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What does labor mobility tell us about skill relatedness and knowledge spillovers?

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Industry restructuring in the ICT sector – What does labor mobility tell us about skill relatedness and knowledge spillovers?

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Abstract:
Industries go through different phases of evolution where old skills become obsolete and new skills are crucial for the industrial renewal process. Industry evolution is usually addressed from the perspectives of production and exports, leaving one factor largely unexplored: human capital. Industry restructuring is a dynamic process where skills developed in one industry move to other industries as individuals change employers. We argue that the labor flows between industries reveal skill relatedness because individuals move to industries that value their existing skills. We also argue that the labor flows differ between high- and low-skill labor. By examining these flows, we can identify spillover effects between industries during restructuring. To address this argument, we analyze all individual-level labor flows originating from the Finnish ICT sector for 1989-2010. This industry sector-level study focuses on three ICT industries (manufacturing, services and software), and we address the differences in labor mobility between the individuals with different professional skill levels. We find several differences in the labor market dynamics over time for each ICT industry and for the different skill levels.

Key words: labor mobility, skill relatedness, ICT sector, knowledge spillovers
JEL: J24, J21, J62

Tiivistelmä:
Toimialat käyvät läpi eri kehitysvaiheita, joissa kussakin olemassa osaamisen merkitys vähenee ja uusi osaaminen on keskeisemmässä asemassa toimialojen uudistumisprosessissa. Aiemmissa tutkimuksissa toimialojen kehitysvaiheita on tarkasteltu erityisesti tuotannon ja viennin näkökulmasta, jättäen yhden teeman pienemmälle huomiolle – henkinen pääoma. Toimialojen uudistuminen on dynaaminen prosessi, jossa yhdellä toimialalle tuotettu osaaminen siirtyy muille toimialoille työntekijöiden vaihtaessa työpaikkaa. Tässä raportissa tarkastellaan työvoimavirtojen eri toimialojen välillä paljastaen toimialojen välisiä riippuvuussuhteita. Tarkastelussa ovat myös korkean ja alhaisen osaaminen eroavaisuudet työvoimavirroissa. Työvoimavirtojen kautta voidaan tunnistaa toimialojen välisiä ulkoisvaikutuksia rakennemuutoksen eri vaiheissa. Tutkimuksessa käytetään yksilötason aineistoa Suomen ICT-teollisuudesta vuosilta 1989–2010. Tarkastelussa ovat erityisesti ICT-sektorin keskeisimmät toimialat: valmistus, palvelut ja ohjelmistokehitys. Tulosten pohjalta voidaan todeta, että työvoimavirroissa on huomattavia eroja toimialojen ja osaamistasojen välillä.

Avainsanat: työvoiman liikkuvuus, riippuvuussuhteet, ICT sektori, ulkoisvaikutukset
JEL: J24, J21, J62

1. Introduction

This paper analyzes how an industrial sector restructures over a period of two decades. Our perspective is labor mobility and related labor flows between different industries. We argue that these flows represent skill relatedness and knowledge spillovers between industries that are crucial elements in understanding the industry restructuring process. We use detailed employee-level data on the ICT sector in Finland to illustrate the patterns and trends of labor flows and skill relatedness. Our case study sheds light on the current policy-relevant issue of how ICT-related knowledge, in the form of human capital, spreads in a national economy, a question that is relevant for all industrialized countries. The analysis provides insights into an important, but often neglected, mechanism of human-capital-based knowledge spillovers. The findings of our research help policy makers to understand and anticipate the dynamics of industry-level restructuring and to identify the differences in the skill-level-based labor markets, as high and low skill labor have very different dynamics.

The ICT industry, like many other industries, has gone through different phases of evolution where part of the human capital embodied skills become obsolete and new skills are necessary for the renewal process. These phases of evolution are emergence, growth, steady state, and decline. The renewal process becomes timely during the steady state stage where the growth potential is exhausted and new sources of growth are called for. If new sources are difficult to identify, the decline phase starts where resources (e.g. capital and labor), start to find better opportunities, which leads to industry-level restructuring. One of the most recent examples of a sector where the restructuring and renewal process has been rapid is the global ICT sector.

During the last two decades, the ICT sector has witnessed a significant overhaul as new countries and regions have entered the market with novel products and services. The sector globally employs people with diverse skills ranging from manufacturing to R&D. The tendency for U.S. and European firms has been to move away from manufacturing activities, now largely outsourced to China and other parts of Asia, toward upstream activities such as design and R&D. For the leading firms in the ICT sector, this change in market dynamics has led to a rapid adjustment process, particularly in the ICT manufacturing industry. This industry overhaul has resulted in major structural changes, particularly in countries where ICT industries have had a significant role in the national economy.

An example of a country where the ICT sector has played a vital role in the national economy is Finland. Finland has a long tradition in ICT, particularly in telecommunications and mobile

phones; however, during the last decade, globalization, intensified competition, and failed business strategies have resulted in significant industry-level changes, which have had a major impact on a national level. The ICT sector in Finland over the past two decades has moved away from manufacturing activities toward high value-added activities, such as R&D and software development. These changes have had a profound impact on the labor markets, even outside the ICT sector.

In this study, we provide insights into the restructuring process by analyzing the labor market dynamics of the ICT sector in Finland during 1989-2010. The sector has played a major role in the Finnish economy, largely due to Nokia's success in telecommunications. In recent years, the whole sector has gone through a significant restructuring process originating from various failures in Nokia's business strategy and enhanced by the global financial crisis that started in 2008. The rapid evolution of the Finnish ICT sector makes it an interesting case study that illustrates the restructuring process and the impact of this process on other sectors. In this paper, we focus on the labor structure of the Finnish ICT sector because labor mobility provides information on the skill relatedness between different industries. Our underlying argument is that skills developed in one industry are useful in other industries. If not, the obsolete skills lead to less desirable employment options, such as unemployment. We show that labor flows form a pattern that connects different industries through their skill relatedness. Furthermore, we argue that the restructuring process and associated labor flows are different for high-skill labor (i.e., university graduates) and low-skill labor (i.e., non-university educated), thus leading to two distinct labor markets with different dynamics.

We build our analysis on recent research that addresses the skill relatedness between different industries, focusing on human capital and labor mobility (Maliranta & Nikulainen, 2008; Neffke & Henning, 2013). These papers state that if individuals can easily move from one industry to another, the industries are likely to draw upon similar skills. Based on this argument, we identify in this study the inter-industry labor flows that provide insights into the skill relatedness and related knowledge spillovers between different industries inside and outside the ICT sector.

