values that affect the economic outcome (Scott, 2000). A common narrative described in the regional learning and innovation literature is that, new knowledge generated by an economic actor will eventually flow to other economic actors both intra- and inter-regionally, this is referred to as knowledge spill-overs, it happens both intentional and unintentional (Mackinnon et al., 2002; Gråsjö, 2012). A regions potential for knowledge spillover effects depends on the character and the volume of the new knowledge, the individual regional economic landscape and place specific attributes and how well integrated this region is within the larger inter-regional network. A higher potential increases the probability of firms, dependent on knowledge spill-over, to locate to this region. And, a higher potential increases the probability for entrepreneurs to take advantage of these spill-overs and to start new knowledge-based firm and generate more innovation (Gråsjö, 2012). These knowledge spill-overs, are as well attributed to regional learning processes, where sharing knowledge and learning from other economic actors will enhance a regions overall innovative milieu, thus, competitive advantage (Asheim, 1996; Mackinnon et al., 2002). And it is these knowledge spill-overs that represent the above-mentioned externalities (Duranton & Puga, 2004).

These concepts of knowledge externalities have contributed to a socio-economic framework that recognizes firms learning advantages through physical proximity, and that these advantages depend to what extent they can access networks of knowledge sharing between firms, research organizations, and other agencies (Bathelt & Cohendet, 2014; Capello & Lenzi, 2018). It is not per se the geographical proximity or the density of these localities that enhance the creation of knowledge, it is instead the characteristics and the structure of the social network of that particular region and the social interaction within them (Huggins & Thompson, 2014; Eriksson & Lengyel, 2019). These social interactions are attributed to the process of facilitating regional learning, economic development, and in the long run, growth (Boschma & Frenken, 2010). Advancements in communication technology have made formalized (or codified) knowledge much more accessible, scholars have therefore aimed their focused on the variety of channels where more embodied personal knowledge (or ‘tacit’) knowledge (Polanyi, 1983) are shared. These channels are networks of personal interaction, rumor, and gossip (Henry & Pinch, 2000), staff-turnover, job-hopping (Power & Lundmark, 2004), and start-ups and spin-offs (Mayer, 2013).

An extensive stream of literature has devoted time to analyze firms’ ‘absorptive capacity’, or their abilities to use, and transform new knowledge to innovative products for commercial use (Cohen & Levinthal, 1990). Findings suggest that a shared set of languages and norms amongst economic actors enhances their ability to process imperfect information, and thus, learn more effectively and innovate more productively (Allen et al., 2007). To further unravel the socio-economic foundation of regional advantages, researchers have investigated, on an incredibly detailed level, how knowledge tend to circulate within and between different kinds of regional industrial systems, as well as the multiple variants of knowledge, diffused and shared within these networks (James, 2017). For example, scholar have categorized knowledge beyond the earlier tacit and codified knowledge, and now distinguish between analytical (science based), symbolic (art-based) and synthetic (engineer based) knowledge (R. Martin & Moodysson, 2013) as well as the ‘know-what’, ‘know-why’, ‘know-how’ and the ‘know-who’ (Lundvall & Johnson, 1994). Scholars have
also focused on how innovation system operate at different multi-scalar boundaries (Asheim et al., 2011) and how the ‘deterritorialization of closeness’ affect the local tacit and the global codified knowledge diffusion.

3.2 Shortcomings of the regional learning and innovation literature

Even though the regional innovation and learning literature has, so far, contributed to a large number of influential concepts and theories - proposed to offer an explanation of the mechanisms behind uneven spatial development of the knowledge economy, this body of literature suffer from some major shortcomings (Mcdowell, 1991; James, 2017). For almost two decades ago, Perrons (2001) pointed out that economic geography has become narrow, overly specialized, and lacking of social perspectives. This narrow line of research tend to focus on “the minutiae of change, in particular the linkages between firms in economic clusters and their detailed mapping of the learning processes” (Perrons 2001, p. 32). She argued that these studies are partial and fail in their attempt to explain the wider consequences of firm’s competiveness and economic change and that the well-being of people in places are most often neglected. Twenty years later, James (2017) among others still recognize this partiality within contemporary learning and innovation literature. He argues that even though there is almost a mutual understanding of the importance of socio-cultural and relational embeddedness of the drivers behind regional learning and innovation processes there is, as of today, some major analytical blind spots that bias this stream of literature. First, studies within this field tend to be firm-centric, and view the workers as ‘atomized agents’ only valuable as an input in the production process (Herod, 2003a; Harvey, 2006a). Second, the majority of regional learning and innovation studies ignore gender as a factor in their analysis (Rees, 2000; James, 2017). And third, the analytical focus of these studies does not target the activities of knowledge production that are associated with a wider social network, such as social reproduction and care (Perrons, 2001). These blind spots are the motivation for this thesis, especially to bring some perspective on the ignored gendered issues within the knowledge economy. These shortcomings of this literature are further discussed below.

3.2.1 A Missing a people perspective

To understand the why a workers perspective is missing in regional learning and innovation literature, it is crucial to recognize that the shift to the knowledge economy meant new forms of waged work based on flexibility, mobility, emotional intelligence, personal performance, networking, and creativity. This shift also meant that the typical knowledge worker is viewed as being liberated from constraints of categorical inequalities based on class and gender. Thus, generating a narrow norm, where social values and structural differences are overlooked (Mcdowell & Dyson, 2011). Over the years, regional learning and innovation studies have underlined that local pools of skilled labor and knowledge spillover of in terms of human capital is the key factors in explaining regional advantage (Glaeser, 2000; Asheim et al., 2011; Florida, 2014). The importance of the individual worker is well understood, however, within this fields of studies the analytical focus is directed to the firm and seldom the worker (Audretsch & Feldman, 2004b; Bathelt & Cohendet, 2014). The small number of studies where the workers are put under the lens, they are treated as a passive input to knowledge production - similar to capital or material resources, were the level of the education they have, access to vocational training and wage cost as well as their spatial distribution is viewed as key determinates for firm behavior (Gray & James, 2007). Michel Porters (1996) influential cluster concept and the New economic geography by Paul Krugman (1991) are examples of how a firm centric way of conceptualizing labor reduces the worker to only its value (Herod, 2003b). Instead of treating the worker as a social agent capable making decisions, the worker is reduced to its attributes and skills and the person behind this ‘atomized agent’ is therefore made invisible (Herod, 2003a; Harvey, 2006a; James, 2008). In other words, it is not the human beings that are used as an input, instead their characteristics or
their capacity to contribute to the knowledge production process. In the closely related entrepreneurship literature, innovation is also recognized as a crucial aspect for staying competitive. The individual entrepreneur is responsible for producing innovation, therefore, much of the scholarly aim target’s the person (Shane, 2003). Despite this understanding of innovation and people, the regional learning and innovation literature has focused more on the economic systems and innovation channels (Fagerberg et al., 2005). As a response to the firm centric conceptualization of labor, Andrew Herod, in the 90s, started a more critical ‘labor geography’ research agenda. Which empirically showed how workers make decisions that reshape the geographies of capitalism that leads to positive outcomes for their work and employment conditions; instead of being pushed around as a consequence of economic changes (Castree, 2007; Rutherford, 2010). Findings within this field show that the shaping patterns of the ‘constrained workers agency’ is place dependent, meaning that specific spatial context produces specific work cultures, employment practices and labor relations (R. Martin, 2000). However, this epistemological shift from a firm centric view to a labor force or worker focused view has not yet been seen in the regional learning and innovation literature, except for a few numbers of studies (James, 2017).

3.2.2 Gender-blindness
The theoretical invisibility of the everyday role for the female knowledge working agency in regional geographies of learning and innovation is an analytical blind spot within the regional learning and innovation literature (Mcdowell, 1991; Rees, 2000; Gray & James, 2007). The gender blindness within this line of research are linked to the, previously mentioned, analytical invisibility of “people” (Alsos et al., 2013; James, 2017). When the ‘people perspective’ is missing within the discourse, gender easily becomes invisible (Alsos et al., 2013). Comparing the entrepreneurial literature within the innovation literature, entrepreneurial researcher has addressed the importance of the link between people and innovation as well as the implication of gender. In other words, the role of the entrepreneurs is analytically examined, while the role of an innovator is treated as a homogenous group (Duvnäs et al., 2012). The geographies of regional learning and innovation is constantly reproduced, and by neglecting the female knowledge working agency the risk of perpetuating constrains for female workers in an overall gender unequal industry is large (Rees, 2000). Especially, when policymakers tend to use highly competitive regions as an example of renewing the economy of their region, example regions that tend to build their organizations on an ‘ideal worker’ often portrayed as a man in his late 20s with no family-life and possibilities to work late-hours and travel (Rees, 2000; James, 2008).

