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KNOWLEDGE AND INNOVATION SUBSIDIES AS ENGINES FOR GROWTH –

The Competitiveness of Finnish Regions

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ABSTRACT: The starting point for the analysis is that the GDP and productivity growth have diverged between regions since 1995. An important part of the growth process is catching-up the firm leading in productivity. We find that in the Finnish economy catching-up has been limited at the NUTS 4-level because it takes place predominantly in small companies and not in large or mature companies. The divergence in productivity growth is explained by the agglomeration of knowledge capital. A micro study at the company level shows solid evidence that growth driven by knowledge capital relies on education and occupation human capital and on agglomeration. Companies with highly paid occupations grow more rapidly. Education human capital plays the most significant role in very advanced companies near the frontier in productivity. The accessibility of educated workforce is also important. R&D investments appear to inherit global spillover characteristics, while regional spillovers are not as important.

Next we study employment and productivity growth explained by public funding of R&D by The National Technology Agency, Tekes, using the same micro-level linked employer-employee data. Both employment and productivity growth are fast in human capital intensive companies and regions. This and the increase of the rate of return on R&D research over the decades provides opportunities for subsidies to R&D to enhance productivity and possibly new jobs for all. However, the importance of public subsidies are hard to judge, since the awarded firms may already have the best technology. Thus part of the productivity gains is just the picking up of winners. We correct this bias by controlling for the public subsidies available in the industry and region. The probability of applying for public funding is 25% lower in rural areas and 12% higher in manufacturing regions than in Greater Helsinki area.

It is shown that public subsidies by Tekes have improved productivity in small and medium-sized companies (SMEs) and in companies near the frontier in productivity. Public subsidies overall fail to augment growth in large firms. One reason can be that public subsidy awards require a joint project with small firms. These projects usually take place long time, up to five years. Productivity effects are unclear and the effects on the small firm partner are hard to judge. Long-term finance can also lead to too low a level of initial funding. Subsidies per sales at the start of the project (although not necessarily yet distributed) are twice as high, 7%, for SMEs than for large firms. We find little evidence that subsidies improve employment, which differs from the importance of knowledge capital as an engine for growth in general.

We then consider the competitiveness of Finnish NUTS 4-level regions in 2002. The competitiveness index includes frontier human capital indices constructed from linked employer-employee data and regional information on innovativeness, agglomeration and accessibility. Human capital and innovativeness play a major role in competitiveness indices. They not only explain regional divergence, but also the high growth in many smaller regions. Agglomeration of human capital explains the top ranking of all the big cities when using a traditional competitiveness index. The Greater Helsinki region is 12%-13.5% more competitive than other areas irrespective of the competitiveness index used. The alternative competitiveness indices are the average of 20 sub-indices, the average after weighting each sub-index by the contribution to joint variation (principal component analysis) and the average after weighted each subindex depending on how they have explained growth (hedonic approach). The top ranking of Greater Helsinki region is explained by human capital being the top in the industry and by agglomeration. The ten most competitive regions in the first average approach are in descending order: Helsinki, Tampere, Oulu, Vaasa, Turku, Jyväskylä, Porvoo, Varkaus, Turunmaa and Salo. The hedonic competitiveness index, giving a weight in each subindex depending on its contribution to past growth, is best able to predict future performance. The hedonic index together with urbanisation dummies explains nearly 30% of the regional growth in 2003-2004. The most IT-intensive regions such as Oulu and Salo are the most competitive based on the hedonic approach.

The final part of the study analyses in greater detail competitiveness in the regions. The innovative and R&D intensive research area runs from Helsinki via the Lahti motorway in the direction of Jyväskylä (with the exception of Lahti and Joutsa) and the human capital intensive area from Helsinki in the direction of Tampere. We can roughly divide Finland into southern, western and eastern parts. The western areas – Pohjanmaa and Oulu region – rely on a high degree of innovativeness. The regions are not necessarily human capital intensive (except for university cities Vaasa and Oulu) but do have skill intensive companies of various sizes. The young workforce is absorbed into regional centres and the ageing of the workforce is clear in the surrounding regions. The emphasis has been on innovative ability that should be further supported. The supply of an educated workforce can be enough in the regional centres but not necessarily in the surrounding areas.

The eastern part of Finland relies on R&D investment and possibly also on subcontracting. A clear example of an exceptional and competitive area is Pohjois-Savo and the smaller city Varkaus. Varkaus has not grown fast in recent years but has reached a high level of competitiveness, which offers good growth prospects in the future. The eastern part of Finland also has many areas where manufacturing is underrepresented. R&D investment and the establishment of industrial clusters are the keys to further growth. On the other hand, the most severe problem is the low growth in trade and private services also related to the fastest rate of ageing in Finland, with Kuopio and Joensuu as the exceptions.

Southern Finland and particularly the Greater Helsinki region are the most agglomerated areas in human capital. The availability of a skilled workforce and good accessibility offer good growth prospects. The growth is based on innovativeness in broad terms, not solely on R&D investment. The growth in these high productivity areas is maintained by human capital. The service sector is overrepresented, while in Helsinki manufacturing employment is only 50% of the average in Finland. The size of the region alone leads to the absorption of resources from other regions and a further concentration of economic activity. The high share of people of working age and easy accessibility give a strategic advantage.

Keywords: human capital, competitiveness, regional growth, linked employer-employee data

JEL-codes:, J21, J31, J32, J50, J53, C22, C23, C41, O15

PIEKKOLA, Hannu, **OSAAMISPÄÄOMA JA INNOVAATIOIDEN TUKEMINEN KASVUN LÄHTEINÄ – Seutukuntien kilpailukyky**. Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2006, 139 s. (B, ISSN 0356-7443; nro 216). ISBN 951-628-431-0.

TIIVISTELMÄ: Tutkimuksen lähtökohtana on seutukuntien kansantuotteen ja tuottavuuden kasvun eroavaisuudet vuodesta 1995. Kansantuotteen kasvu asukasta kohden on ollut nopeampaa suur-Helsingin alueella ja muissa isoissa kaupungeissa, joissa kansantuote asukasta kohden on jo ennestään korkein. Alueiden kasvua selitetään yritystasosta lähtien käyttäen yhdistettyä yritys- ja työntekijäaineistoa Suomessa. Osaamispääomaa on mitattu etenkin teollisuuden yrityksissä. Tutkimuksen perusteella yritysten tuottavuuden kasvua selittää osaamispääomaa, joka nojaa entistä enemmän koulutukseen mutta myös muihin osaamisen tekijöihin. Tärkeimmät inhimillisen pääoman tekijät yrityksessä ovat koulutus ja ammatillinen osaaminen. Yritykset, joissa on ammatillista osaamista, tuottavuuden kasvu on nopeampaa. Taloudellinen kasvu on keskittynyt alueille, joissa koulutettua työvoimaa on parhaiten saatavilla. Koulutuspääomalla on merkitystä kasvulle etenkin niissä yrityksissä, jotka ovat tuottavuuden huippua.

Tutkimuksen perusteella kiinnikuromista ja tuottavuuserojen kaventumista on tapahtunut seutukuntien välillä vähän ja tätä selittää osaamispääoman kasautuminen. Kiinnikuromista tapahtuu myös enemmän vain pienissä teollisuusyrityksissä. T&K investointien alueellisella jakaumalla on vähemmän merkitystä kuin koulutetun työvoiman saatavuudella. T&K työssä tieto/taito leviää globaalisti ja insinöörityön saatavuus ei ole ollut merkittävin pullonkaula. Insinöörien riittävää määrää voinee selittää myös perinteisen teollisuuden merkityksen väheneminen.

Tutkimuksen toisessa vaiheessa tarkastellaan miten julkiset Tekesin rahoittamat T&K tuet vaikuttavat tuottavuuden ja työllisyyden kasvuun. Julkisilla tuilla tähdätään erityisesti uusiin innovaatioihin. Näiden merkitys kasvun lähteenä on suurempi kuin aikaisemmin. Tukien vaikutuksista osa selittyy sillä, että tukea saavat vain todennäköiset menestyjät. Tätä valikointiharhaa on poistettu selittämällä tukia ensin niiden saatavuudella toimialalla ja alueella. Suur-Helsingin alueeseen verrattuna todennäköisyys hakea tukea on 25 % pienempi maaseutumaisissa seutukunnissa ja 12 % suurempi teollisuusvaltaisissa seutukunnissa. Tutkimuksen perusteella julkiset T&K tuet lisäävät tuottavuuden kasvua pienissä ja keskisuurissa yrityksissä ja yrityksissä jotka ovat lähellä tuottavuuden kärkeä.

Julkiset T&K tuet toteuttavat hyvin tavoitteen tukea kaikista innovatiivisimpia yrityksiä. Tukien merkitys on merkittävämpi yrityksissä, jotka ovat lähellä alansa huippua. Pienet ja keskisuuret yritykset, joiden koko on alle 250 työntekijää, näyttävät myös hyötyvän eniten tuista. Suurille ja näistä menestyneimmille yrityksille tuilla ei ole välttämättä merkitystä esimerkiksi yrityksen tunnettavuudelle. Tuet on sidottu pitkäaikaisiin projekteihin ja yhteistyöhön pienten yritysten kanssa, jolloin välitöntä tuottavuuden kasvua ei ole odotettavissakaan. Toisin kuin osaamispääoma yleensä, julkiset tuet eivät ole yrityskoosta riippumatta yhteydessä työllisyyden kasvuun.