The contribution of the aforementioned papers and the current paper is that they focus on the mobility of human capital. Most of the previous research on interaction between industries focuses on the manufacturing sector, and the units of analysis are industrial inputs and outputs. Thus, the role of other sectors and other types of inter-industry connections between different industries has not been well studied. We use the concept of skill relatedness, measured through labor flows, to broaden the analytical perspective from manufacturing to include all industries

covering manufacturing, services, and other destination alternatives, such as the public sector and unemployment. We emphasize the labor market difference-based employees' skill level focusing on the three ICT industries: manufacturing, services and software.

We find significant changes in the inter-industry labor flows originating from the ICT sector during 1989-2010. ICT employment has gone through a major restructuring, which is evident from the increased number of high-skill labor and the decreased number of low- skill labor. Annually, on average 23% of the employees in the ICT sector changed employers (or moved to non-employment), and two-thirds out of these job switches led to outside the ICT sector. The main destinations for the labor flows, outside the ICT sector, are various service industries. The significance of the service industries as destinations increases over time; however, there is a change from traditional service sectors (e.g., wholesale and retail) to specialized business services sectors (e.g., consulting). The increasing role of services coincides with the broader trend where the service sector plays an increasingly significant role in the Finnish economy (Pajarinen et al., 2013). This change toward services is also true for many other manufacturing industries where complementary services are an important source of revenue complementing the product sales (Ali-Yrkkö, 2013).

The remainder of the paper is structured as follows. Section 2 provides an overview of the literature on labor mobility and skill relatedness, and we discuss the previous findings of inter-industry connectivity and labor flows. Section 3 addresses the data and the research setting. Section 4 presents the empirical analysis. Section 5 concludes and provides recommendations for future research.

2. Labor mobility as an indicator of industry and skill relatedness

Three approaches are proposed in the literature for addressing inter-industry relatedness. The first one focuses on economies of scope. Assuming that different industries can be combined into portfolios based on economies of scope among them, relatedness is analyzed as the co-occurrence of industries in different portfolios. Scholars use industry portfolios of firms (Teece et al., 1994; Bryce and Winter, 2009) as well as export profiles (Hidalgo et al., 2007) to identify economies of scope at firm and country levels. These indicators cover many industries, particularly manufacturing industries. However, the portfolio indicators fail to reveal the sources of the similarities in the economies of scope because the focus is on the outcomes of industrial activity.

The second approach addresses the similarities in the resources used in different industries. Whereas the aforementioned portfolio methods observe the outcomes of economies of scope, the resource-based approach focuses on their origins. The interaction of industries is addressed on the basis of final goods, and related input-output tables reveal specific industry linkages and clusters (Daveri & Silva, 2004; Feser & Bergman, 2000; Hill & Brennan, 2000). These studies examine the links between industries based on industry output and input flows; however, the role of labor - human capital - is bypassed. Ignoring human capital is a significant shortcoming because labor embodies intangible capital that is increasingly important in economic growth (Corrado et al., 2005).

The third approach examines the human capital and related labor flows across industries. Inter-industry labor flows occur when an employee leaves a firm in one industry to start a new job in another industry. The decision to move to a new firm depends on two aspects: the attractiveness of the job and the easiness of movement to the job (March & Simon, 1993). The attractiveness depends on how employees see their future work effort against the compensation through financial and other benefits. The easiness of movement depends on the availability of relevant jobs.

The decision to leave not only a firm but also an entire industry provides two insights. First, the easiness of moving to another industry depends on the availability of jobs in the other industry as more jobs are available in larger or faster growing industries. Second, the availability of suitable jobs outside of the original industry depends on the skill match between the old and the new industry. Neffke and Henning (2013) label this skill match as skill relatedness between the industries.

Labor flows are driven by the similarities among the industries' human capital requirements; however, the human capital is sometimes specific to a firm or an industry (Autor et al., 2003). Therefore, changing jobs may render part of an employee's skills obsolete and constrain labor mobility. If an employee moves to an industry that has skill requirements similar to those in the employee's original industry, there is a reduction in the loss of human capital. Thus, we can assume that employers prefer to hire employees who have the required skills for a job. Hence, labor flows are strong between industries that are skill related, and we can argue that this skill relatedness is an important driver of inter-industry labor flows. In the process of industry restructuring, employees with skills relevant to other industries find employment more easily than employees with obsolete skills. The obsolete skills potentially lead to periods of unemployment or retraining to acquire new labor-market-relevant skills.

The skill relatedness between industries has been empirically addressed in two recent efforts (Maliranta & Nikulainen, 2008; Neffke & Henning, 2013). Both studies identify the existence of significant labor flows between industries creating a network of inter-industry flows that reveals skill-related industries. Both papers focus on economy-wide labor flows and emphasize the important role of the flows in understanding industry and labor market dynamics.

Neffke & Henning (2013) use employee-level data on the Swedish economy to identify labor market dynamics. Their aim is to validate a novel research methodology by assessing the degree of skill relatedness between different industries. The authors address the skill relatedness on the employee level and link these results to the firm level. The authors show that companies are more likely to diversify into industries that have ties to the firm's core activities in terms of their skill relatedness measure than into industries without such ties or that are linked by value chain linkages or classification-based relatedness. Their findings indicate that looking at labor-based linkages provides a very different picture of the industry relatedness than can be seen from portfolio or input-output analysis.

The other closely related paper addresses the labor flows through employee-level analysis identifying significant labor flows and linkages between different industries in Finland (Maliranta & Nikulainen, 2008). For example, the authors identify a flow from the "Education" industry through the "Research" industry to the ICT sector. From the ICT sector, there are significant labor flows to the service industries. The limitation of the analysis is the focus on the labor flows from 2000 to 2004, thus omitting labor market dynamics outside these two observation points. In addition, these two years coincide with the steady state period in the ICT sector where restructuring was less prominent compared to previous or later periods. Thus, a longer time series is warranted to consider the industry employment prior and after the two observation years.

Both papers treat the skill level of the labor differently. Neffke & Henning (2013) limit their analysis only to the top half of the employees (management level) and argue that the inclusion of low-skill labor brings unnecessary noise to the analysis. Maliranta & Nikulainen (2008) treat the employees without any stratification and, thus, exclude the potential differences in labor market dynamics.

These limitations of using part of the available data or treating the employees without stratification highlight the need to understand the labor market dynamics in a comparative setting. This

approach allows for the identification of different labor markets for high- and low-skill labor, while keeping all employees in the analysis. Thus, in this study, we complement the aforementioned contributions by *i) addressing the labor flows of the ICT sector for a longer period* and by *ii) considering the differences in the skill level of the employees*.