3.2.2.1 Gender constraints
This ignorance of gender could, to some extent, be explained by a traditional male dominance of the knowledge sectors, particularly sectors such as computer software, engineering, and motorsport industry. But more importantly, the lack of gender analysis is likely a product of persistent masculine social constructions of the high-tech industries, which most of the empirical work of the learning and innovation is based upon (Mcdowell & Dyson, 2011). Wright and Jacobs (1994) amongst others, claims that the occupational masculinity of the IT and engineering sectors is rooted in individualism, independence and the ability to display technical confidence and successfulness, were professional competence is defined in hegemonically masculine terms where the gender characteristics of females are perceived as less successful. While on the other hand, Massey (1995) emphasize that the origins of these masculinity norms should not be viewed as discriminatory or as a product of sexism, instead it should be understood as a set of internalized and deeply rooted broader societal dualism, which lays the foundation for the social relations within the workplace. An epistemological dualism between reason and non-reason, where reason represents the logical and scientific nature of working high-technological sectors, a social construct perceived and validated as masculine (Massey, 1995). Harding (2004) argue similarly
from a feminist standpoint, where she critically addresses that natural sciences is androcentrically biased, in how scientific problems are defined, and how scientific knowledge is produced and applied through new technologies. Her argument derives from the notion that contemporary science is built upon a set of dualisms – nature vs. culture; prerational body vs. rational mind; objectivity vs. subjectivity; public vs. private – where the first notion in these dichotomies are perceived as masculine and the later feminine (Harding, 2004). In line with these ideas, Blake and Hanson (2005) argue that economic regional learning and innovation studies assume a male innovator, due to the masculine assumption embedded in the very definition of technological innovation.

Social network scholars point out another element of gender inequalities in the knowledge intensive-labor mark. They challenge the way how neoclassical economists conceptualize the labor market as homogenous by pointing out that job acquisitions, and promotions are embedded in informal social networks (Granovetter, 1995; Drentea, 1998; Boxman & Flap, 2017). Studies show that interactions within informal social networks can provide valuable information concerning the labor market, for example, if there is a job-opening or characteristics of potential colleagues or bosses (Granovetter, 1995; Feldman et al., 2007). These scholars argue that people who use this type of informal connections are more likely to find higher prestige jobs, higher salary and higher workplace satisfaction (Granovetter, 1995; Drentea, 1998; Boxman & Flap, 2017).

Feminist scholars have also argued that the definition of the economy also holds nuances of stubborn masculine associations (Mcdowell, 1997). In economic analysis, price is the only representation of value. While traditional activities associated with females are not, in monetary terms valued consequently, these activities are excluded from what is essential and necessary for the driving the economy (Mcdowell, 2000). Feminist economic scholars have challenges this stubbornness by exploring, for example, how the wealth of a nation is affected by household labor and child caring and by challenging women and families invisibility in economic behavior (England, 2003; Staveren, 2007). These contributions have at least made conventional economist more aware of the problem of gender-blindness (Mcdowell & Sharp, 2014). While in the field of regional learning and innovation, scholars have not yet appropriately addressed these issues (Mcdowell & Dyson, 2011; Alsos et al., 2013; James, 2017).

### 3.2.3 Knowledge production and social reproduction

Abstracting work from social life concerning family and social reproduction is the third analytical blind-spot of this literature, which is linked to the two previously discussed gaps (James, 2017). Perrons (2001) points out that dividing labor between waged-work and domestic work does not make any sense through a sustainable regional development perspective. These dimensions are essential to understand the well-being of people in regions, and thus, important in a regional economic development agenda. Scholars tends to isolate clusters, almost like islands in the socio-economic landscape (R. Martin & Sunley, 2003). ‘Regional worlds of production’ is analytically distinguish from ‘social world of reproduction’; ‘new industrial places’ are studied individually apart from ‘new reproductive spaces’; and ‘innovative milieux’ are analytically isolated from ‘social reproductive milieux’ (James, 2017). Abstracting networks of knowledge production from wider social network is problematic because the capacity of a worker to perform tasks are not pre-given, but instead socially constructed and sustained, where females typically shoulder the responsibility of provisioning in these wider social networks (Block, 1990). Even though feminist scholars have showed the economic importance of hidden household labor and caring activities (Perrons et al., 2010) – the regional learning and innovation literature is still behind in picking up these intellectual advances. This is especially odd when this literature has paid so much attention in understanding the linkages between firms in industrial clusters and the learning processes (Yeung, 2005a).
Regional economic development analysis has, in broader terms failed to examine the support structure of the household, as well as the institutions that provide opportunities for socially sustainable innovation (Castree, 2007). This separation of a workers knowledge production and a workers existence has also been referred to as the ‘separative self-bias’ where males autonomy outside the family life is glorified (England, 2003). In this way, the regional learning literature reproduces a dualism of immanence and transcendence, where social reproduction belongs to immanence in which the worker is living in the presence of everyday life – considered feminine. And, transcendence is represented by science and technology as a solution for change and development – which is considered masculine. The origins of this ‘masculine transcendence’ can partly be found in the neo-classical economic literature. Nelson (1995) portrays how the neo-classical economic literature conceptualizing the individual in the economic landscape as ‘Homo economics’ – the economic man who interacts with the society without being affected by society, he is self-dependent and only responsible for his actions. This way of conceptualizing has been criticized, both for not including female workers, and a poor representation of male workers (England, 2003). Therefore, the autonomous economic agent sprung from the neo-classical economics need to be questioned and challenged as well in the regional learning and innovation literature.

Much of the regional learning and innovation literature and their closely related fields of research, can be traced back to the influential study by Saxenian (1996) called Regional advantages (Cruz & Teixeira, 2010). Her study explores the continued liveliness and growth of the computer and technology industry in Silicon Valley compared to the relative stagnation and decline of the industry along Route 128 in Massachusetts in the 1970s and 1980s. Her main finding lies in Silicon Valley’s open networks of communication and exchange across firms compared to the more self-sufficient, independent, and vertically integrated structure of Route 128 companies. It is arguably, the Californian company culture characterized by openness to experimentation, risk-taking, acceptance for failure as a way of learning, stronger belief in the transcendent new technology than in employees that explains the regional, decentralized, network-based industrial system of learning. Central in Saxenian (1996) narrative is the ‘Silicon cowboy’, a young, and carefree engineer. Where the majority of these engineers are males, in their 20s and 30s, lacking family ties which arguably blurs the line between work and social life. New working-norms of extra-long office hours and finishing huge workloads in a short amount of time is formed. A tremendous amount of academics and policymakers around the world have tried to analyze ways of extracting and applying the success factors of this pioneering high-tech cluster, according to Google scholar her article been cited 12631, (as of April 2019). Hence, the young and carefree masculine ideal, with a missing distinction between work-life and social life in Saxenian study, is exported and reproduced as part of the solution to enhance regional growth.

### 3.3 Addressing the gaps of the literature

Conducting research on the assumption that the industrial culture, where important learning and spillover mechanism are taking place, is based upon a small set of shared norms which enables and facilities intra- and inter-firm interactions (Boschma & Frenken, 2010; Asheim et al., 2011), are problematic. These narrow norms are far from fully shared, and when regional learning analyses advice regional policy makers and cluster initiative, there is a risk of reproducing patterns of inequalities (Rees, 2000; James, 2017). Hence, the earlier mentioned shortcomings in the regional learning and innovation literature should be viewed as an overall motivation for this thesis. By analytically targeting these gaps and examining a labor force of the knowledge economy, more specifically the ICT-industry of Umeå. I will examine this labor force through the perspective of the individual worker, whom is treated as a social agent with a number demographic characteristics, such as gender. By, examining the individual workers participation in informal
and formal network, it is possible to give the worker one dimension of what is means of being employed represented in the formal network. And, another dimension of social life characteristics, which is represented in by the informal network. By conducting a social network analysis on this particular labor force, the importance of the individual can be addressed, embeddedness of gender constraints can be analyzed and the importance of social life in can to a certain extent be covered. With the shortcoming of the regional learning and innovation literature, the expected findings of this thesis will show that females do not have the same opportunities as males, and that it might be affected by structural and positional network features – as of how influential or central a worker is within his or her network. This line of reasoning derives from the under-representation of females in knowledge intensive industries, the naive idealization of the generic knowledge-worker and lack of incorporating a broader social life perspective to the analytical departure (Rees, 2000; James, 2017).

4 Methodology
To study the dynamics of relational economic activities e.g. social interaction within social networks or within the knowledge economy, this thesis is using the research framework relational economic geography. As described in the theory section, this approach is derived from the relational concept of space (Harvey, 2006b), that focuses on the relational aspects between actors within the socio-economic landscape. It assumes that the economic landscape is relationally constructed and that it is through interactions within networks economic activities occur (Bathelt & Glückler, 2018). The analytical focus targets the fundamental aspects of economic and social life, and the process that drives economic actions, its interaction and its spatial outcome (Bathelt & Glückler, 2018).