Tutkimuksen kolmannessa osassa tarkastellaan Suomen seutukuntien kilpailukykyä vuonna 2002. Kilpailukykyindeksin yhtenä osatekijänä on osaamispääoma alueen teollisuusyrityksissä, jota mitataan suhteessa toimialan osaamispääomaan yleensä. Tärkeä osatekijä kilpailukyvyssä on myös seutukunnan innovatiivisuus, osaamisen kasautuminen ja saavutettavuus kuten kulkuyhteydet. Osaamispääoma ja innovointikyky selittävät keskeisesti seutukuntien eroavaisuuksia kilpailukyvyssä. Nämä selittävät myös ripeää kasvua monilla pienillä paikkakunnilla. Osaamisen kasautuminen ja toimialan tuottavimpien yritysten alueellinen sijoittuminen selittävät kuitenkin sen, että kaikki suuret kaupungit kuuluvat kilpailukykyindeksin kärkipäähän. Suur-Helsingin alue on 12% – 13.5% kilpailukykyisempi kuin muut alueet kaikilla kilpailukykymittareilla mitattuna. Näitä ovat keskiarvo 20:stä kilpailukyvyn osatekijästä, keskiarvo painotettuna osatekijöiden yhteisvaihtelulla (pääkomponenttianalyysi) ja keskiarvo painotettuna osatekijöiden vaikutuksella taloudelliseen kasvuun (hedoninen lähestymistapa). Kymmenen kilpailukykyisintä seutukuntaa paremmuusjärjestyksessä ovat Helsinki, Tampere, Oulu, Vaasa, Turku, Jyväskylä, Porvoo, Varkaus, Turunmaa ja Salo. Painotettaessa kilpailukyvyn osatekijöitä sen mukaan miten ne ovat selittäneet kasvua menneisyydessä hedonisen lähestymistavan mukaan IT-intensiiviset seutukunnat Oulu ja Salo ovat kilpailukyvyn kärkeä. Tämä hedoninen kilpailukykyindeksi selittää myös parhaiten tulevaa kasvua. Muut kilpailukykyindeksit eivät selitä kovin hyvin kilpailukyvyn vaihtelua asukasluvultaan pienissä seutukunnissa, koska mittareissa osaamisen kasautumisella suuriin kaupunkeihin on suuri paino.

Tutkimuksen viimeisessä osassa tarkastellaan eri seutukuntien kilpailukykyä tarkemmin. Tutkimusta ja tuotekehitystä tehdään paljon Helsingistä Lahden suuntaan ja edelleen Jyväskylän suuntaan. Osaamispääomavaltaisen alueen muodostaa suur-Helsingin alue ja radanvarsialueet Tampereen suuntaan. Suomi voidaan tämän lisäksi jakaa pääpirteissään kolmeen erilaiseen alueeseen: läntinen, itäinen ja eteläinen alue. Läntisellä alueella Pohjanmaalla ja Oulun alueella innovatiivisuuden aste on korkea. Alueilla koulutustaso ei ole välttämättä korkea (poikkeuksena korkeakoulukaupungit Vaasa ja Oulu), mutta alueella on erikokoisia osaamisvaltaisia yrityksiä. Nuori työvoima on hakeutunut alueellisiin keskuksiin. Väestön ikääntymisen aiheuttamat ongelmat ovat ilmeisiä myös alueellista keskusta välittömästi ympäröivillä alueilla. Läntisen Suomen painopisteenä on innovatiivisuus, jota on edelleen tuettava. Koulutettua työvoimaa on riittävästi tarjolla alueellisissa keskuksissa, mutta ei välttämättä näitä ympäröivillä alueilla ja muualla.

Itäinen osa Suomea nojaa insinöörityöhön ja T&K investointeihin menestyvillä alueilla. Monet yritykset toimivat myös alihankkijoina. Hyvät kilpailuedellytykset tulevaisuudessa on esimerkiksi Pohjois-Savossa ja Varkauden alueella. Varkaudessa yritysten liikevaihdon kasvu ei ole ollut nopeata viime vuosina, mutta hyvä kilpailukyky tarjoaa kasvupotentiaalia tulevaisuudessa. Itäisessä Suomessa on myös monia alueita, missä teollisuutta on vain vähän. T&K investoinnit ja uusien teollisuusklustereiden luominen ovat avain kasvuun tulevaisuudessa. Tosin menestyvillä alueilla kuten Pohjois-Savossa myös palvelualan kasvu on ollut nopeata.

Eteläinen Suomi ja etenkin suur-Helsingin alue ovat hyvin osaamispääomavaltaisia ja tuottavuuden kärkeä. Osaavan työvoiman saatavuus ja hyvät kulkuyhteydet antavat hyvän kasvupohjan myös tulevaisuudessa. Kasvu perustuu innovatiivisuuteen, jota ei selitä yksinomaan T&K toiminta. Palvelut muodostavat merkittävän osan yritystoiminnasta. Esimerkiksi Helsingissä teollisuudessa työskentelee 10% työllisistä, mikä on vain 50% maan keskiarvosta. Työikäisen väestön suuri osuus ja hyvä saavutettavuus antavat strategisen edun. Väestön keskittyminen pääkaupunkiseudulle tullee jatkumaan. Julkinen tuki kaikista kilpailukykyisimmille ja innovatiivisille yrityksille antaa edellytykset tuottavuuden kasvulle jatkossakin.

Avainsanat: osaamispääoma, kilpailukyky, alueellinen kasvu, yhdistetty työnantaja-työntekijäaineisto

Foreword

Finland has been rated one of the most competitive economies in the world. This study examines growth driven by knowledge capital in the post recession period since 1994. The study uses a broader concept of human capital than that based merely on either R&D expenditures or educational competence. This wider concept is essential in order to understand the growth in Finnish areas. The competitiveness is only determined by the location of R&D activity, but the very large agglomeration effects of the location of skilled workers and the ageing of population are important determinants of growth. This study improves our understanding of the causes of divergence in growth and the efficiency of public subsidies on innovativeness.

This study is part of ETLAs labour market and education economics research programme. The publication is also in Labour Administration Series 294 by Ministry of Labour. In the first phase M.Sc. Antti Kauhanen and M.Sc. Anni Heikkilä participated in the research. The research was carried out by Dr. Hannu Piekkola.

Helsinki, January 2006

Sixten Korkman

Author's foreword

This study considers the growth in productivity driven by knowledge capital, how this process has been affected by public subsidies on R&D and what has been the regional impact of knowledge capital on competitiveness. The research has been financed by the Proact programme initiated by the National Technology Agency, Tekes, and the Ministry of Trade, in the projects *"Human Capital as the Source of Growth and Innovations"* and *"Enhancing Competitiveness and Employment of Finnish Regions"* and by the Ministry of Labour in the project *"Human Capital in Regions, Productivity Growth and Employment"*. My earlier research report *"Human Capital and Wage Formation"* (ETLA series B177) considered human capital, the creation of new jobs and the accumulation of human capital in large companies. This was followed by the research report *"Human Capital Utilisation under Technical Change: Profit Sharing and Wage Dispersion"* (ETLA Series B193), which examined wage determination and particularly performance-related pay. The present study continues to evaluate human capital in linked employer-employee data, adapting the new methodology to the examination of the competitiveness of Finnish regions. We use a wide range of sub-indices of competitiveness at the NUTS 4-level based on econometric estimation using data from Confederation of Finnish Employers and other data available from Statistics Finland.

The research report gives evidence of divergence in growth between regions since the recession of the early 1990s. Knowledge capital is the major reason for this. The research report analyses in greater detail the relative weaknesses and advantages of Finnish regions, with the aim of offering tools to foster future growth.

I would like to first thank Antti Kauhanen and Anni Heikkilä who participated in the initial phase of the project. Special thanks also go to Confederation of Finnish Employers for providing the main data, Rita Asplund, Mika Maliranta, Aki Kangasharju and Jyrki Ali-Yrkkö for comments and advice, Roderick Dixon for checking the English, and The Research Institute of the Finnish Economy for an inspiring work environment. Pekka Tiainen, Päivi Järviniemi, Tuomo Alasoini and Mika Maliranta have participated in the supervising group by Ministry of Labour and their advice has been an important asset in the research. I would finally like to thank those who financed the project and the Proact programme for providing an enthusiastic and unconditional framework for undertaking the research.

Hannu Piekkola

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1. Introduction

It can be said that human capital is a more important factor for growth than ever. Workers with knowledge capital are described by Strassman (1999):

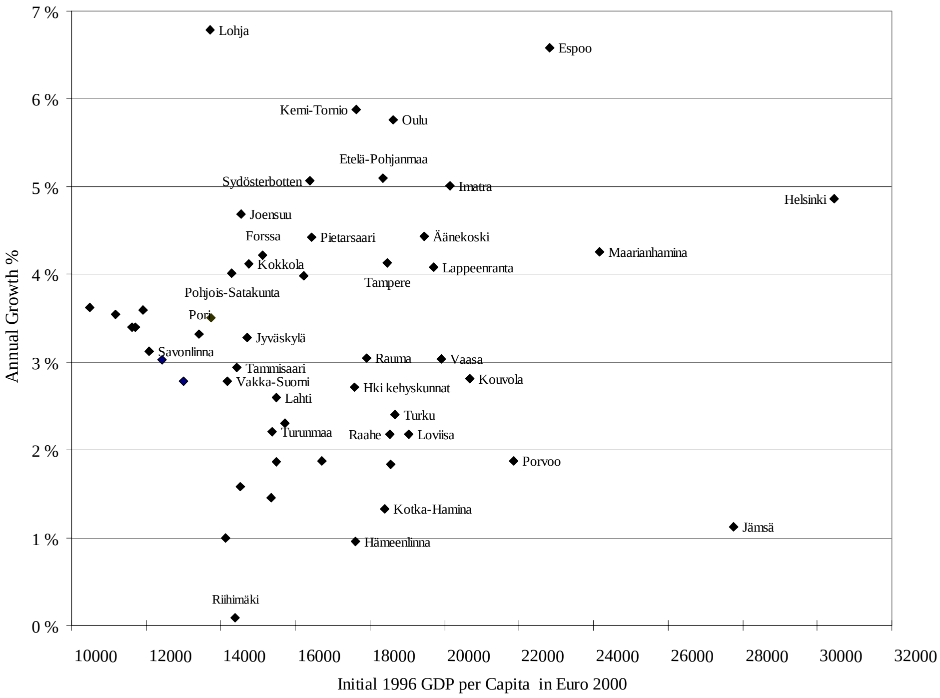
"They are the people who leave the workplace every night (and may never return), while storing in their heads knowledge acquired while receiving full pay. They possess something for which they have spent untold hours listening and talking, while delivering nothing of tangible value to paying customers. Their brains have become repositories of an accumulation of insights about "how things work here" – something that is often labeled with the vague expression "company culture". Their heads carry a share of the company's Knowledge Capital, which makes them shareholders of the most important asset a firm owns, even though it never shows up on any financial reports. Every such shareholder of knowledge assets in fact becomes a manager, because information acquisition and information utilization are the essence of all managerial acts."