3. Data and research setting

To address the restructuring of the ICT sector and the sector's skill relatedness to other sectors, we use detailed employee-level data to analyze the labor flows originating from the Finnish ICT sector. The data source is the Finnish Longitudinal Employer-Employee Data (FLEED) constructed at Statistics Finland. This data set links various administrative registers on individuals and firms and covers all working-age individuals (16-70 years), including the self-employed.

The labor flows in the ICT sector are identified based on the employment status. Employees that were employed in an ICT industry firm in year *t-1* and that in year *t* have an employment status in a different firm (or elsewhere) are considered labor flows. The destination of a labor flow is defined based on year t employment (or non-employment).

We define the individual's employment on the basis of the employment status and industry during the last day of the year. Ideally, we would use the main employment status of the year; unfortunately, this information was not available for all years. This fact could potentially lead to a bias if the employment during the last month (or day) of every year would be different from other months of the year. To identify this potential bias, we conducted a background analysis where we focused on the level of unemployment over the years during each month. We found that unemployment is lower in December than in January. This finding provides evidence that using the last day of the employment status is not creating bias toward unemployment.

We also address the labor flows based on the employee's skill level. The skill level is approximated by the educational background based on classifications by Statistics Finland. The employees with a university degree (bachelors or higher) are perceived as highly educated with potentially specialized skill sets and potentially having different labor market dynamics than less educated (no university degree) employees with potentially non-specialized, generic skill sets. In the remainder of the paper, we label the employees with a university degree as high-skill labor and the rest as low-skill labor. We acknowledge that this approximation does not always hold true because employees with low education may have very high levels of skills; however, we assume that education and the level of skill specialization are closely related.

We divide the ICT sector into three industries: ICT-related manufacturing, ICT-related services, and software. The standardized industry classifications and their concordance with the subsector definitions are listed in Table 1. We also consider a variety of different destinations for the labor flows, including both employment and non-employment options. The destinations include ICT, primary production, manufacturing, services, non-private employment and non-employment. The full list of destinations is presented in Table 2.

Table 1. Definition of the ICT industry (NACE rev. 2)

Main sector	**Industry name**	**Industry code**
ICT manufacturing	Manufacture of electronic components and boards	261
	Manufacture of computers and peripheral equipment	262
	Manufacture of communication equipment	263
	Manufacture of consumer electronics	264
	Manufacture of magnetic and optical media	268
	Repair of computers and communication equipment	951
ICT services	Telecommunications	61
	Data processing, hosting and related activities; web portals	631
Software	Computer programming, consultancy and related activities	62
	Software publishing	582

Table 2. Destinations from the ICT sector

ICT sector
ICT manufacturing
ICT services
ICT software
Primary production
Agriculture, forestry and fishing
Mining and quarrying
Manufacturing
Manufacture of food, beverages and tobacco products
Manufacture of textiles, wearing apparel and leather products
Manufacture of wood and paper products, and printing
Manufacture chemical, pharmaceuticals, rubber and non-metallic products
Manufacture of metals and metal products
Manufacture of computer and electrical products
Manufacture of machinery and transport equipment
Manufacturing – other
Services
Repair services
Utilities
Construction
Wholesale and retail
Transport
Accommodation and restaurant
Media
Information and financial services
Other business services
Other services
Healthcare
Leisure services
Non-private sectors
Employment in non-private sectors
Non-employment
Unemployed
Retired
Student
Military
Other

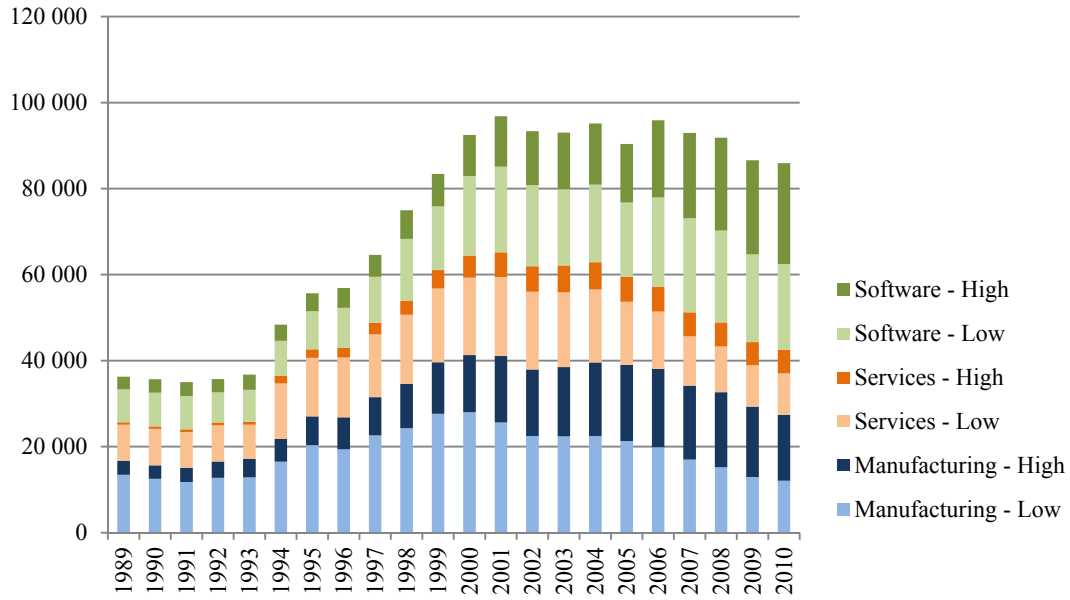
As mentioned above, we focus on the labor flows from and within the ICT sector. The last category of non-employment includes labor flows to unemployment, education and retirement. The labor flows to different industries suggest skill relatedness, whereas labor flows to non-employment suggest potential skill redundancy, indicating that the individuals have less relevant skills with low demand in the labor market.

4. Empirical analysis and results

4.1. Employment in the ICT sector

In this study, we focus on the labor mobility from the ICT sector during 1989-2010. This lengthy time period consists of various phases from the emergence of the ICT sector in the 1990s to the slowdown in the latter part of the 2000s. This evolution can be depicted by observing the sector's employment. The number of employed persons in the Finnish ICT sector was approximately 40,000 in the early 1990s and peaked at approximately 100,000 in the early 2000s. Furthermore, the change in skill levels is evident in all three industries (Figure 1).