Guiding this thesis is the three principles that constitute the foundation of the relational research framework: context, path dependencies, and contingency (Bathelt & Glückler, 2018). These principles should be viewed as tool of conceptualize and understanding the particular context examined, and more, the empirical analysis in this thesis will not directly target these principles, instead they are used a basis for analyzing the constraints and opportunities for knowledge workers, where the context and history of the examined industry is important in order to understand the outcome of this analysis.

4.1 Validity and rigorousness of the method
4.1.1 Quantitative methods
There are several of challenges to be aware of when analyzing behavioral and social aspects with a quantitative method, such as the one used in this thesis (Bryman, 2012). An overall problem with quantitative research it models a created, fixed and frozen artificial reality – whereas the ‘real’ social reality is alive and constantly being created through processes of interaction. The network measure used as an independent variable in this thesis is a construct, and the concept this measure is supposed to reveal is assumed rather than real (Bryman, 2012). It is therefore important to understand that findings from this thesis show a plausible explanation of the ‘real’ reality. Nevertheless, the relevance and importance of any findings should not be undermined. First, because the research-design is unique and first of its kind in this particular setting. And second, the network and gender perspective this thesis brings has been stressed by several scholars to deserve more attention in regional studies (Alsos et al., 2013; Huggins & Thompson, 2014; James, 2017). Any patterns or trends found should, therefore, be viewed as a starting point for more comprehensive research.
4.1.2 The relational economic geography framework
Under the scope of the relational economic geography framework, regions are viewed as socially constructed entities, dependent on the particular economic, social, cultural, and political settings and realities under which people in firms and other organizations interact e.g., (Malmberg & Maskell, 2002). By conducting a social network analysis, it is possible to examine these relational activities (Borgatti et al., 2018), and gain understanding of how these interactions operate, as well as a better insight in the dynamics of regional economic development (Bathelt & Glückler, 2018).

When conceptualizing space as relational, especially in an era of globalization, it is necessary to understand that regional economic actors are part of a global network that, to some extent, will affect their behavior and decisions. Because this thesis analyses network on micro-level (intra-firm), there are forces and mechanisms that stretches outside the investigated relational context of this thesis that can only be theoretically assessed. Thus, it is necessary to have this in mind when interpreting the results. Furthermore, when using the relational approach, it is also important to be aware of the limitation of generalizing possible findings. For instance, this approach highlights that importance of the context to understand relational activities, context, which by definition, differ from place to place. Therefore, even if these findings are convincing, they should be carefully compared with other regional contexts.

4.1.3 Modelling social networks
It is a difficult task to ensure the validity and reliability of the data when modeling behavioral and social aspects with a qualitative method. When designing a networks based case study, several validity threats have to be addressed (Dul & Hak, 2008). Three validity threats have been identified by W. Martin (2012) construct validity, internal validity, external validity, which was taken in to consideration for this thesis.

- To avoid issues of construct validity, W. Martin (2012) suggests that multiple sources of evidence should be used, establish a chain of evidence, and have informants review the case study. Unfortunately, only one source of evidence was used in this analysis, this is further discussed in section 7 and proposed as improvements of future studies. Establish a chain of evidence – this was done by running multiple statistical tests: non-parametric t-test, bi- and multivariate models as well as visualizing the modeled networks. Have informants review the case study – when handling the data senior researchers and the thesis supervisor reviewed the outputs.

- To avoid issues of internal validity, W. Martin (2012) suggests testing casual relationships. This was indirectly done by modeling two different (formal and informal) networks with the same firm.

- To avert the threats of external validity W. Martin (2012) suggest using rival theories in a single case and replication in multiple cases. Rival theories in a single case – this could not be done, only a quantitative approach was used, for future improvements of the method qualitative approaches is recommended, also further discussed in section 7.
5 Method and data
This section provides background information about the data used in the analysis, the statistical methods used, the definition and theoretical derivation of measured variables, and the explanation of the analytical strategy.

5.1 Data section
When conducting the social network analysis, a primary cross-sectional data-set that was used collected between October 2018 and January 2019 within the region of Umeå. Firms located inside this study area was approach and asked if they wanted to participate in a research project. Some of the workers of these firms was stationed outside the study area but was kept in the data-set as long as they were employed at a workplace located inside Umeå region. As a basis for the social network analysis, an employer and employee matched micro-data set were used to descriptively examine the evolution of the Umeå’s ICT-industry between 1996 and 2016.

5.1.1 Collection of Survey data
The business incubator Uminova provided a register of firms within the Umeå region that in some way is connected to high-technological research and development and innovation. Potential firms was identified using a register provided by Uminova and contacted if they wanted to participate in a study, if yes, a survey was sent out to them to fill in. The target group of this thesis was workers within the ICT-industry, that define their work as programing, developing or software engineering, the firms were initially asked how many employees they had that matched this description. Here, a lower limit of six programmers, developers, or software engineers was set. If the firm agreed to participate, a survey was digitally distributed to all workers, which they could fill in online.

There is no clear-cut definition of the work role of a developer, programmer, or software engineer. Depending on the context, it may have different meanings; this unclear definition could, therefore, potentially bias some of the cases. When the firms CEO’s or team leaders was approached, they were asked compile a list of their employees who, according to their own perception of what a programmer, developer or software engineer is. A difference between smaller and larger firms could be recognized, for instance, in smaller firm an individual could be involved in HR, sale and developing while the in larger firms they have a more distinctive roles.

In the survey, the participants were asked to nominate their colleagues accordingly: “Who are the people you need to collaborate with, in your current projects in order to get your work done? Pick as many of your co-workers as you like.” – By mapping these nominations, the professional network could be created (see appendix). They were also asked nominated who they socialize with: “Who are the people you socialize with outside of work-related situations? Pick as many of your co-workers as you like.” (see appendix). By mapping these nominations, the socialization network within the firm could be examined. The survey contained a list of the participant’s co-workers within their firm when nominating their peers the chose people from this list.

5.1.2 Key Variables
Social networks operate at multiple levels, interaction between individuals within firms (intra-firm networks), interactions between firms (inter-firm network) and interaction between geographical areas (spatial networks) (Colombo et al., 2011). It is commonly distinguished between formal and informal network, especially in the context of intra-firm networks. Where the
formal networks represent the authority structure of a company, for instance, whom a worker is dependent on to retrieve crucial information in order to get work done (Podolny & Baron, 1997). And, Informal networks relates to the emotional attachment to other co-workers, such as, whom worker consider as a friend and who they socialize with at their workplace, and who you can seek advice both work and non-work-related advice from (Kuipers, 2009).

Social interaction allows actors to get to know each other, to create a tie with similar ideas, and to share relevant information. An actor within a network, which occupies a central role is likely to be perceived as trustworthy by other actors in the network (Tsai & Ghoshal, 1998). As demonstrated by Kuipers (2009), when an informal network at a workplace is similar to the formal network, a worker is more likely to identify with both the shared the organizational beliefs and values at the workplace as well as internalize them. Social network analysis is a tool to understand networks and the dynamics of their participants (Serrat, 2017), where the general hypothesis in is that an actor’s position in a network determines, to some extent, the constraints and opportunities that this actor will experience. It is, therefore, analytically beneficial to identify this actors position to predict outcome such as behavior and performance (Borgatti et al., 2018).

Centrality measures are a theoretical construct that characterizes a node (or person) in a network (Borgatti et al., 2018). In this thesis, these measures are used to examine the influence and the connectivity of individuals participating in both the formal and the informal network. Two kinds of centrality measures, eigenvector centrality, and in-degree centrality was used, both as dependent and independent variables in the statistical analysis. The in-degree centrality indicates how well a node is connected in terms of direct connections going into the node (number people that of nominated a person in the survey). This measure represents an index of the node’s communication activity (Rusinowska et al., 2011). Eigenvector centrality is a measure of a node’s influence within a network. All nodes are given a relative score, where a node which connects to high-scoring node gets a higher centrality score. A high eigenvector score means that a node is connected to many nodes who also have high eigenvector scores (Newman, 2010).

The formal networks are related to collaboration and work activities, how influential a node is with this network is, therefore, the analytical focus on this thesis. The formal network is therefore represented by eigenvector centrality and is referred to as ‘formal measure’. Since the informal network is related to the socialization process, direct ties are more interesting to measure because whom a person choose to socialize with is not directly an effect of ties from other nodes (Borgatti et al., 2018). The informal network is therefore represented by in-degree centrality, and is from this point referred to as ‘informal measure’. To be able to compare the treat all individuals as a sample population, the formal and the informal measure was standardize to a scale from 0-1.