New view on the development of economic growth have emerged, which has an important bearing on the evolution of Finnish regions and their competitiveness. Finland is ranked as one of the most competitive countries, see Global Competitiveness Report 2005-2006 (www.weforum.org/gcr). One attribution of this is high tertiary enrolment, since Finland exhibits clear growth in higher educational attainment levels relative to the rest of Europe (see, for example, comparisons across countries at the NUTS 2-level in Badinger and Tondl (2002)). Finland can also be said to be an R&D-driven economy and thus innovation activities are an important source of regional growth, see Lehto (2000). The average GDP growth of 2.5% in 1980-2004, which exceeded the average of 2.2% in the Euro area, has been accompanied by a rapid growth of 3.6% since 1996 and also regional divergence.

Figure 1.1 below shows the GDP growth in NUTS 4-level areas in the period 1996-2002. It is seen that, while growth is rapid, the Finnish regions exhibit no clear tendency of income convergence over the period under consideration. Large cities such as Espoo (6.6%) and Helsinki (4.8%) have grown rapidly, while the average growth rate is 3.6%. Loikkanen and Susiluoto (2002) have very similar findings. This book is about this development.

Chapter 2 considers human capital as an engine for growth. This study uses linked employer-employee data in 1996-2002 to explain the determinants of productivity growth at company level. This is used to examine growth generated by human capital in the regions.

Figure 1.1 Initial GDP per capita and GDP Growth per capita in Finnish Regions 1996-2002



Chapter 3 examines the efficiency of public subsidies by the National Technology Agency, Tekes. The primary aim of the subsidies is to improve the innovativeness of companies leading to higher productivity growth. It is also of some interest to examine the employment effects. An abbreviated version of this chapter is forthcoming in Economics of innovation and new Technology.

Chapter 4 examines the competitiveness of Finnish regions at the NUTS 4-level. The chapter relies on the estimates of knowledge capital that were found to be important in Chapter 3. Competitiveness is also evaluated in terms of how well the various competitiveness indices explain growth

Chapter 5 analyses in greater detail competitiveness in Finnish regions using diagrams for each region. The four main criteria are human capital, innovativeness, industry structure and agglomeration. The competitiveness is mainly evaluated at the level of regional centres so that less attention is paid to rural areas.

2. Knowledge Capital as the Source of Growth

2.1 Introduction

Regional disparities are of major policy concern in the European Union, not least because of the inclusion of new transition economies in the EU, see Tondl and Vuksic (2003). Until the 1990s, disparities in growth between countries have gradually decreased. At the same time, migration has led to a population concentration in the urban regions and big cities. However, Quah (1997) finds that the Cohesion countries, Spain and Portugal, with higher growth, have also experienced a divergence in growth between regions. Cappelen *et al.* (2003) note that, within the old EU member states, very little convergence has occurred between regions since the 1980s. Ottaviano and Pinelle (2004) find that there has been negative convergence of GDP growth among the Finnish regions since 1994, while there was clear convergence before then. Ciccone (2003) shows large agglomeration effects in labour productivity in Europe. At the same time, in contrast to Ciccone and Hall's (1996) study of US states, Böckerman (2002) finds for Finland only limited spillovers from economic density after control for the industrial structure of the region.

This chapter examines the role of knowledge agglomeration for growth in Finland. The companies in the data are members of the Confederation of Finnish Industries and 75% of them belong to the manufacturing sector. Kangasharju and Pekkala (2001) find that manufacturing industries can explain regional disparities in growth in Finland.

Human capital accumulation can explain growth through schooling and learning-by-doing (Lucas (1988), Mankiw *et al.* (1992)). De la Fuente and Doménech (2000) and Bassanini and Scarpetta (2002) find the elasticity of output with respect to education human capital (years of education) to be about one third in the OECD countries. Benhabib and Spiegel (1994) and Brunello and Comi (2004) find that the growth rate of total factor productivity depends particularly on a nation's level of human capital and not on the growth rate of human capital.[1] Thus edu-

[1] Krueger and Lindahl (2001) argue this to be due to measurement errors in growth rates. Temple (2001), assuming a different functional relationship between income and human capital, replicates the Benhabib and Spiegel study and concludes that also changes in human capital do affect growth rates.

cation provides a permanent advantage that may increase in importance with time in the labour market. Human capital can also have a specific role in a small open economy with a regulated labour market. Bassanini and Ernst (2001) argue that countries with coordinated industrial-relations systems and strict employment protection tend to specialise in industries with a cumulative knowledge base.

The share of the labour force employed in innovation activity is also an important part of knowledge capital. Romer (1990) was one of the first to describe technological innovations as nonrival and stemming from monopolist competition. Benhabib and Spiegel (2005) separate innovations driven growth from the catch-up process, which is described as Romer-type imitation of new technology. They find a non-linear relationship Nelson-Phelps-type catch-up model of technology diffusion. This is because countries with too low initial human capital stock exhibit slower total factor productivity growth than the leading nation. Faberberg *et al.* (1997) find that the superior growth performance of rich regions in the 1980s can be explained by the share of the business sector workforce employed in R&D.

Human capital plays an important role as Finland exhibits clear growth in higher educational attainment levels relative to the rest of Europe (see, for example, comparisons across countries at the NUTS 2-level in Badinger and Tondl (2002)). Finland is a knowledge- and R&D-driven economy and thus innovation activities are an important source for regional growth, see Lehto (2000). The present study uses linked employer-employee data for Finland. This type of linked data is extensively used in the study of human capital formation, starting with Abowd *et al.* (1999). Linked employer-employee data allow the estimation of wider concepts of human capital that include returns from individual- and firm-specific experience and occupational careers. We are interested in estimating both individual and firm heterogeneity in wage formation. Individual heterogeneity, as captured by the person-specific fixed effect, can be subsequently used to assess the returns on education. The remaining part of the person-specific fixed effect is the part of wages that cannot be explained by observed characteristics (to the econometrician) and we refer to this as the unobserved human capital of the individual. Abowd *et al.* (2003) define overall human capital as the sum of person-specific effects and returns on experience. They examine the share of workers in companies below the 25^{th} and above the 75^{th} percentile of overall human capital over the period 1986-2000 in seven US states, and the interactions of the shares. They find that aggregate human capital is positively related to labour productivity.

Three main company- and regional-level growth determinants are examined in this study: (i) the productivity growth effects of education, experience and unobserved human capital and related agglomerations of human capital, (ii) the growth effects of firm-specific occupation human capital and R&D work, and (iii) the catching-up process at company and regional levels.

The rest of the chapter is structured as follows. Section 2.2 presents the model, and Section 2.3 describes the data and the procedure for assessing person- and firm-specific human capital. Section 2.4 gives some stylised facts of regional growth and human capital, and Section 2.5 presents the results of the estimation. Section 2.6 concludes.

2.2 The Model

Benhabib and Spiegel (2005) integrate two types of processes often studied in the context of disaggregated models of technology diffusion.[2] The first one is the Nelson-Phelps model of technology diffusion:

$$\frac{\dot{A}_{jt}}{A_{jt}} = g(KC_{jt}) + c(KC_{jt})\left(\frac{A_{Mt}}{A_{jt}} - 1\right), \tag{1}$$

where A_{jt} is total factor productivity TFP, $g(KC_{jt})$ is the component of TFP that depends on the level of knowledge capital KC_{jt} in company j at period t (human capital in a country in Benhabib and Spiegel) and $c(KC_{jt})(A_{Mt} / A_{jt} - 1)$ shows catching-up with the leading company M in the industry. The knowledge capital KC_{jt} affects the speed of catching-up. It is natural to assume a choice of knowledge capital such that $c(.)$ and $g(.)$ are increasing functions. The technological leader with the fastest growth will emerge within finite time. Beyond that point the followers, lagging behind in the level of TFP, catch-up the leading company until the growth rate of TFP is the same for all the companies. This also implies that companies most abundant in initial human capital

2 An endogenous growth model such as Badinger and Tondl also links human capital explanations to the catching-up theory (see also Abramovitz, (1997; Castellani and Zanfei 2003). Griffith *et al.* (2003) include a positive spillover from the assimilation of existing R&D capacity. Pigliaru (2003) examines convergence caused by technological catching-up.

are closest to the leader and experience slower growth in the adjustment process.