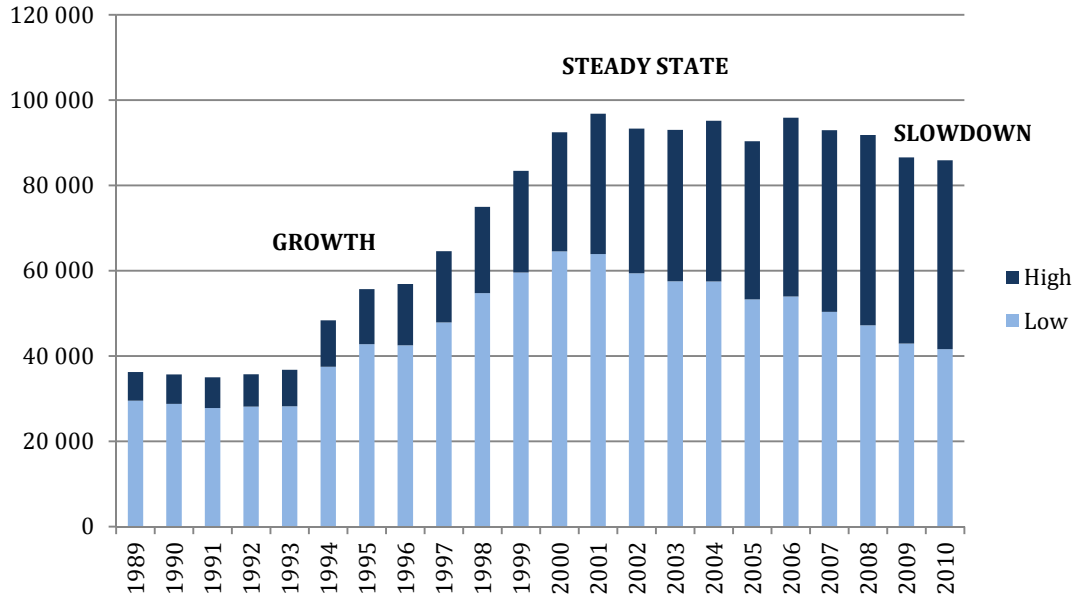
Figure 1. Employment in the ICT sector 1989-2010 (by industry and skill level)



The reason for the decreasing trend in employment after 2000 is the decline of ICT manufacturing and ICT services (e.g., telecommunication services). Only the software industry is increasing its share of the total ICT sector employment from less than 30% in the early 2000s to approximately 50% in the latter part of the 2000s. This trend is a result of changes in the global market dynamics, where manufacturing is moving to low-cost countries and part of the services are becoming commoditized due to new technologies that are less labor intensive. Overall, the ICT sector has become increasingly focused on high-skill tasks, such as R&D and software development. This change is clearly visible when looking at the distribution of skill levels in the whole ICT sector (Figure 2). The share of employees with a high skill level was 23% during 1989-1999,

39% during 2000-2007, and 50% during 2008-2010. These percentages illustrate a rapid structural change in the sector.

Figure 2. Employment by skill level



Following the trend of employment, in the remainder of the paper, we present our results using three periods. The periods represent different stages of the ICT sector in Finland. The period of 1989-1999 was the era of emergence and strong growth led by Nokia and its surrounding cluster. The period of 2000-2007 represents the steady state ending with the first signs of Nokia's troubles in maintaining its global market position. The last period of 2008-2010 is the time when the whole ICT sector started to experience major problems as a result of Nokia's weakening position.

4.2. Shares of labor mobility

Before addressing the labor flow destinations in more detail, we should identify how common these labor flows are. In Table 3, we present the shares of ICT sector employees that have changed their employment status in one of the ICT subsectors, and we differentiate between high- and low-skill labor.

Table 3. Share of employees changing employment status in the ICT sector (%; averages)

Share of flows	1989-1999	2000-2007	2008-2010	ALL
Manufacturing - High	19%	17%	11%	17%
Manufacturing – Low	**24%**	**25%**	**19%**	**23%**
Services - High	**16%**	29%	21%	**21%**
Services – Low	15%	**29%**	**22%**	21%
Software - High	25%	23%	19%	23%
Software – Low	**27%**	**24%**	**20%**	**25%**
High	21%	22%	16%	21%
Low	**22%**	**26%**	**20%**	**23%**

Bolded values indicate the higher value between the high- and low-skill levels.

In Table 3, we included all labor flows, both within and outside each of the three industries. The share of employees leaving an ICT firm was, annually, on average 23% of the total sector employment during 1989-2010. When looking at the share of employees leaving a firm in the ICT sector, we can see that the employees with a low skill level are marginally more likely to change employment. There are differences between the industries. In manufacturing, low-skill labor is more likely to change employment; however, in services and software, the skill level matters less. We do not see significant differences across time.

While the share of employees leaving an ICT firm reveals the overall development, we are more interested in the employees that leave their respective industry. Thus, we exclude within-industry flows in the remainder of this study and focus on the labor flows between the three industries and flows outside the ICT sector (Table 4).

Table 4. Share of departing employees leaving their original industry (%; averages)

Share of outside flows	1989-1999	2000-2007	2008-2010	ALL
Manufacturing - High	63%	69%	**91%**	69%
Manufacturing – Low	**74%**	**74%**	90%	**76%**
Services - High	73%	59%	81%	69%
Services – Low	**78%**	**61%**	**82%**	**72%**
Software - High	64%	64%	62%	64%
Software – Low	**71%**	**70%**	**67%**	**70%**
High	61%	59%	72%	62%
Low	**71%**	**66%**	**77%**	**70%**

Bolded values indicate the higher value between the high and low skill levels.

Table 4 shows the differences over the periods for each industry and skill level. Overall, approximately two-thirds of the labor flows are going to outside of the original industry. The industry-

specific results show that in manufacturing, during the last period, the labor flows were going heavily to outside of the industry (approximately 90%). For ICT services, the change is similar to ICT manufacturing, with somewhat lower shares of outside labor flows in the last period. For the software industry, the share of outside labor flows is fairly stable across all periods. Thus, we identify significant changes between the industries and over time.