5.1.3 Control variables
Demographic characteristics such as age, level of education, position in the firm and, gender were also gathered in the survey (see table 1). Age was used as continues variable and was assumed to enhance the formal measure, e.g., the workers influence. This reasoning is in line with (Perrewe et al., 2014). While, the age variable is expected to have a lesser impact on the prediction of the informal measure, how socially integrated a worker. Scholars recognize a workers level of education as an important factor for his or her level of knowledge (Glaeser, 2000; Asheim et al., 2011; Florida, 2014). Level of education was used as a categorical variable, where initially six different educational levels were recoded to have enrolled in higher education studies vs. have not enrolled in higher education studies. Education is thought to hypothetically affect a person’s influence in the formal network as well as how social integrated a worker is at their workplace.
Depending on a worker has a junior, senior or managerial position at the firm, the influence this person has will likely be affected (Eckhardt et al., 2009), but are less likely to affect who you socialize with. Hence, these positions was categorically controlled for in the statistical analysis. And finally, gender was also controlled for categorically. Motivated by the research gap earlier pointed out in the regional learning and innovation literature, where criticism is directed towards a gender-blindness of in this line of research (Rees, 2000; James, 2017).

5.1.4 Representativeness of the data and missing values
For several persons who filled out the survey, information about the demographics was missing, which led to omitted cases. The total number of participants was 204 for, after omission 159 (table 1), a 22 percentage decrease of cases. Some outliers with high centrality measures could be identified, these were not omitted due to the fact that they might be well-connected individuals. By controlling for the individual’s position within the firm such as junior or manager etc. the notion of people being more central due to having a managerial position was disregarded (Eckhardt et al., 2009).

The representativeness of the primary sample data set is, to some extent, questionable. Compared with the microdata set there is a significantly smaller share of females. A possible explanation for this is that the survey did only target knowledge workers identified as developers or software engineers. While the microdata contained all possible occupations linked to this industry, such as HR and sales. However, with an 80 % participation rate of the surveys and sample population over 200 individuals, the findings from the statistical analysis should be considered valid.

5.2 Method

5.2.1 Software tools and bivariate analysis
A Social network analysis was conducted, using the primary-data collected from the survey. R-Studio was used to transform the raw data into network format, where the R-package Statnet, was used to run the centrality algorithms. For the visualization of the networks, the software Gephi was used. And, all the statistical modeling was performed in Stata 14.

Before running the regression on the network data, a T-test was performed between the two centrality measures, in-degree and eigenvector centrality (Peck, Olsen, & Devore, 2015). Since none of these variables was normally distributed a Kolmogorov-Smirnov two-sample test was performed instead, examining any differences in the cumulative distributions of the two centrality measures and the difference between females and males for the two centrality measures. As a nonparametric test, it does not require a normally distributed population (Peck et al., 2015).

5.2.2 Multivariate analysis
Findings in the bivariate analysis showed that both the key variables and the control variables showed to some degree a correlation with each other. These correlations indicates that all the considered variables might affect the position in either the formal or the informal network. Running a simple linear regression might risk of capturing these mediating effects and bias the prediction. Hence, to model the relationship between the independent variables, and the dependent variables a multivariate regression analysis was the method of choice. Network data on the individual workers were gathered within firms, which created a potential risk of the standard error being dependent on firm-level. This potential problem was tackled by clustering the standard error on firm-level. Meaning that the standard errors are assumed to be independent across the population, but allowed to correlate within the clusters (Cameron & Miller, 2015). To capture the any firm-effect, a multilevel model was also performed but no significant difference could be distinguished from a regular linear regression model (Peck et al., 2015). Initially, all
independent variables (formal measure, informal measure, age, education, position in the firm and gender) was individually run against the dependent variables. Next step was to, run all the independent variables against the dependent. And, the final step, for both models, an interaction was added between gender and the centrality measure (formal and informal measures) used as a dependent variable. The interaction effect was added to check if the independent centrality measure might be affected if the individual is male or female. Here the hypothesis is that females do not have the same opportunities as males and that it might be affected by structural and positional network features – as of how central and influential a worker is within his or her network. This line of reasoning derives from the under-representation of females in the ICT-industry, the naive idealization of the generic ICT-worker and lack of incorporating a broader social life perspective to the analytical departure (Rees, 2000; James, 2017).

5.2.3 Post-estimation
Necessary post-estimation tests were performed where all the assumptions of a regression analysis (Gelman, 2007) were met, except for one case. In model 1 (the formal network model), the residuals were not equally distributed across the regression line, which indicate heteroscedasticity and could potentially bias the model’s prediction. But as argued by Fox (1997) amongst others, in the ‘real world’ partial redundancy occurs; hence, unequal error variance is only necessary to correct when the problem is of great magnitude. The greater the redundancy, the greater the inflation of variance (Fox, 1997; Gujarati, 2002). However, this calls for great caution when interpreting the model outputs.

5.3 Ethical considerations
When doing research that involves human beings and their experiences, it is imperative that ethical issues are considered and be aware of how the study can affect the subject. Next follows some general ethical guide lines that was followed in this thesis, as well as how they were followed.

- Informed consent, means that the individual participating in the study is fully informed about all the aspects of participating.
- Voluntary participation, participants are free to withdraw data connected to them at any time.
- Do no harm, the process of evaluating collected data cannot in any way harm the (unintended or otherwise) participants.
- Anonymity, the identity of the participant remains unknown (Swedish Research Council, 2002).

Conducting research on social networks poses different ethical challenges compared to other types of social and ethnographical studies, especially when researching whole-networks, or networks that are meant the capture all the individuals interacting within a network. It is impossible to collect data of these individuals anonymously because the participant need to identify themselves in order to nominate others. Therefore, the participants needs to be fully aware and informed how the data is supposed to be used (Borgatti et al., 2018).

These above ethical guidelines were followed by making sure that the person filling in the survey had all of the information that might reasonably influence their willingness to participate, the purpose of the study, expected time-frame and procedures. The approached individuals were informed of their rights to decline to participate and, at any time, withdraw their answers and everything connected to them, as well as the consequences of doing so. They were also given incentives for participation, and the overall aim of the study was explained. And finally, the
participants was informed who to contact with questions. To guarantee that the participants had understood the terms and conditions, they were asked to give their consent before participating. If they did not tick the consent box at the beginning of the survey, they could not proceed with filling out the rest, and no data could be connected to them.

6 Result
Understanding the contextual background of the industry and region is important to be able to analyze the networks but also to be able to translate findings to other contexts (Tsai & Ghoshal, 1998). The development of an industry in the knowledge economy is shaped by the dynamics of knowledge creation, where the inflow of workers to an industry constitutes the source of this knowledge. And how the workforce composition of an industry changes over time reflects the evolution of that industry (Kraft, 2013). By studying the changes and development of the labor force, it is possible to gain the understanding of how different kinds of knowledge, within an industry, are formed, combined and valued over time (Ter Wal & Boschma, 2011; Martynovich & Henning, 2018). Guided by this thesis research framework, relational economic geography (Bathelt & Glückler, 2018), the evolution of ICT-industry of Umeå will be presented first in this section. Next, the result from the statistical analysis will be displayed, performed with the aim to examine potential factors that might influence the positions and structure in the formal and informal network, as well as examine the relationship between the two networks. And last, a selection of the networks studies in this thesis are visualized and analyzed in order to gain insight on how these networks operate at firm-level.

6.1 Evolution of the ICT-industry of Umeå
6.1.1 Growth and expansion
By studying figure 1, an overall view of the development of the ICT-industry, both from a national and regional perspective, can be gained. Both Sweden and Umeå increased their ICT workforce by 110% from 1996 to 2016. Looking more closely at the patterns of employment growth, it reveals several phases of growth and decline. The first phase, 1996-2000, is recognized by explosive growth in employment, especially on a national level. According to Johansson (2004), the expansion of small and medium-size firms was particularly significant during this phase. The dot-com crash in 2001, a period of extreme growth in the use and adoption of the internet led to a speculative bubble that eventually burst (Chen et al., 2018), this took its toll on the industry, with a declining growth rate (figure 1) and massive lay-offs (Martynovich & Henning, 2018). The employment growth resumed its upward trend in 2005, with a slightly steadier pace but slowed down a bit during the financial crisis in 2008-2009. Since 2010, the upwards trend continued, and, between 2015-2016, there seems to be an acceleration in growth.