The alternative model formulation presented by Benhabib and Spiegel uses a logistic model of technology with opposite spillover effects given by

$$\frac{\dot{A}_{jt}}{A_{jt}} = g(KC_{jt}) + c(KC_{jt})\left(1 - \frac{A_{jt}}{A_{Mt}}\right) \qquad (2)$$

$$= g(KC_{jt}) + c(KC_{jt})\frac{A_{jt}}{A_{Mt}}\left(\frac{A_{Mt}}{A_{jt}} - 1\right).$$

The difference in the dynamics under the logistic model is the term A_{Mt} / A_{jt}. The distance to the frontier company slows down the adoption speed, which creates a non-linear relationship between the technological capital and catching-up. An example of this is new technology in some other industry. This can be more easily adopted if the industries resemble each other in knowledge capital structure. Benhabib and Spiegel show that for constant knowledge capital and therefore for constant technological progress $g_j(KC_j)$ and catching-up $c_j(KC_j)$:

$$\lim_{t\to\infty} \frac{A_{jt}}{A_{Mt}} = \begin{cases} \dfrac{c_j + g_j - g_M}{c_j} & c_j + g_j - g_M > 0 \\ \dfrac{A_{jt_0}}{A_{Mt_0}} \quad if & c_j + g_j - g_M = 0 \\ 0 & c_j + g_j - g_M < 0 \end{cases}. \qquad (3)$$

The steady-state growth relationship thus depends on the catch-up rate c_j and the difference in the growth rate due to innovative capability $g_j - g_M$. For a high enough catch-up rate, $c_j + g_j - g_M > 0$, the leader will pull others towards the same technological level and productivity differences will converge. For a low enough catch-up rate, $c_j + g_j - g_M < 0$, the level of human capital is too low and growth rates continue to diverge. The logistic type of technological diffusion thus allows the emergence of non-converging industries. The level of knowledge capital has to be high enough for the adoption of new technology, see also Basu and Weil (1998). Impediments to the transfer of a specific technology, such as the location of R&D activity, are not the major issue. Benhabib and Spiegel also discuss the Romer-type (1990) split of human capital to raise either returns on innovations g_j, or on imitation, raising catch-up c_j. With linear technology, it is obvious that all human capital can be used either for innovations or for imitations.

By defining $B_{jt} \equiv (A_{jt} / A_{jt_0})e^{-g_M t}$ we can express the growth equation in terms of stationary variables:

$$\frac{\dot{B}_{jt}}{B_{jt}} = c(KC_j) + g(KC_j) - g(KC_M) - c(KC_j)B_{jt}. \tag{4}$$

Let $d \ln A_{j,t}$ represent the growth rate in log TFP of company *j*. The empirical testable specification may be written, following Benhabib and Spiegel, as

$$d \ln A_{jt} = b + \left(g - \frac{c}{s}\right)\ln KC_{jt} + \frac{c}{s}\ln KC_{jt} \ln\left(\frac{A_{Mt}}{A_{jt}}\right)^s + \varepsilon_j, \tag{5}$$

where s equals 1 if the pure catch-up model holds following a Nelson-Phelps type model of technology diffusion, and s equals -1 if the logistic form of technological diffusion is appropriate. In the Nelson-Phelps type model (s = 1) catching-up is positive and positively related to the level of knowledge capital. In the logistic specification (s = -1), knowledge capital intensive companies grow faster with no convergence. The coefficients to be estimated are b, g, c using firm-size dummies and regional characteristics as additional controls. The estimation results can also be used to evaluate the appropriate value of s.

In this study, knowledge capital $KC_{j,t} = \xi(h_{j,t}, l_{j,t,h>h(Q3)}, \psi_{j,t})$ is a function of the average individual- and firm-specific human capital $h_{j,t}$, a function of the fraction of workers in the highest skill category $l_{j,t,h>h(Q3)}$, and a function of the firm effect $\psi_{j,t}$. $l_{j,t,h>h(Q3)}$ represents the fraction of workers above the 75th percentile for human capital across companies over the period (we also use the fraction of workers below the 25th percentile and interactions). $\psi_{j,t}$ is a firm effect in addition to the time-specific firm-level human capital explained by seniority, performance-related pay, R&D work and occupations. These capture intangible human capital engaged in the human resource management and innovative capabilities, which are not transferable across companies. In the knowledge capital we include regional knowledge capital spillover, $SPIL_{r,t}$, which is independent of the catching-up process, where subscript r indicates region r (1,…,R). This consists of the spillover from education human capital in region r and the influence of other regions. As described in Appendix 2A, spatial weights are based on a negative exponential function with the distance decay parameter depending on the distances between neighbouring regions, following Funke and Niebuhr (2000). The half-decay distance that reduces the spatial interaction by one-half is set, on average, at 289 km for education human capital (twice as high in Northern Finland with the long distances).

The leading technology is assessed in the 19 industries shown in the following table. The Company with frontier technology is the one with the highest average productivity in the industry. We do not use the interaction of the catch-up term with knowledge capital because of the endogenous nature of this interaction with other explanatory variables. Each of the 19 industries may instead be considered to contain its own human capital specific catching-up process that is taken into account here.

Table 2.1 Industry Classification

	Frequency	Percent
Mining	92	1.0
Food Industry	530	5.8
Clothing, Textile Industry	529	5.8
Paper and Pulp, Timber	1279	14.0
Oil, Chemicals	294	3.2
Rubber, Non-metallic	698	7.6
Base Metal, Metal Products	675	7.4
Machinery	690	7.5
Computers, Electrical Machinery, Optical	725	7.9
Manufacturing in Transport Industry	441	4.8
Manufacture of Furniture	252	2.8
Recycling	12	0.1
Construction	1693	18.5
Trade	421	4.6
Hotels, Restaurants	37	0.4
Transport	158	1.7
Finance	25	0.3
Services	318	3.5
Telecommunications	283	3.1
Total	9152	100

TFP in company *j* is also measured relative to other companies and time periods. We apply the multilateral total factor productivity index (TFP) introduced by Caves (1982). (For analysis using a similar productivity measure in Finnish data, see Ilmakunnas *et al.* (2004).) Company *j* is compared with a hypothetical average benchmark company so that

$$d\ln A_{j,t} = \ln(TFP_{j,t}) - \ln(TFP_{j,t-1}) \text{ , where} \qquad (6)$$

$$\ln(TFP_{j,t}) = \ln(\frac{V_{j,t}/L_{j,t}}{\bar{V}_{j,t-1}/\bar{L}_{j,t-1}}) + \frac{S_{j,t}+\bar{S}_{j,t-1}}{2}\ln(\frac{K_{j,t}/L_{j,t}}{\bar{K}_{j,t-1}/\bar{L}_{j,t-1}}), \qquad (7)$$

and where $V_{j,t}/L_{j,t}$ = labour productivity, $K_{j,t}/L_{j,t}$ = capital intensity and $S_{j,t}$ = one minus the labour cost share of value added. Upper bar superscript indicates the respective values for the average-company benchmark. The index has the advantage of being based on a translog production function, thus being a second-order approximation of the true but unknown production function. The index is exact if the true production function is translog.

2.3 Data and Estimation of Human Capital

The labour data are from the Confederation of Finnish Industry and Employers, where 75% of companies are in the manufacturing sector. The original data with 3,096,771 observations cover the years 1996-2002 and include both blue- and white-collar employees. The data include a rich set of variables covering compensation, education and profession. The white-collar employees receive salaries and the blue-collar workers are remunerated on an hourly basis. Employee data are linked to financial statistics data from the Balance of Consulting and Suomen Asiakastieto, mainly to include information on value added and capital intensity (fixed assets). The manipulation of the linked employer-employee data is further described in Appendix 2B. After checks for real births and deaths of companies the original data included 2,359 companies and the firm-effect could be identified for 1,421 companies based on job transferees. The sample including all observations for employees with one or more job transferees in the time period under consideration (286,000) accounts for 13% of all observations in the 1,421 companies with at least 30 job transferees. These companies, at the same time, cover most of the employee-year observations, 2.09 million out of 2.76 million.

We are interested in estimating both individual and company heterogeneity in wage formation. Individual heterogeneity, as captured by the person-specific fixed effect, can be subsequently used to assess the returns on education. The remaining part of the person-specific fixed effect is the part of wages that cannot be explained by observed characteristics (to the econometrician). We refer to this as the unobserved human capital of the individual.

Abowd *et al.* (2002) develop a numerical solution to deal with the large set of firm dummies in the Least Squares Dummy Variables Estimator. We use the two-step method suggested by Andrews *et al.* (2004). We include dummy variables for the company heterogeneity that are estimated at the first step in the data covering only individuals that move from one company to another and sweep out the worker heterogeneity by taking deviations from individual means. The dependent variable is the natural log of the hourly wage $\ln(y_{ijt})$ of a person *i* working in company *j* at time *t* measured as a deviation from the individual mean wage over the time period. This is first expressed as a function of individual heterogeneity, company heterogeneity and measured time-varying characteristics for movers as a deviation from individual means.

$$\ln(y_{it}) - \mu_{yi} = \beta(x_{it} - \mu_{xi}) + \gamma(w_{it} - \mu_{wi}) + \sum_{j=1}^{J} \psi_j (D_{it}^j - \mu_{Di}^j) + e_{ijt} \ . \quad (8)$$

$\beta(x_{it} - \mu_{xi})$ shows the compensation for time-varying human capital stated as a deviation from the individual mean human capital: hence it contains time dummies and experience expressed up to the fourth power. $\gamma(w_{it} - \mu_{wi})$ shows the respective time-demeaning for all firm-specific variables: occupations, seniority, R&D work and performance-related pay. θ_i is the compensation for time invariant human capital (individual fixed effect). $D_{it}^j - \mu_{Di}^j$ is the firm dummy as a deviation from individual mean (zero for any worker *i* who does not change company). e_{ijt} represents a statistical error term.