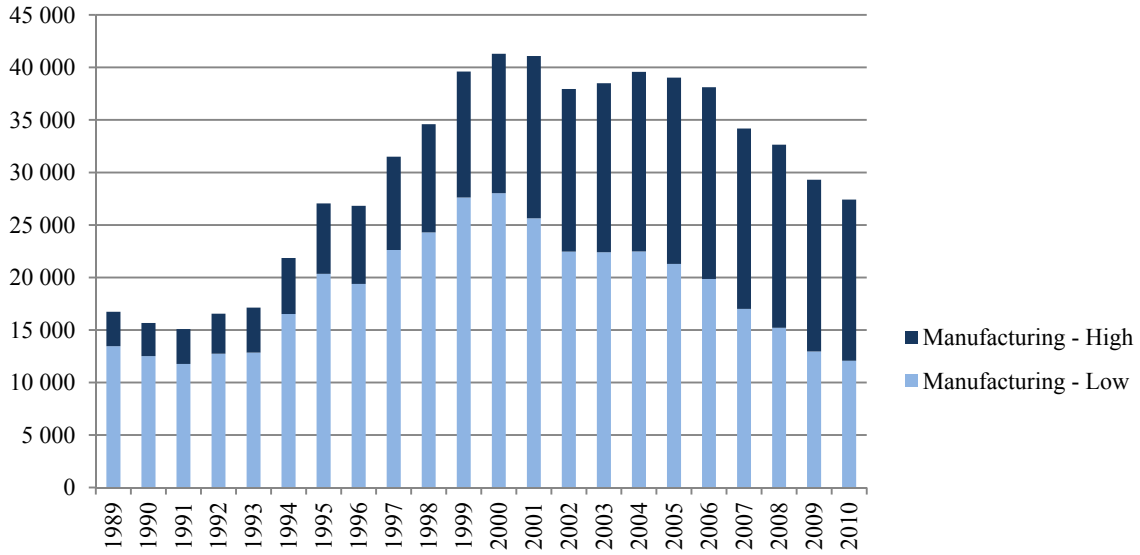
Regarding the differences between the skill levels, the results show that employees with a low skill level are marginally more likely to move to outside-ICT destinations. To discuss the destinations and differences between the skill levels in detail, in the following, we address the labor flows of each originating industry separately.

4.3. Destinations of the labor flows

4.3.1. Destinations for ICT manufacturing

Before discussing the destinations of the labor flow from ICT manufacturing, it is useful to examine the trend of employment in the industry (Figure 3). ICT manufacturing has gone through a significant structural change as evident in the employment structure of the industry. We observe two distinct trends; growth and decline of the overall employment and the decreasing number of low-skill labor.

Figure 3. Employment in ICT manufacturing



In the following, we focus on the destination of the employees leaving the manufacturing industry. Table 5 represents the share of each labor flow destination originating from the ICT manufacturing sector. We have excluded the internal labor flows within the industry to highlight the outflows. The results are averages for each period, and labor flows higher than 5% of the total flow are highlighted.

Table 5. Destinations of labor outflows from ICT manufacturing

	HIGH SKILL			LOW SKILL		
Period	89-99	00-07	08-10	89-99	00-07	08-10
ICT						
Manufacturing	--	--	--	--	--	--
Services	4%	2%	1%	1%	1%	1%
Software	12%	15%	11%	6%	3%	4%
PRIMARY PRODUCTION						
Agriculture, forestry and fishing	0%	0%	0%	0%	0%	0%
Mining and quarrying	0%	0%	0%	0%	0%	0%
MANUFACTURING						
Food, beverages and tobacco products	0%	0%	0%	0%	0%	0%
Textiles, wearing apparel and leather	0%	0%	0%	0%	0%	0%
Wood and paper products, and printing	1%	1%	0%	1%	1%	0%
Petroleum, chemical, pharma, and rubber	1%	2%	1%	1%	4%	1%
Metals and metal products	2%	2%	1%	4%	4%	1%
Electrical products	10%	5%	5%	8%	5%	12%
Machinery and transport equipment	2%	3%	3%	2%	3%	1%
Other	1%	0%	0%	1%	1%	0%
SERVICES						
Repair services	1%	1%	0%	1%	1%	2%
Utilities	0%	0%	0%	0%	0%	0%
Construction	0%	1%	0%	1%	2%	1%
Wholesale and retail	14%	9%	4%	9%	8%	6%
Transport	1%	1%	1%	1%	2%	1%
Accommodation and restaurant	0%	0%	0%	1%	1%	1%
Media	0%	0%	0%	0%	0%	0%
Information and financial services	4%	1%	1%	1%	0%	0%
Other business services	7%	13%	12%	1%	3%	4%
Other services	1%	2%	3%	1%	4%	5%
Healthcare	0%	0%	0%	0%	0%	1%
Leisure services	1%	1%	1%	0%	1%	1%
NON-PRIVATE EMPLOYMENT						
Employment elsewhere	13%	11%	16%	11%	7%	7%
NON-EMPLOYMENT						
Unemployed	7%	10%	20%	23%	26%	30%
Retired	1%	1%	2%	2%	2%	4%
Student	4%	5%	6%	13%	14%	10%
Military	2%	1%	0%	2%	1%	1%
Other	12%	12%	9%	8%	7%	6%
TOTAL	100%	100%	100%	100%	100%	100%

Note: *'dark grey'* marks the destinations where the share of flows is 10% or higher during any of the periods, and *'light grey'* marks the destinations where the share of flows is 5%-10% during any of the periods.

Looking first at destinations within the ICT sector, the results show significant skill relatedness between the manufacturing and software industries for high-skill labor but not for low-skill labor. Interestingly, software is a skill-related ICT destination for high-skill labor only, suggest-

ing that only highly specialized skills are in demand. The demand for high-skill labor is explained by the rapid growth of the software industry. Furthermore, the lack of ties of low-skill labor to other ICT industries is the first indication of the within-sector skill redundancy.

For the non-ICT manufacturing industries, only manufacturing of electrical products (excluding computers) is a major destination for both educational levels. However, its significance diminishes over time for high-skill labor, whereas for low-skill labor, electronics manufacturing has an increasing importance. Because ICT manufacturing and electronics manufacturing often are closely related and rely on similar skill sets, we are not surprised to find this connection.

For the service sector industries, wholesale and retail are significant destinations, partly explained by their large size. For high-skill labor, the wholesale and retail industry played a significant role until the last observation period, and for low-skilled labor, the industry has maintained its significance. The most striking change in the labor flow destinations is the emergence of the other business services industry as a very significant destination for high-skill labor. Its increased importance is explained by the composition of the business services industry that includes management consultancy, engineering activities (technical testing and analysis), and advertising and market research. This result shows that high-skill labor has unique opportunities for specialized expert-level employment based on the specific nature of the required skill sets, whereas the generic nature of the skill sets for low-skill labor directs their labor flows to less-specialized tasks. Furthermore, employment outside the private sector is a major destination for both high- and low-skill labor. Non-private sector employment consists mainly of public sector employers and non-profit organizations.

Examining the non-employment destinations, we see interesting developments. For high-skill labor, unemployment increases significantly over time. This trend is a clear change in the labor market and an obvious sign of decreasing skill relatedness and increasing skill redundancy. The same is true for low-skill labor; however, for low-skill labor, unemployment is common during all periods, with an increase in the last period. Another indicator of the skill mismatch is the need for education. Individuals with obsolete skills are inclined to retrain themselves to have better employment opportunities.