Comparing the industry of Umeå region with the entire Swedish ICT industry, it appears that Umeå was a bit behind in terms of employment growth during the late 90s, particularly the last years leading up to the dotcom crash. The decline after this crisis was not as severe for Umeå as for Sweden, around four years later Umeå was back to the same number of workers as before the crash, which for Sweden took almost ten years (figure 9). Umeå’s industry entered a growth phase, from 2006 to 2016, not seemingly affected by the financial crisis. In 2010 Umeå exceeds the national growth of employment, which submerged again in 2016.
Figure 1: ICT sector employment growth in Umeå and Sweden, years 1990–2016.
Source: Based on Statistics Sweden register data. SNI2002 sector codes: 72210, 72220, 72400, 72100, 72220, 72600, 72300, 30020, 72220, 72600, 72300, 72400, 72400, 73101, 73102, 73103, 73104, 73105, 62300, 73101, 73102, 73103, 73104, 73105, 73201, 73202 and 73203.

6.1.2 Dynamics of the ICT-industry
Enterprises and establishments are newly formed, reformed and, closed down. By following individuals and their connections to enterprises and establishments over time, it is possible to examine the dynamics within an industry. By using FAD-data (The dynamics of enterprises and establishments) the changes in enterprises and establishment structures, as well as mapping of the employees’ mobility in the labor market, require that there is control over existing enterprises and establishments as well as over start-ups, shut-downs, mergers and spin-offs. Figure 2, displays the total number of establishment in the ICT-industry within Sweden, which grew from around 12 000 to over 20 000 during the time measured (2000-2016). The amount of newly formed establishments was relatively stable over the measured period. And the number of establishment that lasted from one year to the other shows a decline in the aftermath of the dotcom crash and from 2003 up till 2016 a steady increase. This indicates that the majority of the start-ups managed to survive. The number of establishment in Umeå grew from around 125 to almost 250 (figure 3).
6.1.3 Labor Mobility

The mobility of the ICT-industry labor force of Umeå was examined by looking at where these people resided at the age of 18 and the prior location of the last workplace. Figure 4, clearly shows that the majority of people within the industry resided in Västerbotten County at the age of 18. People who resided in East Sweden and South Sweden represent a smaller fraction of the workforce and seem to relatively stagnant over time. The expansiveness of this industry (figure 1) is therefore attributed to a small but noticeable increase in the inflow of people form the Northern
part of Sweden together with the increase of people in residing in Västerbotten County at the age of 18. When examining the location of the previous workplace (figure 5), it obvious that majority of people changing workplace did it within the County of Västerbotten. In terms in-movers, east Sweden seemed to be the highest contributing part, especially between 2000 and 2006.

Figure 4: Residing location at the age of 18, for individuals who are currently employed within the Umeå region ICT-industry, years 1996-2016.
Source: Based on Statistics Sweden data register. SNI2002 sector codes: 72210, 72220, 72400, 72100, 72220, 72600, 72300, 30020, 72220, 72600, 72300, 72400, 72400, 73101, 73102, 73103, 73104, 73105, 62300, 73101, 73102, 73103, 73104, 73105, 73105, 73201, 73202 and 73203.

Figure 5: Prior location of workplace for individual employed within the ICT-industry of Umeå region, years 1996-2006.
Source: Based on Statistics Sweden FAD-data register. SNI2002 sector codes: 72210, 72220, 72400, 72100, 72220, 72600, 72300, 30020, 72220, 72600, 72300, 72400, 72400, 73101, 73102, 73103, 73104, 73105, 62300, 73101, 73102, 73103, 73104, 73105, 73105, 73201, 73202 and 73203.
6.1.4 Education
Concerning the educational level of workers, it is observable that the share of people with higher education has over time surged: from 41.4% in 1996 to 58.9% in 2016 (figure 6). This suggests that higher education is a strong prerequisite for getting employed in the ICT-industry. Warhurst et al. (2006) recognize a similar trend and claims that the importance of higher education, relevant experience and an interest in computing have become more important for getting more advanced IT-jobs. This is connected to a growing level of competition over jobs and demand of higher sets of skills when the complexity of tasks increases due to sector evolving. And, a flexible educational system that improves the availability and of specialized educational programmes that proved knowledge and skill relevant for the sector (Martynovich & Henning, 2018). This growing demand for skills in mathematics and data is evident when looking at the educational track of the workforce (figure 7). Natural science, mathematics and data grew on the behalf of Technology and Manufacturing and so significantly more than the other educational tracks, from 18.7% in 1996 to 36.3% in 2016. Individuals with a background in Social since and the humanities constitute a relatively stable share during the recent decades in the industry, empathizing the need of a broader mixture of technical, organizational, business and management skills. However, Martynovich and Henning (2018) findings indicate that when the Swedish IT-sector was facing difficult times i.e., the dotcom crash around 2000 and the financial crisis at the end of 2000s, the educational profile of people entering the labor market was narrower. Arguably, pointing to a consolidation of the expectation of the wanted skill-portfolio. During the phases of expansion the inflow of individuals had a broader educational track. Firms are more likely to generate higher profits, thus, enabling them to hire individuals with broader skill portfolios and provide them with on-the-job training and experience at the workplace.

Figure 6: Level of education for the ICT workforce of Umeå, years 1996-2016.
Source: Based on Statistics Sweden data register. SN12002 sector codes: 72210, 72220, 72400, 72100, 72220, 72600, 72300, 30020, 72220, 72600, 72300, 72400, 72400, 73101, 73102, 73103, 73104, 73105, 62300, 73101, 73102, 73103, 73104, 73105, 73105, 73105, 73201, 73202 and 73203.
6.1.5 Gender composition
When looking at the gender compositions of the ICT workforce, it is evident that both Umeå and Sweden shows a long term negative trend, where Umeå has a significantly higher percentage of females compared to Sweden’s ICT workforce (figure 8). In 2007, Umeå turns the negative trend around, and the percentage of females increase by 3-4% up till 2014, this mirrors the later growth phase of Umeå mentioned above. The last two years indicate a negative trend again. As for the Swedish ICT-industry, none of their growth phases can be seen in the percentage of females in the ICT-industry. Instead, it shows a steady decline, dropping almost 10% between 1996 and 2016. When comparing the absolute numbers of female and male employees (figure 9) it appears like the female ICT-worker population of Umeå shows a small increase whereas for Sweden, the population seems to more or less stagnant. Thus, the growth of this industry is explained by the increasing male population of ICT-workers.
6.2 Statistical Analysis

A statistical analysis was performed to examine potential factors that might influence the positions and structure in the formal and informal network, as well as examine the relationship between the two networks. The informal measure is the key independent variable for predicting the dependent variable formal measure, and in the other model, it is the other way around. Education, gender, and position are binary control variables for both models. Descriptive statistics of the variables are shown in table 3; worth noticing here is that the majority of the
participants are males, have studied at the university and have a senior position. For the continuous variables, formal measure has a mean of 0.079 and a max value of 0.666, compared to informal measure with a mean of 0.081 and max of 0.363 and the average age of the participants is 37.3 years. The two-sample Kolmogorov-Smirnov tests performed on the formal vs. informal did not show any significant result, which indicates that both centrality measures have a similar distribution (see appendix). Regarding the gender composition in the networks, the upper part of the formal measure distribution (>75%) e.g., individuals with the highest influential score, 78.2% of these individuals are males. Compared to the entire sample population, where 81.5% are males. And, looking at the bottom part of the distribution, (<25%) the share of male was 91.1% (table 1). This shows that the share of females tends to be higher in the upper part of the distribution compared to males. While examining the gender composition in the informal network, the opposite pattern of the formal network appears. Here, the share of males (76.2%) are lower in the bottom end (<25%) of the distribution and higher (83.7%) in the upper part (>75%). This observation is also supported by the two-sample Kolmogorov-Smirnov test, testing the difference between female and male distribution for the informal the formal measure. Even though there was no significant difference between male and the female distribution, the cumulative distribution plot (figure 10) shows that females has a higher value on the formal measure (x-axis) at a lower cumulative values (y-axis), and somewhere half-way through cumulative curve the female line crosses the male line, showing that the formal measure are in general higher for males (see figure 10). The opposite pattern mentions above, is also visible in the cumulative distribution plot (see appendix) of the informal measure and the formal measure, likewise - the Kolmogorov-Smirnov test did not come out significant for the informal measure either.

**Table 1: Descriptive statistics**

Table showing descriptive statistics of the variables used in the analysis.

<table>
<thead>
<tr>
<th>Continuous variable</th>
<th>Median female</th>
<th>Median male</th>
<th>Gender composition (male) &lt;25%</th>
<th>Gender composition (male) &gt;75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal measure</td>
<td>0.081</td>
<td>0.06</td>
<td>91.1%</td>
<td>78.2%</td>
</tr>
<tr>
<td>Informal measure</td>
<td>0.081</td>
<td>0.04</td>
<td>76.2%</td>
<td>83.7%</td>
</tr>
<tr>
<td>Age</td>
<td>37.3</td>
<td>63</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Categorical variable</th>
<th>Count.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>no uni. studies (base)</td>
<td>29</td>
</tr>
<tr>
<td>Uni. studies</td>
<td>149</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male (base)</td>
<td>145</td>
</tr>
<tr>
<td>Female</td>
<td>33</td>
</tr>
<tr>
<td>Position</td>
<td></td>
</tr>
<tr>
<td>Manager (base)</td>
<td>38</td>
</tr>
<tr>
<td>Junior</td>
<td>11</td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
</tr>
<tr>
<td>Partner</td>
<td>10</td>
</tr>
<tr>
<td>Senior</td>
<td>107</td>
</tr>
</tbody>
</table>

Note. Formal and informal measure are both used as dependent and independent variables.
Figure 10: Cumulative distribution of the informal measure, female vs. male.