The firm effect is measured within a group of companies, where there is movement of workers between companies. (In the group two companies are linked by a job transferee and these two are linked to a third by a job transferee etc.) In each group the firm effect is defined with respect to a reference (omitted) company when firm dummies are used. Following Abowd *et al.* (2002), we assume that the average effect is the same across groups and take the firm effect $\hat{\psi}_j$ as a deviation from the grand mean in each group. Almost all, 99.8%, belong to the largest pool, where companies are linked to each other via job transferees. Estimates of firm heterogeneity are obtained by computing $\hat{\psi}_{j(i,t)} = \sum_{j=1}^{J} \hat{\psi}_j D_{it}^j$, where $j(i,t)$ indicates the worker's job at employer *j* at date *t*. In the second step, $\delta\hat{\psi}_{j(i,t)}$, where δ is a scalar, is placed in the following equation

$$\ln(y_{\mathrm{it}}) - \mu_{wi} \; = \; \beta(x_{it} - \mu_{xi}) + \gamma(w_{it} - \mu_{wi}) + \delta(\hat{\psi}_{j(i,t)} - \mu_{\psi i}) \; + e_{ijt} \; , \qquad (9)$$

where $\mu_{\psi i}$ is the individual mean of the firm effect. The second step estimation covers all workers in the sample of companies for which the firm effects were identifiable.

The formation of linked employer-employee data is described in Appendix 2B. The original data included 2,359 companies and the firm-effect could be identified for 1,421 companies. The sample including all observations for employees with one or more job transferees in the considered time period (286,000) accounts for only 13% of all observations in the 1,421 companies with at least 30 job transferees, 2.09 million. Given the data dimension with 1,421 firm dummies, it was not possible to solve even the reduced two-step method suggested by Andrews *et al.* (2004) using the STATA econometrical package in the Windows environment. Instead, we adopted an analogous estimation procedure using the SAS system for Windows. The estimation of the first-stage wage equation (8) is shown in column 1 in Table 2A.1 in the appendix. Time-varying human capital includes experience up to the fourth potency. Time-varying company characteristics include seniority, performance-related pay, the share of R&D employees and job mobility across occupations (blue-collar work and white-collar work in 17 categories as listed in Table 2A.1).

Results from the second-stage estimation (9) are reported in column 2 in Table 2A.1 in the appendix. The coefficients for the first-stage estimation for the sample with job transferees do not largely differ from the coefficients for the larger sample also covering non-movers, see columns 1 and 2 in Table 2A.1 and also Table 4 in Andrews *et al.* (2004). Table 2A.1 also reports the Chow test for breaking estimation between movers and non-movers. It indicates that coefficients are not statistically different from each other. Seniority payments are though somewhat lower for all except mobile workers. This is explained by the seniority returns being high especially in the first years of service. The 17 occupations are available in white-collar work. It is seen that earnings are on average higher in the blue-collar than in the white-collar occupations in the data covering mainly manufacturing.

The person effect is the person average using the second-step estimation results: $\theta_i = \mu_{yi} - \hat{\beta}\mu_{xi} - \hat{\gamma}\mu_{wi} - \mu_{\psi i}$, where $\hat{\beta}$ and $\hat{\gamma}$ are the estimated values of the coefficients. The person effect θ_i can now be regressed against all time-invariant variables. The decomposition of the person effect θ_i uses the estimates of

$$\theta_i = Int + z_{i\in e} u_e \eta_e + u_2 Gen_i + \varepsilon_i \ , \tag{10}$$

where Int is the intercept, η_e is the education level (from $e = 1,...,E$), u_e is the respective coefficient, $z_{i\in e}$ indicates the worker belonging to this education group (zero otherwise), Gen_i indicates gender and ε_i is the statistical error. Five educational levels are identified for five fields: (i) general education, humanities, aesthetics, medical and health, field unknown, (ii) commercial and clerical work, law, social science, (iii) technology and natural science, (iv) transport and communication and (v) agriculture and forestry (the field not specified at the elementary or doctorate level and vocational education also includes an unspecified field). Unobserved human capital is the person effect that cannot be explained by education and gender $\alpha_i = \theta_i - z_{i\in e}\hat{u}_e\eta_e - \hat{u}_2 Gen_i$. Unbiased estimates of returns on education rely on the assumption that $\text{cov}(\alpha_i, \eta_e) = 0$ and $\text{cov}(\alpha_i, Gen_i) = 0$. In other words, unobserved individual heterogeneity is assumed to be uncorrelated with the education level (and gender). A positive bias in the estimate of returns on education will be generated if a missing variable such as talent or excess demand for skilled workers explains both higher levels of education and unobserved human capital. It is possible that returns on education also capture unobserved human capital for those who are talented and have not much work experience.

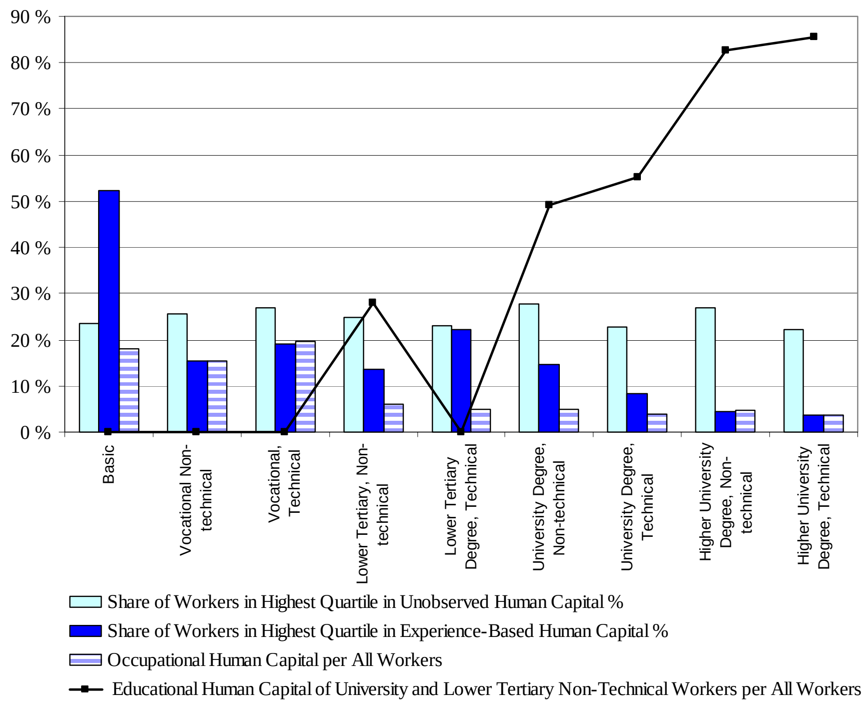
Table 2A.2 in the appendix shows the estimation results. (In what follows we only use data for 1,421 companies with an estimable firm effect covering 2.10 million employees.) As is seen, returns on education increase monotonously with the educational level, at least within the education fields. All workers with higher university education, except those in the health and service sector, belong to the highest quartile for the distribution of education human capital over all the workers. As a measure of education human capital we take into account both the share of the highly-educated and the relative rate of return in each highly educated group

$$Educational\ HC_{j,t} = \sum_{i_t=1}^{I_t} z_{i_t \in H} u_H \eta_H / \sum_{i_t=1}^{I_t} i\ , \tag{11}$$

where $z_{i \in H}$ indicates that the worker belongs to the highly educated group H (where the rates of return are indicated by the solid line in Figure 2.1). Thus, the difference to a compensation weighted average measure is that the denominator is not the number of highly educated workers, but all the workers in the company. We also include non-technical lower-level tertiary degrees in the highly educated group. The exclusion of workers with technical lower-level tertiary degrees can be justified by the lower wages in the technical than in the non-technical field. The selected workers closely form the share of workers belonging to the highest quartile of education human capital.

Figure 2.1 shows the breakdown of experience-based human capital and unobservable human capital into nine educational categories, using five educational degrees (basic, vocational, lower tertiary degree, university degree, higher university degree) divided, with the exception of the first category, into technical and non-technical fields.

Figure 2.1 Educational and Occupation Human Capital and Share of Workers over 75th Percentile of the Overall Unobserved or Experience-Based Human Capital



It can be noted that the share of individuals belonging to the highest quartile of experience-based human capital generally decreases with the educational level, although variation in average ages causes some heterogeneity at the vocational and lower tertiary levels. Unobserved human capital is fairly evenly distributed, as is expected by the design of the model. Occupation human capital decreases with the educational level, which can also be explained by the relatively high income level of blue-collar occupations in manufacturing.

2.4 Regional Distribution of Productivity and Resources

In the following, we shall first take a graphical look at total factor productivity and human capital in the regions by controlling for industry (19 industry dummies), years, and interactions between industry and year in the period 1996-2002. The regional distribution of employees at the establishment level is taken into account in the setting of region dummies for each company. Each region is given the weight of establishment-level employment located there relative to total employment in the company (region dummies for each company hence sum to unity). 20% of employees are located in Helsinki. Using the location of the head-office as the reference would instead give 50% which is more than twice as high. In addition, we use constrained OLS regression. The purpose is that the reference is the representative employee rather than any single region (as when a single region dummy is omitted). The separate constraint states that region dummies weighted by manufacturing employment add up to zero.

Starting from 85 NUTS 4-level regions (1999) those with only a few manufacturing plants are combined, the municipalities of Espoo and Vantaa are considered separate from the Greater Helsinki region, and a satellite region around the Greater Helsinki region is constructed (initially establishment data is available at the municipal level). There are 56 regions. Figure 2.2 shows total factor productivity using eq. (8). Figure 2.3 shows education human capital across regions.

Figure 2.2 suggests that total factor productivity is higher in the municipalities located in the Helsinki region, and in those situated along the railway line and motorway from Helsinki to Pirkanmaa (including Tampere) and in the central part of Finland around the Jyväskylä region. The coastal area in Western Finland has also performed well. Also regions with pulp and paper or metal industry such as Kotka-Hamina, Imatra and Lappeenranta have higher productivity than the country average.