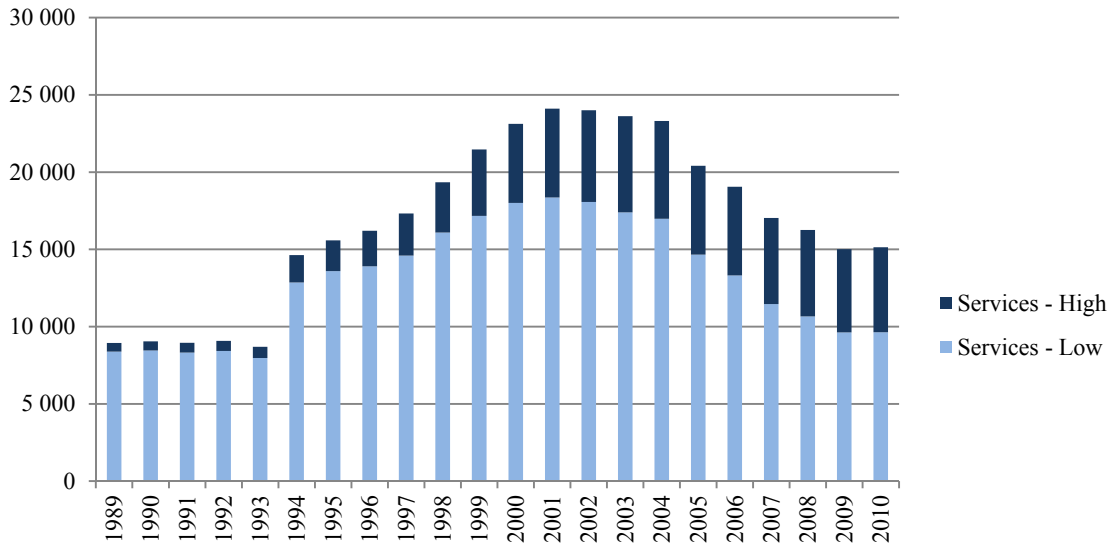
To summarize the findings for ICT manufacturing, we find that the main destinations for high-skill labor are software, decreasingly wholesale and retail, and increasingly specialized business services and unemployment. For low-skill labor, the main destinations are increasingly manufacturing of electrical products (excluding computers), wholesale and retail, unemployment, and

studying. The changes indicate significant industry-level restructuring with a high level of skill redundancy. Furthermore, we now have the first evidence of two distinctly separate labor markets for high- and low-skill labor.

4.3.2. Destinations for ICT services

The ICT service industry consists of telecommunications, data processing, hosting and related activities including web portals. Thus, ICT services are typically infrastructure-oriented services building on products bought from the ICT manufacturing sector and, thus, represent a different part of the value chain. Before addressing the labor outflows from the ICT service industry, let us again examine the trend in employment.

Figure 4. Employment in ICT services



Similar to the ICT manufacturing industry, we identify a growth and a decline in the ICT service industry employment. The skill-level distribution also follows the ICT manufacturing industry because the number of high-skill labor increases in the last years. A noteworthy observation is that the share of high-skill labor is lower in services than in manufacturing. This finding raises the question to what extent the destinations and skill redundancies in services differ from manufacturing.

In the following, we focus on the labor flows originating from the ICT services sector (Table 6). We have excluded the internal labor within the service industry to highlight the external flows.

The results are averages for each period, and labor flows higher than 5% of total flows are highlighted.

Table 6. Destinations of labor flows from ICT services

	HIGH SKILL			LOW SKILL		
Period	89-99	00-07	08-10	89-99	00-07	08-10
ICT						
Manufacturing	11%	4%	1%	1%	1%	1%
Services	--	--	--	--	--	--
Software	7%	30%	19%	2%	13%	10%
PRIMARY PRODUCTION						
Agriculture, forestry and fishing	0%	0%	0%	0%	0%	0%
Mining and quarrying	0%	0%	0%	0%	0%	0%
MANUFACTURING						
Food, beverages and tobacco products	0%	0%	0%	0%	0%	0%
Textiles, wearing apparel and leather	0%	0%	0%	0%	0%	0%
Wood and paper products, and printing	1%	1%	0%	1%	0%	1%
Petroleum, chemical, pharma, and rubber	0%	1%	0%	0%	0%	0%
Metals and metal products	0%	0%	0%	0%	0%	0%
Electrical products	1%	0%	1%	0%	0%	0%
Machinery and transport equipment	1%	1%	1%	0%	0%	0%
Other	0%	0%	0%	0%	0%	0%
SERVICES						
Repair services	0%	0%	0%	0%	0%	0%
Utilities	0%	0%	1%	0%	0%	0%
Construction	1%	2%	3%	2%	6%	8%
Wholesale and retail	10%	7%	6%	9%	7%	8%
Transport	3%	1%	1%	2%	2%	1%
Accommodation and restaurant	0%	0%	0%	1%	1%	1%
Media	3%	4%	12%	2%	4%	11%
Information and financial services	6%	3%	3%	5%	1%	1%
Other business services	8%	9%	11%	2%	6%	9%
Other services	2%	5%	6%	2%	7%	8%
Healthcare	0%	1%	1%	0%	0%	1%
Leisure services	12%	5%	3%	2%	2%	2%
NON-PRIVATE EMPLOYMENT						
Employment elsewhere	6%	4%	6%	11%	14%	5%
NON-EMPLOYMENT						
Unemployed	10%	11%	12%	22%	14%	17%
Retired	8%	3%	4%	14%	5%	6%
Student	4%	4%	4%	11%	10%	7%
Military	1%	0%	0%	2%	1%	1%
Other	4%	3%	3%	7%	3%	3%
TOTAL	100%	100%	100%	100%	100%	100%

Note: *'dark grey'* marks the destinations where the share of flows is 10% or higher during any of the periods, and *'light grey'* marks the destinations where the share of flows is 5%-10% during any of the periods.

Although the employment trends between ICT manufacturing and ICT services appear to follow a similar path, the results differ significantly in labor flows. We identify significant labor flows from the ICT service industry to the software industry for both high- and low-skill labor. The share of labor flows to software, for high-skill labor, accounts for 30% of all outside flows from ICT services during the steady state period of 2000-2007. This result indicates very strong skill relatedness between these two industries.

Non-ICT manufacturing activities do not play a role in the ICT-services labor flows; however, the service sector plays a significant role. The destinations in the service sector from the ICT service industry are decreasingly wholesale and retail for both skill levels, increasingly construction for low-skill labor; the media for both skill levels during the last period, increasingly other business services (i.e., management consultancy, engineering activities (technical testing and analysis), and advertising and market research), particularly for high skill labor; and other services (i.e., employee outsourcing services and administrative support activities).