Figure 11: Cumulative distribution of the formal measure, female vs. male.
When checking for bivariate correlation, both the network characteristics and the demographic characteristics show a correlation between as well as in-between each other. These correlation suggests a multivariate analysis is needed to understand the relationship between the factors better. If only using bivariate analysis, the potential mediating effects might end up unobserved, thus, bias the prediction.

A multivariate regression analysis was used to test the association between the formal and the informal network as well as checking for any main effects from any of the control variables. Model 4 has the highest R-squared value of 0.25, showing that the variance of the response data around the mean is explained by the model up to 25%. And Model 1 and 3 has an R-squared value of 0.22. In both model 1 and 3, a high centrality measure in both the formal network or the informal network shows statistically significant associations with high centrality measures in the other network (see figure 12), confirming the rather strong correlation in table 4. For every unit increase of the informal measure (independent variable), there is a substantial increase of the formal measure. Note that this result needs to be interpreted with care, since the post estimation test showed tendencies of heteroscedasticity. As shown in model 3, for every unit increased in the formal measure (independent variable), there is substantial increase in the informal measure. The effect of a workers social position on the informal measure is higher than the other way around. The scale of the centrality scores (dependent variables) was normalized and ranges from 0-1.

6.2.1 The effect of gender
To analytically target the person behind the ‘atomized agent’, and to examine the industry from a gender perspective, a possible interaction effect was examined to gain knowledge of how the centrality score (formal and informal measures) might depend on gender. As model 2 in table 4 shows, there is no statistically significant interaction effect. Which indicates that gender does not have any direct effect whether an individual with a high informal measure will have a high formal measure, instead the prediction for male and females are similar. On the other hand, in model 4 (figure 2) the interaction term came out significant, indicating a difference between genders. The Female#Formal measure’s coefficient (0.442) which states a positive number, this should be regarded as having a steeper prediction compared to males. Analyzing the interaction effect in a margins plot is more intuitive; looking at figure 12 it appears like the effect of being female is associated with having a higher informal measure for the same formal measure. In other words, for a centrality measure in the formal network (indicating a workers influence at the workplace) the female worker prediction tells us that she needs to have a higher centrality score, compared to her males colleagues in the informal network, to be able to have the same centrality score for the formal network. This indicates that in general, females needs to be more socially integrated than males to be able to be more influential in the formal network. The median for female’s formal score is 0.078 and for males 0.055, which shows that the female as well as the male sample population is distributed in the beginning of the predictor lines in figure 14. This indicates that more than half of all the females cases have a lower indegree centrality score. Moreover, reading the female coefficient (without the interaction) in model 4, it shows a significant negative output (-0.0419) which suggest that, when eigenvector centrality is equal to zero, there is a significant negative effect of being female in terms of indegree centrality score.
6.2.2 Demographic characteristics
Looking more closely at the control variables in model 1, except for informal measure the age variable was the only one who came out significant. Assume everything else stays the same, increasing the age by one year corresponds to 0.0016 increase in eigenvector score. This is in line with theory that more experience increases a worker's influence (Perrewe et al., 2014). Age, on the other hand, was not significant, in the informal network model (3 and 4). Surprisingly, a University education was only significant in model 4, indicating that those who studied at the university have on average 0.0196 higher informal measure. This partially confirms what has been stated in the literature, the educational capital is positively correlated with the level of knowledge an individual possesses, hence also crucial for social status (Glaeser, 2000; Asheim et al., 2011; Florida, 2014).
Table 2: Estimated coefficient from several multivariate OLS-regression models.
Estimated coefficient from four multivariate OLS-regression models of indegree centrality and eigenvector centrality by education, age, positon and an interaction between gender and eigenvector cent.

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(With interaction)</td>
<td>Informal Network</td>
<td>(With interaction)</td>
<td></td>
</tr>
<tr>
<td>Formal network</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Informal measure</td>
<td>0.588** (0.159)</td>
<td>0.551* (0.0167)</td>
<td>0.357*** (0.08)</td>
<td>0.309** (0.0772)</td>
</tr>
<tr>
<td>Female</td>
<td>0.00953 (0.0129)</td>
<td>-0.00762 (-0.46)</td>
<td>-0.00330 (0.008)</td>
<td>-0.0419* (0.0153)</td>
</tr>
<tr>
<td>University Education</td>
<td>-0.0167 (0.0130)</td>
<td>-0.0153 (-1.14)</td>
<td>0.0163 (0.007)</td>
<td>0.0196* (2.31)</td>
</tr>
<tr>
<td>Age</td>
<td>0.00116* (0.0004)</td>
<td>0.00113* (0.0004)</td>
<td>-0.000600 (0.0005)</td>
<td>-0.000602 (0.0005)</td>
</tr>
<tr>
<td>1. Junior</td>
<td>0.0195 (0.0192)</td>
<td>0.0183 (0.018)</td>
<td>-0.00535 (0.0251)</td>
<td>-0.00520 (0.0238)</td>
</tr>
<tr>
<td>4. Other</td>
<td>0.0165 (0.0188)</td>
<td>0.0138 (0.018)</td>
<td>-0.0250 (0.0292)</td>
<td>-0.0208 (0.0276)</td>
</tr>
<tr>
<td>5. Partner</td>
<td>-0.00000271 (0.0275)</td>
<td>-0.00129 (0.0277)</td>
<td>0.00106 (0.0309)</td>
<td>0.000475 (0.02)</td>
</tr>
<tr>
<td>6. Senior</td>
<td>0.0213 (0.0161)</td>
<td>0.0197 (0.0163)</td>
<td>-0.0116 (0.0223)</td>
<td>-0.0116 (0.0163)</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.0174 (0.0314)</td>
<td>-0.0131 (0.0296)</td>
<td>0.0720 (0.0352)</td>
<td>0.0729 (0.0296)</td>
</tr>
<tr>
<td>R^2</td>
<td>0.22</td>
<td>0.23</td>
<td>0.22</td>
<td>0.25</td>
</tr>
<tr>
<td>N</td>
<td>159</td>
<td>159</td>
<td>159</td>
<td>159</td>
</tr>
</tbody>
</table>

Note: Standard errors in parentheses, * p<0.05, ** p<0.01, *** p<0.001.
6.3 Social Network analysis
The firms formal and the informal networks are in this section visualized next to each other in sociograms, in which nodes are represented as points and the ties as lines. This is to visually show the difference between the two networks, as well as compare pattern found in the statistical analysis. The formal networks represent how people cooperate within the firm, and the informal represent how people that socialize with their colleagues. The size of the node is dependent on its centrality measure, and the color represent gender, green is female, purple is male and orange is not specified. The node id, identify the same individual in both networks. When creating these sociograms a forced based algorithm was used which simulates a physical system where the ties are repelling forces and the nodes are pushing forces, this system eventually reaches an equilibrium (Borgatti et al., 2018).

In figure 9, the formal network is to the left and the informal to the right. Node 3, 8 and 0 are the most central in the formal network, hence assumed to be influential. When comparing their position in informal network it appears like node 0 been moved to the periphery, indicating fewer ties to her co-workers hence, a lower indegree centrality measure. In figure 10, one of the larger firms who participated in this study is visualized. A general pattern that some of the influential nodes in the formal network also seems to be occupying a central position in the informal network is distinguishable. In figure 11, one of the smaller firms is being visualized. The most influential nodes in the formal network are occupied by two males and two females. And when comparing it to the informal network, there are no direct similarities in the overall structure. A noticeable overall pattern for these three figures is that females are to larger degree located in the periphery of the networks, meaning that they neither score high in the influential centrality measure or the social centrality measures, confirming the finding in the statistical analysis. The few cases of females occupying a central position in the formal network, these position are not mirrored in the
informal network. For males, the pattern is opposite, individuals with high centrality in the formal network can also be found in a central position in the informal network.

Figure 9: Networks of medium-sized firms. Formal network (left) informal network (right), consist of 17 nodes females (green) = 3, males (purple) = 14 and not specified = 1. The size of the node represents the centrality score, a higher score = larger node.