Figure 2.2 Total Factor Productivity

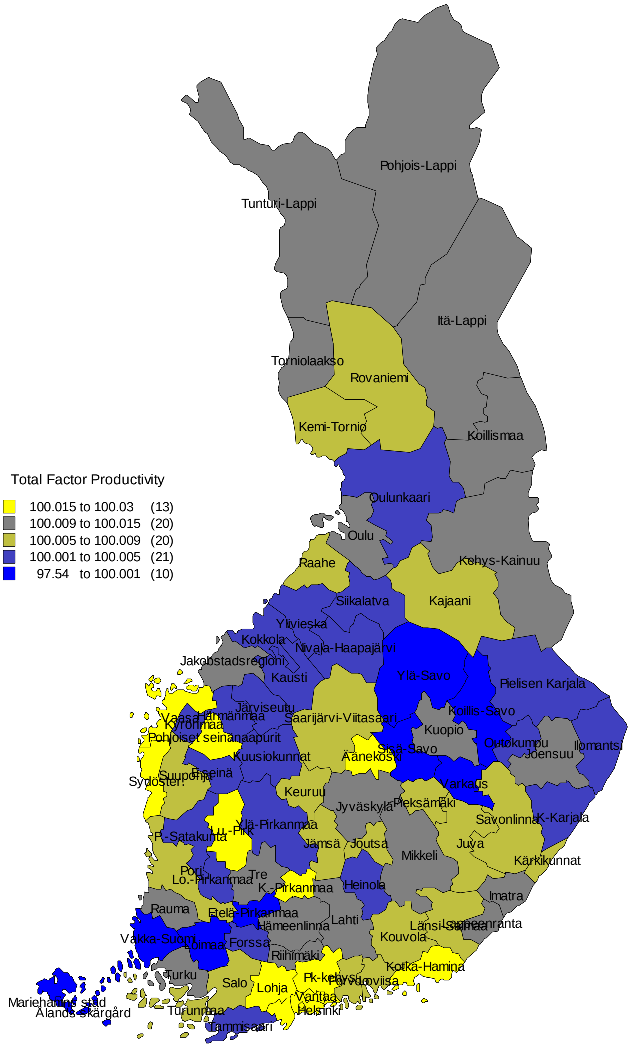


Figure 2.3 Education Human Capital

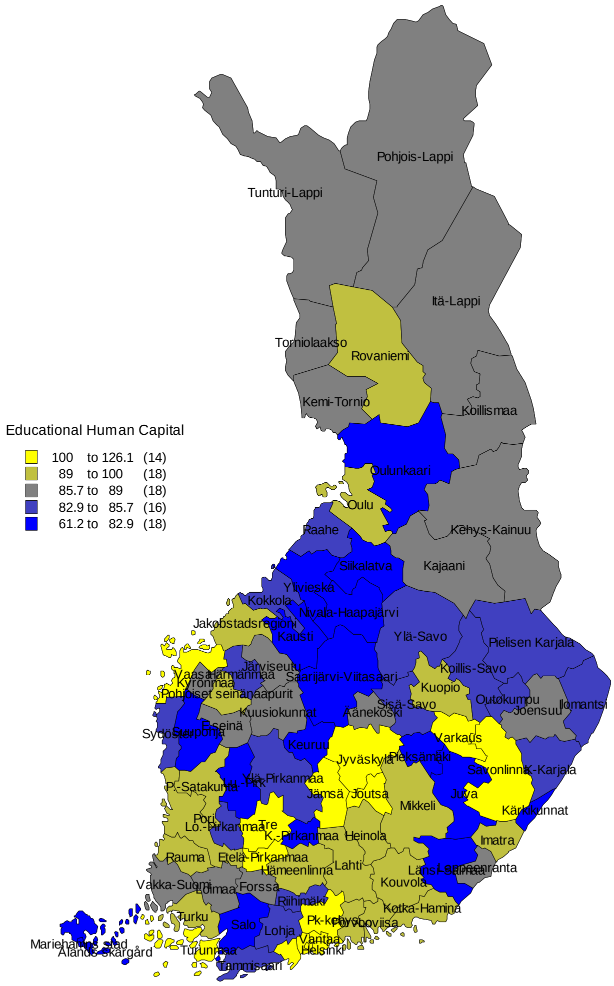


Figure 2.3 shows the regional education human capital, which is our most important measure of human capital. The figure indicates that regions with higher than average total factor productivity tend to have human capital intensive manufacturing. Only Varkaus and Turunmaa, although rich in manufacturing based on education human capital, are low total factor productivity regions. These are regions where many large industrial companies have gone through major restructuring and also regional GDP growth of 1.8% was below the national average of 3.6% in 1996-2002.

In Chapter 4 of this volume a regional competitiveness index is constructed, which includes these human capital components at the personal, company and regional level. In addition, alternative measures of innovativeness are included covering also remunerations and the share of R&D workers. Badinger and Tondl (2002), reviewing patent applications, find Uusimaa, South Finland and North Finland to be among the most innovative regions in Europe, and R&D workers are concentrated in high total factor productivity areas within these larger regions. Chapter 4 shows that the frontier of the R&D intensive research area stretches from Helsinki via the Lahti motorway towards Jyväskylä, as well as towards Tampere.

2.5 Results

This section uses the constructed human capital variables to explain company-level productivity growth and regional productivity growth resulting from knowledge capital. Table 2.2 summarises the variables and correlations between the individual- and firm-specific human capital variables using information for those companies for which the firm effect could be estimated. The average figures and the correlations are very similar for all companies, since the use of 1,421 companies with identifiable firm-effect instead of the original 2,359 companies reduces the number of employees in the data only by 110,000. This represents a 5% decrease in the number of person-year observations.

Abowd *et al.* (2001) find that the firm effect is positively related to the level of human capital (and to the person effect), while here the correlation is negative (Table 2.2) in accordance with most of the empirical literature, see for example Gruetter and Lalive (2003), Barth and Dale-Olsen (2003) and Andrews *et al.* (2004). The firm effect, ψ_i, has a negative correlation in particular with the unobserved human capital (correlation of -0.53). All other individual-based components of log wages *ln(y)* are not correlated strongly with the firm effect. The exception is the positive relation of experience human capital to average seniority.

Table 2.2 Summary and Correlation Table

Person-Average Variable	Person Effect	Human Capital	$u\eta$	α	Exper. H.C.	Gender H.C.	ψ	Occup. H.C.	Senior H.C. *10	PRP	R&D H.C.
Mean	1.179	2.723	0.239	1.187	1.297	-0.247	0.030	0.142	0.034	0.009	-0.002
Std	0.491	0.382	0.230	0.422	0.394	0.087	0.283	0.101	0.003	0.009	0.004
Mean Blue-Collar	1.144	2.665	0.147	1.234	1.284	-0.237	0.038	0.230	0.033	0.007	0.000
Mean White-Collar	1.220	2.790	0.347	1.132	1.311	-0.259	0.021	0.038	0.035	0.011	-0.003
Person Effect	**1**	0.59	0.47	0.86	-0.63	0.21	-0.43	-0.08	-0.37	0.06	-0.21
Human Capital	0.59	**1**	0.22	0.57	0.23	0.01	-0.59	-0.19	0.17	0.14	-0.11
Education $u\eta$	0.47	0.22	**1**	0.00	-0.37	0.02	0.05	-0.42	-0.27	0.15	-0.42
Unobserved α	0.86	0.57	0.00	**1**	-0.52	0.02	-0.53	0.11	-0.29	-0.02	0.00
Experience H.C.	-0.63	0.23	-0.37	-0.52	**1**	-0.03	-0.03	-0.05	0.63	0.07	0.14
Gender H.C.	0.21	0.01	0.02	0.02	-0.03	**1**	0.01	0.13	0.02	0.04	-0.07
Firm Effect ψ	-0.43	-0.59	0.05	-0.53	-0.03	0.01	**1**	0.02	0.00	0.08	-0.06
Occupational H.C.	-0.08	-0.19	-0.42	0.11	-0.05	0.13	0.02	**1**	-0.05	-0.23	0.36
Blue-Collar	-0.03	-0.01	-0.06	-0.02	0.03	0.018	0.105	**1**	0.015	0.058	0.305
White-Collar	-0.03	-0.17	-0.03	-0.03	-0.12	0.02	-0.10	-0.10	-0.06	0.12	-0.12
Seniority H.C.*10	-0.37	0.17	-0.27	-0.29	0.63	0.02	0.00	-0.05	**1**	0.10	0.11
Blue-Collar	-0.31	0.29	-0.30	-0.25	0.63	0.062	0.042	0.015	**1**	0.202	0.038
White-Collar	-0.45	0.02	-0.35	-0.33	0.64	-0.007	-0.065	-0.101	**1**	-0.029	0.197
PRP	0.06	0.14	0.15	-0.02	0.07	0.04	0.08	-0.23	0.10	**1**	-0.18
R&D H.C.	-0.21	-0.11	-0.42	0.00	0.14	-0.07	-0.06	0.36	0.11	-0.18	**1**
Firm-Average Variable	Educat H.C.	Educat H.C. of Highly Edu-cated	Unobser. H.C.	ψ	Occup. H.C.	Senio-rity H.C. *10	Share of R&D Workers	Highly Educat. Spill-over	R&D Worker Share Spillov.	Log TFP Growth	Log TFP Catch. Up
Mean	0.210	0.094	1.137	0.018	0.156	0.028	0.092	0.007	0.012	-0.017	4.533
Std	0.092	0.103	0.382	0.383	0.067	0.015	0.142	0.015	0.038	0.574	1.644
Number of Obs	7532	7532	7532	5698	7532	7532	7532	7532	7532	5490	7532

The table includes 1.13 million blue-collar and 0.96 million white-collar workers and related means and respective correlations of occupational and seniority human capital. Human capital is the sum of educational $u\eta$, unobserved α and experience human capital. Educational human capital at firm level is the per capita value of the sum of educational human capital $u\eta$. Correlations for blue and white-collar workers are withing the respective group.