The main difference between ICT service industry and the ICT manufacturing industry lies in the changes in importance of specific service sector destinations. With ICT services, the destinations are diversified over time with significant flows to high productivity areas, such as consultancy and media industries. Wholesale and retail are a diminishing destination, and interestingly, the construction industry is becoming a more significant destination. The importance of the construction industry, as a labor flow destination, relates to outsourcing activities. The ICT services sector covers telecommunication services where firms traditionally have built their own network infrastructure with in-house resources. This division of labor changed over time as the telecommunications firms outsourced most of the infrastructure work to outside contractors. Furthermore, these contractors are classified within the construction industry. Thus, our finding is explained by the workers building the infrastructure, changing firms from telecommunications to construction.

Non-private employment is a significant destination for both skill levels; however, its role has diminished for low-skill labor during the last period. Unfortunately, our data do not allow for the breakdown of this sector as more disaggregated results would provide very interesting insights.

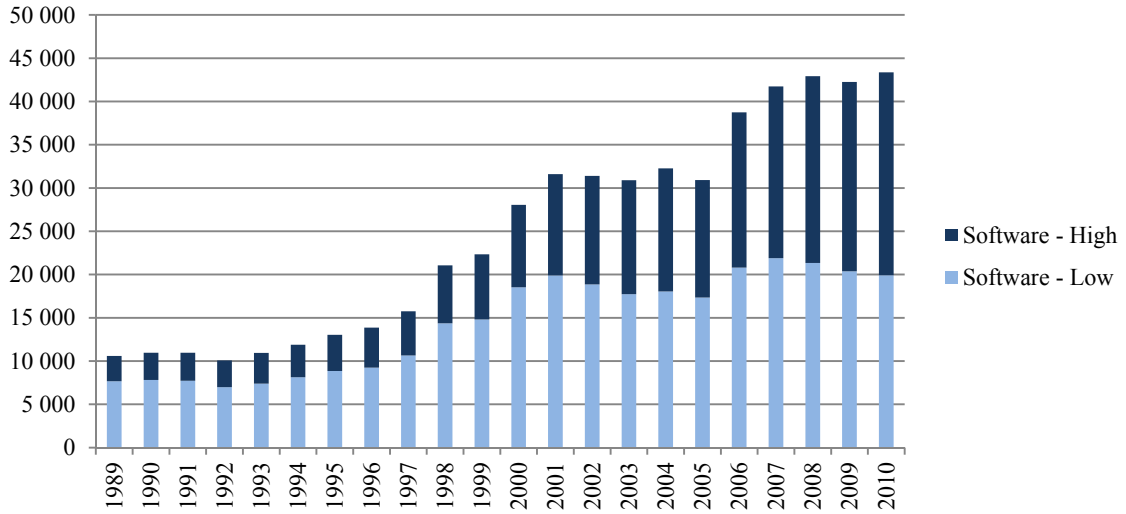
The labor flows to non-employment destinations indicate that unemployment is a major destination for both high- and, particularly, low-skill labor; however, overall unemployment is lower than in ICT manufacturing. Retirement is higher in ICT services than in ICT manufacturing, suggesting that the downward trend in employment of the whole ICT service industry can partly be explained by layoffs and retirements. Some of the employees to be laid off might have been given an opportunity to retire instead of getting fired. Regarding ICT manufacturing, for low-skill labor, studying is a major destination in ICT services.

To summarize the findings for the ICT service industry, we find that the main destinations for high-skill labor are software, decreasingly wholesale and retail, and increasingly media and specialized business services, non-private employment, and unemployment. For low-skill labor, the main destinations are increasingly software, construction, wholesale and retail, media, unemployment, and studying. Regarding ICT manufacturing, we argue that the labor flows indicate a significant restructuring process. Furthermore, this process is different for high- and low-skill labor.

4.3.3. Destinations for software

The software industry consists of computer programming, consultancy, and software publishing. All of these areas have seen a tremendous growth during the last 20 years. This change is also evident in employment figures (Figure 5). This growth applies to both labor skill levels; however, during the last years, the industry has started to increasingly employ high-skill labor, whereas the level of low-skill labor has remained largely on the same level.

Figure 5. Employment in software



Software development typically has high productivity and relies on specialized skills. Over the years, this perception of high productivity has been reinforced by the emergence of an array of new software technologies that have substituted many of the existing hardware solutions and even business models. This employment trend suggests that the outgoing labor flows of the software industry are significantly different from those of ICT manufacturing and service industries.

In the following, we focus on the labor flows originating in the ICT software industry (Table 7). As with the two other ICT industries, we have excluded the internal labor within the software industry to highlight the external flows. The results are averages for each period, and labor flows higher than 5% of the total flow are highlighted.

Table 7. Destinations of labor flows from software

	HIGH SKILL			LOW SKILL		
Period	89-99	00-07	08-10	89-99	00-07	08-10
ICT						
Manufacturing	8%	7%	6%	4%	4%	3%
Services	6%	8%	6%	6%	7%	9%
Software	--	--	--	--	--	--
PRIMARY PRODUCTION						
Agriculture, forestry and fishing	0%	0%	0%	0%	0%	0%
Mining and quarrying	0%	0%	0%	0%	0%	0%
MANUFACTURING						
Food, beverages and tobacco products	1%	0%	0%	0%	0%	0%
Textiles, wearing apparel and leather	0%	0%	0%	0%	0%	0%
Wood and paper products, and printing	1%	1%	1%	2%	1%	0%
Petroleum, chemical, pharma, and rubber	1%	1%	0%	1%	1%	0%
Metals and metal products	0%	0%	0%	0%	0%	0%
Electrical products	2%	1%	2%	1%	1%	1%
Machinery and transport equipment	1%	2%	2%	0%	1%	1%
Other	1%	0%	0%	0%	0%	0%
SERVICES						
Repair services	0%	1%	0%	0%	0%	0%
Utilities	1%	1%	0%	0%	0%	0%
Construction	1%	1%	1%	1%	1%	2%
Wholesale and retail	17%	8%	6%	18%	9%	7%
Transport	1%	1%	1%	1%	2%	1%
Accommodation and restaurant	0%	0%	0%	0%	1%	1%
Media	1%	1%	1%	1%	1%	2%
Information and financial services	6%	4%	3%	5%	3%	3%
Other business services	8%	13%	17%	5%	10%	10%
Other services	3%	4%	5%	3%	5%	5%
Healthcare	0%	0%	1%	0%	0%	1%
Leisure services	1%	1%	2%	1%	1%	2%
NON-PRIVATE EMPLOYMENT						
Employment elsewhere	22%	23%	15%	16%	18%	12%
NON-EMPLOYMENT						
Unemployed	11%	12%	16%	16%	12%	15%
Retired	1%	2%	3%	1%	3%	5%
Student	3%	5%	5%	10%	13%	10%
Military	1%	0%	0%	1%	2%	1%
Other	4%	4%	4%	5%	5%	7%
TOTAL	100%	100%	100%	100%	100%	100%

Note: *'dark grey'* marks the destinations where the share of flows is 10% or higher during any of the periods, and *'light grey'* marks the destinations where the share of flows is 5%-10% during any of the periods.