Figure 10: Network of large firms. Formal network (left) informal network (right), consist of 30 nodes females (green) = 2, males (purple) = 24 and not specified = 4. The size of the node represents the centrality score, a higher score = larger node.
Figure 10: Network of small firms. Formal network (left) informal network (right), consist of 10 nodes females (green) = 3, males (purple) = 7. The size of the node represents the centrality score, a higher score = larger node.
7 Discussion

7.1 A re-statement of the research problem

By ignoring issues of gender, especially in male-dominated occupations such as knowledge-intensive industries, there is a risk of reproducing patterns of gender inequalities and constraints, such as barriers of equal advancements, discriminatory practices and social exclusion (Rees, 2000; Gray & James, 2007; James, 2017). Furthermore, by ignoring labor market inequalities it is difficult to promote a socially inclusive regional economic development (Rees, 2000). Despite that the regional learning and innovation literature have generated influential concepts and theories, there is a number of shortcoming in the literature that might reproduce patterns these patterns of unequal opportunities (McDowell, 1991; Rees, 2000; James, 2017). First, the majority of these studies are firm-centric, thus neglecting the individual as an agent capable of making decisions and only treating these individual as value. Second, this literature suffers from gender-blindness, where gender issues in an often gender unequal sector are simply ignored. And third, these studies do not differentiate between work and social life, which is problematic because the conceptualization of worker does not incorporate social reproduction. Conducting research and creating policies without addressing these gaps pose a potential risk that the contemporary regional development might perpetuate constraints that that hinders females as well as male workers to participate in the knowledge creating activities. Motivated by these shortcomings, the aim of this thesis was to examine if constraints for workers in the knowledge economy might be embedded and reproduced within firms social networks. To carry out the study, formal and informal networks within firms in the ICT-industry of Umeå was analyzed through a social network analysis and subsequent regression analysis on the network characteristics of each individual. As a basis for the analysis and to better understand the context of Umeå, the evolution of the ICT-industry was examined.

7.2 A re-statement of the result

7.2.1 Evolution of Umeå ICT-industry

The number of employees in the ICT-industry of Umeå has grown about 110% from 1996 to 2016. This rapid growth is similar to the national ICT-industry. However, Umeå had a weaker growth phase in the beginning of the measured period of time, but a faster average growth pace from the 2005 and onwards. And, it is the large inflow of male worker that explains the rapid expansion of the industry. Over time, the share of female workers shows a negative trend, this trend is particularly evident for the Swedish ICT-industry. In fact, Umeå shows an overall higher share of female workers within this industry compared to the Sweden. There is even a weak tendency of an increasing share of female workers during the growth phase of Umeås ICT-industry (2005 and onwards).

The inflow of labor to the ICT-industry of Umeå between the years 1996 to 2016 is characterized by a growing share of people that have studied at the post-secondary level for two years or more. This trend suggests that higher education is a strong prerequisite for being employed in the ICT-industry in Umeå. The educational track of Umeå’s ICT-labor force shows an increasing share of people coming from natural science, mathematics and data, thus confirming an overtime increasing demand for highly skilled labor. Previous research by Warhurst et al. (2006) confirms this trend and argues that the increase of competition over jobs and a demand for certain skills when the complexity of tasks increases is a consequence of this industry evolving.

Findings from the analyses of the ICT-industry evolution of Umeå indicate that Umeå as a region has been able to provide an environment for firms and organization to thrive and facilitate innovation. The labor mobility analysis and educational characteristics support this claim and
adds to it by indicating that Umeå has a flexible and adaptive education system, able to match the increasing demands from the industry. Here an assumption is made that the majority of people who was residing in Västerbotten at the age of 18 also studied within the region, seemingly reasonable considering that Umeå University enrolls around 34 000 students.

The prior workplace of the Umeå ICT-workers was to a large extent located within the region. This suggests that much of the individual embedded knowledge stayed in within the region, thus, enhancing the regional learning processes, increases the competitive advantage of the region. This line of reasoning derives from findings by and Boschma and Frenken (2010) and Huggins and Thompson (2014), who shows that intra-regional labor mobility is positively associated with performance and innovative capacity. A worker moving from one workplace to another has ties with previous colleagues, this intra-regional co-worker network is recognized as important for knowledge spillovers (Huggins & Thompson, 2014). All in all, this suggests that the ICT-industry of Umeå has a somewhat cohesive intra-regional network. This is particularly interesting when the Umeå region is quite peripheral to the larger metropolitans of Sweden, that are known for attracting highly skilled workers within the knowledge-intensive sectors (R. Martin & Trippl, 2017).

Even though the gender composition is skewed for Umeå ICT-industry (around 34% females), the expansion of the industry is marked by a significantly higher share of female workers compared to the national average. Arguably, Umeå could be viewed as a case that is above average when it comes to integrating females into the knowledge economy. On the other hand, viewing Umeå as a positive role model for addressing issues concerning the female knowledge worker agency highlights how deeply embedded this problem is within the knowledge economy. Even if Umeå represent a best case-scenario with around 34% females, this industry is far from equal regrading gender composition. Furthermore, this shows how other regions are probably much worse off when it comes to integration of female knowledge workers.

7.2.2 Formal and informal networks
The statistical analysis of the relationship between the formal and the informal network showed that a central position in the formal network is associated with a central position in the informal network and vice versa. In other words, the ability to connect with other co-workers, through work-unrelated social activities increase the probability of having a more influential position amongst the other ICT-workers at the firm. These findings are in line with previous research such as Seibert et al. (2001) and Bartol and Zhang (2007), who further argues that network centrality is found to be positively correlated with increased power and promotion. And, having more high-level contacts enhances access to information and mentoring, which translates into better career opportunities in terms of promotion and salary.

With respect to the first research question, it was found that individuals who occupy an influential position within the ICT-industry of Umeå are to larger degree male, have studied two years or more at the University and have a senior position at the firm. It is noteworthy to state that the share of male workers in the data-set was 81.5%. While examining the distribution of the formal measure (how influential the workers are at their workplace) it was evident that the upper part of the distribution showed a higher share of females compared to the lower part, which indicates that females are more likely to have an influential position in the ICT-industry of Umeå. This result is a somewhat contrary to findings by Truss et al. (2012) who noticed that female knowledge workers in a UK setting, are more likely to end up in job roles featuring lower status and less autonomy. Regarding gender composition of the informal network (how well socially integrated
the worker is at the workplace), here, findings indicated the opposite pattern of the formal network. The share of females is lower in the upper part of the distribution and higher in the lower part, which implies that females are less likely to participate in social activities with their co-workers outside office hours.

The second research question in this thesis was to determine whether there are any recognizable constraints or opportunities from the positional and structural features of formal and the informal networks in the knowledge economy. Findings from the regression model suggest that females need, in general a higher informal measure compared to males to get a more influential position within the professional network. In other words, how well socially integrated a worker is at their workplace seems to be more important for females if they want to gain a more influential role at the firm. These findings can to a certain extent be seen in the descriptive statistics and non-parametric tests, where the pattern shows that females are more frequently located in the lower parts of the distribution of the informal measure and for the formal measure they are found in the upper part. This trend is also visible when looking at the sociograms, where females ICT-workers tend to be more peripheral in the informal network compared to the formal. For those cases where a female occupies an influential position, these are not mirrored by the position in the informal network. Whereas, influential males are to some extent likely to have a high informal measure. Kuipers (2009) shows that when a worker’s formal network is similar to the informal, identification and internalization of the organizational beliefs tend to be stronger, which arguably could to be the case for these male workers.

These above-stated results indicate that constraints and discriminatory practices are embedded within the analyzed networks at ICT workplaces, females are to a certain extent, not as socially integrated at the workplace as males tend to be. At the same time, females, in general are more positively affected by a higher informal measure than males tend to be. When it comes to occupying a more influential position in the formal network, it could be interpreted as females need a higher informal measure to have the same opportunity as their male co-worker. These results are in line with Department of Labor (1995) findings, which showed the lack of access to diverse information networks is a barrier for female carrier advancement. In addition, Gray and James (2007) findings suggest that being excluded from informal networks in knowledge-intensive firms affect a workers ability to advance in the workplace. Also, in agreement with the findings in the current thesis, are studies done by Fisher (2008) and Davies-Netzley (1998). They found that females who do make it to influential positions are often “outsiders on the inside”, that is they are less integrated in informal networks and outside the influential, central circle of high-level contacts. This means that females are excluded from top networks and informal relationships that are necessary for further career advancement.