It is seen that in the mainly manufacturing companies that have been considered white-collar workers have more human capital, which is here the sum of unobserved, education and experience-based human capital. This is primarily explained by higher returns on education. The difference is small because blue-collar workers have more unobserved and occupation human capital. Table 2.2 also shows that returns on education are negatively correlated with returns on experience (-0.37) and to occupation human capital (-0.42). Occupation human capital interacts negatively with returns on education for blue-collar workers, explaining the findings in Figure 2.1 (and positively with R&D work). It is seen that blue-collar workers with high seniority payments are also endowed with human capital. This gives support to the idea that long experience in the company is especially important for the human capital accumulation of blue-collar workers. On the other hand, the human capital of white-collar workers is instead unrelated to seniority or to occupation human capital (note also the low correlation of occupation human capital to the educational degree). Note also that the negative relationship exists only between returns on the education of white-collar workers and occupation capital of blue-collar workers. Within the two groups the correlation between education and occupation human capital is close to zero. Apart from seniority and occupation human capital (which is insufficiently recorded in statistics for blue-collar workers) all other correlations are fairly similar for white-collar and blue-collar workers and are not reported.

We continue to analyse all components of human capital separately. We are able to include in the model many time-varying components including occupations, R&D work and performance-related pay. It appears that with our set of observable characteristics, the unobserved part of wage compensations plays a lower role. In the later analysis, unobserved human capital does not explain productivity growth, although, as discussed, this may also be due to the returns on education capturing part of the effect.

Table 2.3 shows the OLS estimation results in explaining company-level growth. Explanatory variables include individual human capital (education, unobserved, experience) and company-level human capital (occupation, firm effect, performance-related pay PRP, returns on R&D work). We use average seniority rather than seniority payments. A high value of it is a sign of a mature company. Spillovers from the agglomeration of education human capital are included, while those from the agglomeration of R&D workers turned out to be insignificant.

The OLS estimations in columns 2 and 3 are the preferred models, while the first column excludes interaction terms. Column 4 uses no weights. We also evaluate the human capital that is important for companies near or far from a frontier company, where companies are split by the mean value of the productivity gap (columns 5 and 6).

It is seen from column 1 in Table 2.3 that companies with more education human capital generate stronger growth. In columns 2-3 education and occupation human capital are interacted, which has a strong positive effect on growth. The coefficient for education human capital is no longer significant. We find the *growth* of education human capital to be negatively related to TFP growth. These findings are similar to those of Benhabib and Spiegel (1994), who explain, using more aggregated measures of education human capital, productivity growth in 61 countries. The importance of education human capital cannot be interpreted in terms of pure labour productivity augmenting technology, since it is the level and not the rate of change in education and occupation human capital that is important.

Table 2.3 Total Factor Productivity Growth

				No Firm Weights	Far from Frontier	Close to Frontier
Constant	-1.662***	-1.417***	-1.424***	-1.728***	-1.966***	-1.440***
	[3.3]	[3.5]	[3.5]	[15.8]	[5.2]	[3.2]
Catching Up Frontier Firm	0.184**	0.172**	0.169**	0.229***	0.218***	0.181*
	[2.0]	[2.0]	[2.0]	[20.1]	[5.8]	[1.9]
Catching Up, Education H.C. Spillover			0.179***	0.091	-0.292	0.381**
			[2.6]	[0.9]	[1.4]	[2.0]
Education Human Capital	1.037**	0.771	0.775	0.533***	0.559	0.996
	[2.1]	[1.4]	[1.4]	[2.8]	[1.0]	[1.5]
Difference Education Human Capital	-0.539	-0.423	-0.423	-0.336*	-0.814**	-0.395
	[1.3]	[1.1]	[1.1]	[1.9]	[2.6]	[0.7]
Education H.C. Agglomeration	-0.555***	-0.447**	-0.771**	-0.475	1.817	-1.036**
	[2.6]	[2.3]	[2.6]	[1.0]	[1.5]	[2.6]
Workers Above 75% for Unobserved H.C.	0.109	0.044	0.045	0	0.535***	-0.11
	[0.9]	[0.3]	[0.3]	[0.0]	[3.9]	[0.6]
Workers Below 25% for Experience H.C.	-0.219	-0.796	-0.782	-0.306**	-0.411	-0.724
	[0.8]	[1.1]	[1.1]	[2.4]	[1.3]	[1.1]
Workers Above 75% for Experience H.C.	0.186	-0.487	-0.462	-0.193	-0.266	-0.368
	[0.6]	[0.6]	[0.5]	[1.4]	[0.8]	[0.4]
Workers Below 25%, Above 75% for Experience H.C.		4.902	4.814	1.492***	-0.012	5.488
		[1.3]	[1.3]	[2.8]	[0.0]	[1.4]
Firm Effect	0.109	0.048	0.045	0.047	0.333***	-0.076
	[1.2]	[0.5]	[0.5]	[1.2]	[3.7]	[0.5]
Occupation Human Capital	1.202***	0.733	0.715	1.365***	1.095*	0.881
	[2.6]	[1.6]	[1.6]	[5.8]	[1.7]	[1.5]
Education H.C., Occupation H.C.		7.426*	7.226*	1.574	6.886*	7.804
		[1.8]	[1.8]	[0.9]	[1.8]	[1.5]
Returns to PRP	-6.255*	-5.883*	-5.804*	-0.802	-5.770**	-6.278*
	[1.8]	[1.9]	[1.9]	[0.6]	[2.4]	[1.7]
Returns to R&D Research	20.876	12.313	13.433	12.241	-5.156	20.476
	[0.6]	[0.5]	[0.5]	[1.6]	[0.2]	[0.7]
Seniority /100	-1.074*	-1.640**	-1.628**	-0.381*	-0.326	-2.662*
	[1.8]	[2.1]	[2.1]	[1.9]	[0.6]	[1.9]
Seniority Squared/1000	0.054	0.257	0.268	0.166**	0.105	0.577
	[0.2]	[0.6]	[0.7]	[2.1]	[0.4]	[0.8]
Firm Size	0.077***	0.069***	0.070***	0.054***	0.067***	0.072***
	[3.6]	[3.4]	[3.5]	[7.3]	[4.2]	[3.3]
Observations	4411	4411	4411	4411	1982	2429
R-squared	0.187	0.199	0.2	0.135	0.168	0.238

Absolute value of z statistics in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.
Estimation includes female share (insignificant), 5 area, 19 industry and year dummies.

It is seen from Table 2.3 that low-productivity companies appear to catch up with the top-productivity firm in the industry. This shows some variation as indicated by the standard deviation of catching up 1.64 with a positive mean value of 4.53. The interaction of the catching-up term with education human capital spillover is positive in column 3. Column 6 also shows that catching-up and agglomerated education human capital is especially important for companies near the productivity level of the frontier company.

Thus catching-up takes place particularly in human capital abundant, high-productivity areas.

A natural consequence of the Benhabib-Spiegel model is that imitation is more important for companies that are far from frontier companies, whereas high productivity companies have to invest more in innovations in order for the growth to continue. It is seen from columns 5 and 6 that the engines for growth are fairly similar in companies close and far from the frontier. One difference is that the firm effect and the share of the workforce belonging to the highest quartile in unobserved human capital is important in companies far from the frontier.

The company effect can also be considered a proxy for the unobserved components of technology (intangible capital, managerial ability) that is also captured by other company-level characteristics: occupation human capital, R&D work and PRP. The human resource practices in a company as explained by performance-related pay (PRP) or returns on R&D work do not play a very important role in the growth process. We can conclude that high productivity growth companies are not only characterised by a high share of educated workers but also by highly paid professions, by workers with unobserved human capital and by intangible capital. This is especially true for companies that are not near the frontier in productivity.

It is seen from Table 2.3 that companies are very heterogeneous when assessing the importance of work or job experience. The share of workers belonging to the highest quartile in experience-based human capital has an insignificant effect on growth in columns 1-6. However, the coefficient for the interaction between the share of employees belonging to the highest and lowest quartile of overall experience capital is positive in column 4. It is seen that average experience is likely to fail to capture productivity effects since ignoring the importance of having a heterogeneous workforce with young and old workers. We also note that seniority has a non-linear effect so that companies with a very stable workforce and high average seniority tend to grow more slowly.

The catching-up turned out to be positive with significant interactions to regional education human capital. We use Monte Carlo simulation to determine the magnitude of the productivity effects and assess the robustness of our estimates especially with respect to the catching up (see King *et al.* (2000). The simulation is based on the OLS estimation with no company weights. Figures 2.4 through 2.7 show the simulation analysis results using the model reported in column 4 in Table 2.2. Figure 2.7 shows the catching up and seniority effects using the partial model analogous to that reported in column 1 in Table 2.2 with no interaction terms.