The results of the ICT software industry show that there are significant labor flows to the other two ICT industries. Both industries are minor destinations for high-skill labor, and for low-skill labor, only the ICT service industry is a minor destination. This result indicates the critical role

software plays for the other ICT industries because software development is the joining element between all three industries.

Regarding ICT manufacturing and ICT services, the non-ICT manufacturing industries are not significant destinations for employees with software industry experience. The labor flows from the software industry to the services sector show a decreasing importance of wholesale and retail and an increasing role of other business services (i.e., management consultancy and advertising and market research). The importance of the wholesale and retail industries has dropped significantly over the years for both skill levels; however, these industries remain an important destination. The destination that is gaining the most significance over the periods is the other business services sector, where the lead industries are management consultancy, engineering activities (technical testing and analysis), and advertising and market research.

We find a decrease in non-private employment and a relatively low and steady level of unemployment; furthermore, for low-skill labor, the role of education is important, similar to other ICT industries. Unemployment is clearly on a lower level than in ICT manufacturing and ICT services and is particularly low during the peak of the ICT sector (2000-07). For both high- and, particularly, low-skill labor, education is a significant destination.

To summarize the findings for the software industry, we find that the main destinations for high-skill labor are ICT manufacturing and services; decreasingly wholesale and retail and non-private employment; and increasingly specialized business services and unemployment. For low-skill labor, the main destinations are ICT services, decreasingly wholesale and retail, and increasingly business and other services, non-private employment, unemployment, and studying. Based on the trends of unemployment and education, we argue that restructuring in the software industry is significantly lower than in the other two ICT industries. The software industry appears to experience restructuring due to partial skill redundancy that leads to retraining, rather than major skill redundancy that results in unemployment.

5. Discussion and conclusions

This study examines the human capital-based links between different industries. The approach and findings of this study complement earlier research on labor flows on a national-economy level (Maliranta & Nikulainen, 2008; Neffke & Henning, 2013). These insightful studies identified intensive within- and between-industry labor flows revealing a new perspective on labor

market and industry dynamics. In this paper, we take a specific case study approach. We zoom into a single industry sector to understand its labor market dynamics and related knowledge spillovers in greater detail.

The results show that employment in the ICT sector increased significantly during the 1990s, remained fairly stable in the mid/early 2000s, and started to gradually decline toward the end of the decade. The sector has gone through an internal restructuring where low skill-labor step by step has been replaced by high-skill labor. In the three ICT industries (manufacturing, services and software), employment has seen different trends. Employment in manufacturing and service industries has declined in recent years, whereas in the software industry, employment has increased significantly.

The destinations of labor flows change over time, indicating unique labor market characteristics. This paper shows that the skill relatedness differs in each of the ICT industries. Software skills are in high demand, whereas skills in manufacturing and services are less relevant, resulting in labor adjustments through periods of unemployment. The increasing unemployment indicates that some of the skills are not applicable outside the original industry.

Furthermore, we find that a significant share of the labor outflows ends up in the service sector. As in many other developed countries, in Finland, there is an ongoing structural change toward a service-based economy. Already, over half of the service sector employees work on demanding expert and management tasks, and particularly, the demand for high-skill professionals is expected to increase also in the coming years (Pajarinen, et. al, 2013). The demand for high-skill labor in the service sector is also evident in our analysis because we find a change in destinations for ICT labor flows from traditional service sectors (e.g., wholesale and retail) to specialized business services sectors (e.g., consulting).

This paper provided many insights for the discussion of industry restructuring and labor market dynamics in the ICT sector but also raised many questions that require more emphasis in future research. This study analyzes the case of a single industry sector. To broaden our understanding of industrial renewal processes and related knowledge spillovers, more industry sectors and different contexts should be covered. We hope that the efforts and method presented here not only provide unique insights but also illustrate to decision makers the relevance of identifying the differences in labor market dynamics for different industries and labor skill levels.

References

Ali-Yrkkö, J. (2013): ”Mysteeri avautuu. Suomi globaaleissa arvoverkoissa”, ETLA B 257.

Autor, DH. – Levy, F. – Murnane, RJ. (2003): “The skill content of recent technological change: an empirical exploration”, Quarterly Journal of Economics 118: 1279–1333.

Bryce, DJ. – Winter, SG. (2009): “A general inter-industry relatedness index”, Management Science 55: 1570–1585.

Corrado, C. A. - Hulten, C. R. - Sichel, D. E. (2005): “Measuring Capital and Technology: An Expanded Framework”, In C. Corrado, J. Haltiwanger & D. Sichel (Eds.), Measuring Capital in the New Economy. NBER Studies in Income and Wealth, Volume 65.

Daveri, F. - Silva, O. (2004): “Not only Nokia: what Finland tells us about new economy growth”, Economic Policy, 19(38), 117-163.

Feser, E. J. - Bergman, E. M. (2000): “National Industry Clusters Templates: A Framework for Applied Regional Cluster Analysis”, Regional Studies, 34(1), 1-19.

Hidalgo, CA. – Klinger, B. – Barabasi, A-L. – Hausmann, R. (2007): “The product space conditions the development of nations”, Science 317: 482–487.

Hill, E. W. - Brennan, J. F. (2000): “A Methodology for Identifying the Drivers of Industrial Clusters: The Foundation of Regional Competitive Advantage”, Economic Development Quarterly, 14(1), 65-96.

Maliranta, M. - Nikulainen, T. (2008): "Labour Force Paths as Industry Linkages: A Perspective on Clusters and Industry Life Cycles", ETLA Discussion Papers 1168.

March, JG. – Simon, HA. (1993): “Organizations”, (2nd edition). Blackwell Publishers: Cambridge, MA.

Neffke, F. - Henning, M. (2013): “Skill relatedness and firm diversification”. Strategic Management Journal 34: 297–316.

Pajarinen, M. - Rouvinen, P. - Ylä-Anttila, P. (2013): “Services: A New Source of Value”, ETLA Brief Nr. 11.

Teece, DJ – Rumelt, R, - Dosi, G. – Winter, S. (1994): “Understanding corporate coherence -Theory and evidence”, Journal of Economic Behavior and Organization 23: 1–30.