7.3 Broader discussion and implications

In terms of unpacking the person behind the ‘atomized agent’ it is clear that workers in this thesis are more than just an abstract input of ‘human capital’, they are human beings embedded in gendering and sexing practices, which to some degree explain male and female worker supply. This thesis has pointed out potential patterns of discriminatory practices embedded in the networks of firms, which indicates an exclusion of the female knowledge worker and which arguably is evidence of masculine rooted firm culture. The lack of access to informal practices hinders the female worker from participating in knowledge creating activities, which decreases career opportunities. These findings support Wright and Jacobs (1994) claims, that the occupational masculinity of the IT and engineering sectors is rooted in hegemonically masculine terms where the gender characteristics of females are perceived as less successful. Moreover,
Massey (1995) emphasize that the origins of these masculinity norms should not be viewed as discriminatory or as a product of sexism, instead it should be understood as a set of internalized and deeply rooted broader societal dualism, which lays the foundation for the social relations within the workplace. By following her line of reasoning, the relative high share of females occupying an influential role in the studied intra-firm network, could be interpreted as somewhat a challenging this dualism. A dualism of rational male role of transcendence (where science is development, change and progress) and the emotional female role of immanence (associated with living in the present and social reproduction)(Massey, 1995; Harding, 2004). At the same time, it should also be noted that the share of females are low.

By taking on the research agendas of economic geography, as the intellectually and policy-relevant discipline within regional development, this thesis brings a new perspective to this discourse. By challenging the long-standing analytical gender blindness, the firm centric view and the lack of acknowledging social production in the regional learning and innovation literature, findings from this thesis demonstrate the danger of assuming a male innovator or approaching this field in a genderless approach. In line with James (2017) arguments, the results in this thesis indicate that we can no longer conceptualize the knowledge worker as acting autonomously. In order to understand regional economic development, the learning activities, and social interaction at the workplace, the worker can, no longer, be analytically separated from its wider existence. The contemporary role of the knowledge worker simply does not comply with Saxenian’s (1996) ‘silicon cowboy’. As this thesis shows, males and females likely to engage differently in relational networks of the knowledge economy, which implies that the dynamics of regional learning mechanisms are far more complex than the mainstream claims of the regional learning and innovation literature, which highlights the importance of applying a gender as well as a workers perspective to future research and policy making.

7.4 Limitations of the thesis
The above-stated findings are indeed important, however, some limitations of this thesis should be noted. The response rate of the surveys determines the representativeness of the sample data, which therefore is essential to discuss when this might bias the output. It is also important to understand the problem of heteroscedasticity in statistical analysis, and how these might affect the result. And finally, the limitations of the research framework also needs to be discussed.

Some bias may arise from the survey data. There was an 80% participation rate among the workers, meaning that almost 20% of the knowledge workers within the firms were missing. This could bias the data in multiple ways, for instance, if some of the more influential workers was missing, the high end of the network measures might have looked different. And thus, affect the prediction, especially considering the low number of influential female workers. However, an 80% participation rate should be viewed as a rather good representation of the population, especially when the network measures are standardized and compared to the other workers in 16 different firms. Following the Borgatti et al. (2018) reasoning that capturing the entire network is, of course, ideal but since the answering a survey is voluntarily it is often hard to get a 100% response rate. This thesis dealt with missing data by focus on who was nominated instead of the ties going out from the nominee. Even though potential nomination are missing, the members of the network could still be analyzed as long as they gave their consent.

The representativeness of the sample data set is, to some extent, questionable. Compared with the microdata set there is a significant smaller share of females. A possible explanation for this is that the survey did only target knowledge workers identified as developers or software engineers, while
the micro data contained all possible occupations linked to this industry, such as HR and sales. These kinds of occupation have traditionally had a higher share of female workers (Mcdowell & Dyson, 2011), which likely explain the difference in gender composition between the sample and the microdata set.

An assumption were made that everyone who answers a survey interprets the questions in the same way – in reality, this simply may not be the case, but, it is necessary to get an overall picture. And the survey used had 87 questions, which was time-consuming, and people tended to skip questions here and there, which led to some omitted cases when running the regressions. Nevertheless, the network measures was standardized and calculated for all the people who gave their consent to the study, therefore one can argue that the omitted cases had marginal effects on the predictions. Especially since the non-parametric test, which included all observations, indicated similar patterns compared to the findings in the regressions analysis.

The regression models, which uses the formal measure as an independent variable, showed tendencies of heteroscedasticity, meaning that the distribution of the standard error was not equal throughout the predicted line. Instead, a funnel shape was visible, indicating that the predictions was less accurate at higher formal measures. This may of course bias the output, something that probably could be avoided if the sample population was larger. However, when looking at the residual plot (see appendix) one can confirm that even though the slope of the predicted line could change, the intercept and the general pattern would still be the same - the informal measure is thus positively associated with the formal measure.

7.5 Future research
The main finding of this thesis highlights the importance of incorporating a worker perspective, addressing gender issues as well as social reproduction into the research agenda of the regional learning and innovation literature. Addressing dimensions of social reproduction is only made indirectly through the analysis of the informal network. Hence, suggestions for future studies targets the use of variables representing such as, family status, number children, parental leave, to examine how the work-life balance might impact regional economic growth and development.

The guiding principles of the relational economic geography framework, could not be in detail investigated done due to narrow time frame. Most effort targeted the understanding of ICT-industry context of Umeå. Future studies on the current topic are therefore recommended to conduct more comprehensive investigations of the relational frameworks principles. For instance, analyzing policy documents and regional development goals would provide an understanding for how the institutional landscape has affected the development of this part of the economy, an understanding that is necessary for future policymaking and development goals.

In terms of understanding the patterns of gender inequalities at within the knowledge economy, qualitative studies need to be carried out. A suggestion is to conduct interviews that capture the worker’s experience of how these discriminatory practices operate and are embedded in everyday life. And, compare and potential findings with qualitative studies similar to this thesis; this would bridge the modeled reality with the experience of the real world, thus, generate a more comprehensive understanding of social exclusion of female workers, and gender inequalities at in knowledge intensive industries.
8 Conclusion
The aim of the present thesis was to examine whether female workers in the knowledge economy are experience any constraints at their workplaces, constraints that might be embedded within formal and informal networks where workers interact with each other.

This thesis has identified that females are less likely to be integrated into the informal network at their workplaces compared to their male co-workers, while at the same time females, in general, need a higher socialization ‘measure’ than males to occupy a more influential position in the formal network. Which, indicates that constraints and discriminatory practices are embedded within the analyzed networks at the ICT workplaces. Further, this pattern of social exclusion could be interpreted like females are excluded from top networks and informal relationships that are somewhat necessary for further career advancement. The thesis has also shown that Umeå as a region has provided a fruitful and growth stimulating environment for ICT-firms to prosper and facilitate innovation. While at the same time, Umeå been more successful than the national average of the ICT-industry of integrating female knowledge workers.

Even though Umeå represents one of the better cases when it comes to integrating females in the knowledge economy, this thesis has identified constraints for the female worker embedded within the intra-firm social network of the ICT-industry. This implies that other regions are probably worse off than Umeå when it comes to integrating females in to knowledge creation activities. Taken together, the results from the thesis suggest that males and females are likely to engage differently in relational networks of the knowledge economy, which acknowledge that the dynamics of regional learning mechanisms are far more complex than the mainstream claims of the regional learning and innovation literature. Which, arguably highlights the importance of applying a gender as well as a workers perspective to future research and policy making.

The generalizability of these results is subject to certain limitations. For instance, the representativeness of the sample data set is to some extent, questionable. Compared with the microdata set there is a significantly smaller share of females. A possible explanation for this is that the survey did only target knowledge workers identified as developers or software engineers. While the microdata contained all possible occupations linked to this industry, such as HR and sales. However, with an 80 % participation rate of the surveys and sample population over 200 individuals, the findings from the statistical analysis should be taken seriously.

Considerably more work will need to be done to determine how the dynamics of an individual choice of the worker, gender differences and a work-life balance that involves social reproduction affect regional economic development in the knowledge economy. Future studies are recommended to explore this topic with qualitative methods, how embedded constraints and discriminatory practices are experienced by the knowledge worker.
References

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doi:10.1016/S1574-0080(04)80018-X


doi:10.1093/jeg/lbu027


Appendix

Table 1: Bivariate table showing pairwise correlation among network centrality score and demographic characteristics.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Network characteristic</th>
<th>Demographic characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Formal measure</td>
<td>Informal measure</td>
</tr>
<tr>
<td>Centrality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formal measure</td>
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<td></td>
</tr>
<tr>
<td>Informal measure</td>
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<td>1.0000</td>
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<td>Demographic</td>
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<td></td>
</tr>
<tr>
<td>Gender</td>
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<td>0.0414</td>
</tr>
<tr>
<td>Education</td>
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<td>0.0623</td>
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<td>Age</td>
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<td>-0.0358</td>
</tr>
<tr>
<td>Position</td>
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<td>-0.0077</td>
</tr>
</tbody>
</table>

Figure 1: Cumulative distribution function, showing formal measure vs. informal measure.