Figure 2.4 Education Human Capital

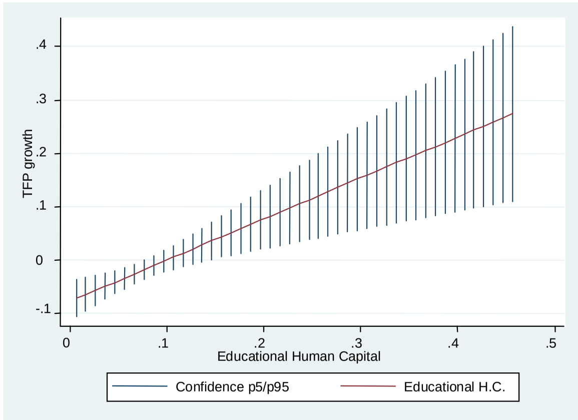


Figure 2.5 Occupation Human Capital

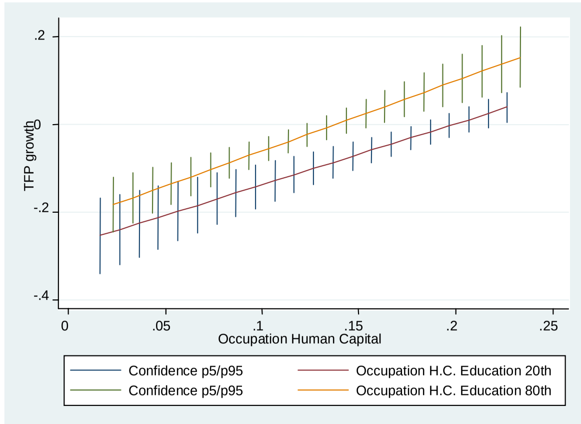


Figure 2.6 Catching-up, Experience 1st Quartile

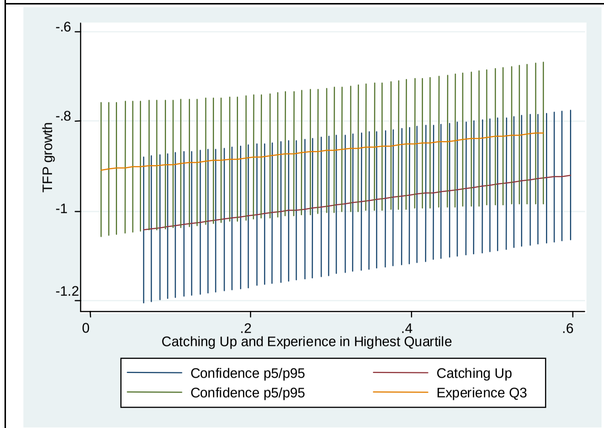


Figure 2.7 Seniority

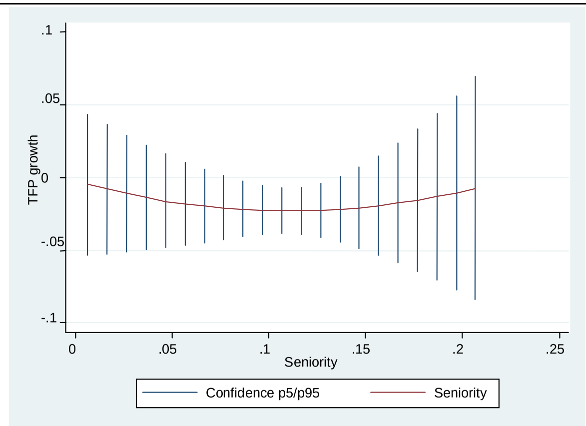
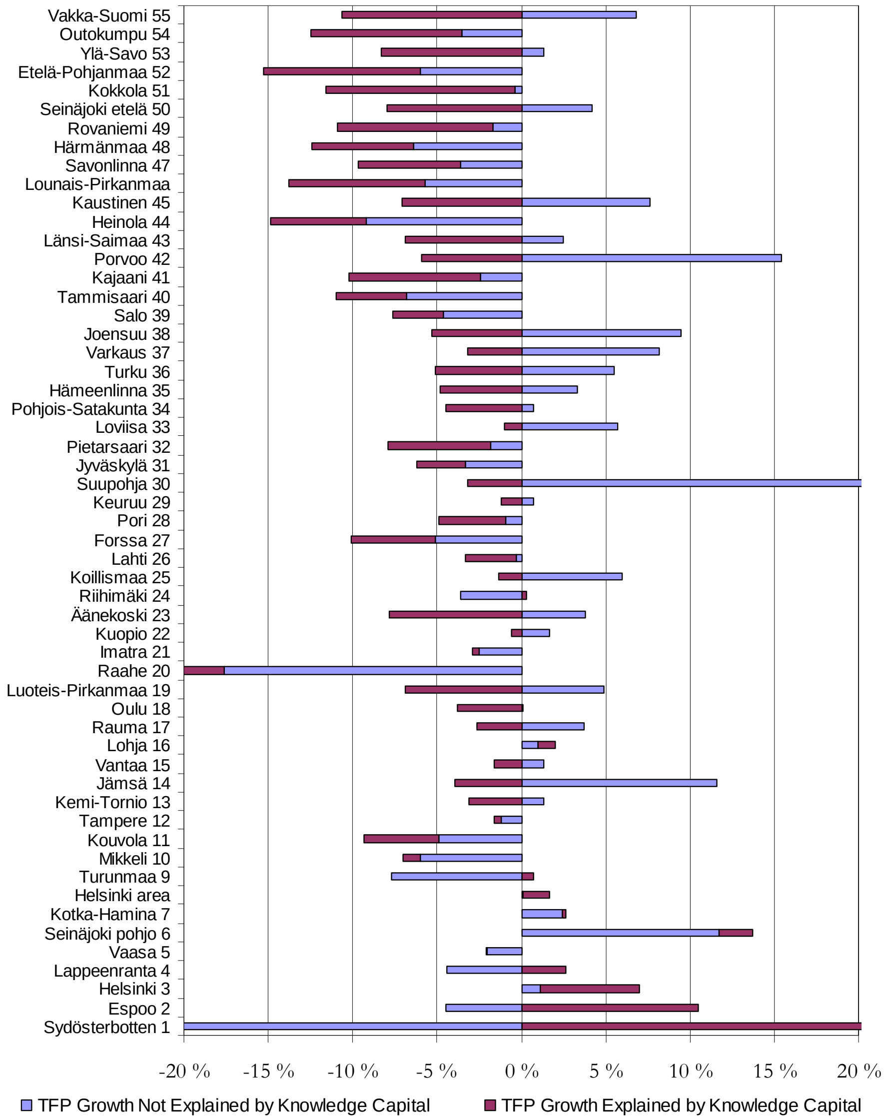


Figure 2.4 shows that an increase in the level of education human capital by around one standard deviation (14 log points) raises productivity growth by around 8 log points. This effect reflects a noticeable fraction of the standard deviation in total factor productivity growth (56.7 log points). Figure 2.5 shows that the growth effect associated with occupation human capital is negative in general when educational human capital is set at the 2nd decile and positive when occupation human capital exceeds its mean value of 0.142 and educational human capital is set at the 8th decile in the overall distribution of education human capital.

Productivity growth is not strongly changing in the share of workers belonging to the highest quartile in work experience or in seniority in Figures 2.6 and 2.7. It is seen that the confidence interval for the catching up effect is also very high. Regional productivity growth may diverge when catching-up depends on agglomeration of skills. We spatially allocate growth and knowledge capital embodied in the companies by using regional dummies in the growth equation. In the company-level estimation, each regional dummy is given the weight of the establishment-level employment of the company located there, as was done already in the construction of Figures 2.2 and 2.3. We also proceed with constrained OLS regression, because the reference is the representative employee rather than any single region. The separate constraint states that regional dummies weighted by manufacturing employment total zero. We aggregate 85 NUTS 4-region level dummies to 56 to combine less densely populated areas with little manufacturing.

In Figure 2.8 TFP growth not explained by human capital shows a coefficient for 56 regional dummies using constrained OLS estimation. The estimation simply added regional dummies to the estimation used in column 3 in Table 2.3 (including interaction of industry and time dummies and dropping six regional dummies). Another estimation is similar but excludes knowledge capital controls. All variables listed in Table 2.3 from catching-up to education human capital agglomeration are, therefore, dropped. The regional distribution of productivity growth, as explained by knowledge capital, is then the OLS estimate of regional dummies in the first model, including all relevant variables, subtracted by the OLS estimates of the latter. In Figure 2.8 the regions are arranged from 1 to 55 according to the decreasing level of total factor productivity.

Figure 2.8 TFP Growth Explained by Human Capital and Other Factors in Selected Regions



It should be noted first that only a few of the regional dummies are significant. However, regions in close proximity have similar characteristics. It is seen that the total factor productivity growth (the sum of that explained by knowledge capital and other factors) tends to be higher in areas where the TFP level is already high, but not always. (The correlation is 0.45.) The high-productivity, large cities of Espoo, Tampere and Oulu are not among the leaders in productivity growth.

Figure 2.8 shows that total factor productivity growth explained by knowledge capital is, on the other hand, clear in high productivity areas. (The correlation between productivity growth explained by knowledge capital and the TFP level is 0.79.) In regions that are not among the 25 most productive areas, knowledge capital promotes productivity more than the average in none of the areas. Regions with productivity growth explained by human capital are concentrated in the Greater Helsinki region or within a radius of 100 km from Helsinki in the direction of Tampere. Thus, according to our results, there is a limited or even negative catching-up between the productivity levels of the different regions in Finland.

Turn next to regional productivity growth on a map. Figure 2.9 shows the regional distribution of productivity growth using only industry dummies, time dummies and interaction between industry and time dummies (column 1 in Table 2A.3 in the appendix). Figure 2.10 presents the regional distribution of productivity growth, as explained by knowledge capital. (i.e. subtracting column 2 from column 1 in Table 2A.3 in the appendix).

Figure 2.9 shows that regions around Helsinki and eastern Uusimaa are strong productivity growth areas followed by Turku, the Swedish-speaking coast around Vaasa, Kuopio and Joensuu. The high growth in Northern Finland is due to there being few companies in the very large region that has been considered a single area (56 instead of 85 regional dummies are used). Figure 2.10 shows that total factor productivity growth is particularly well explained by knowledge capital in the high productivity areas within a 100 km distance from Helsinki in the direction of Tampere. Knowledge capital appears to generate growth in regions around the university cities of Kuopio and Lappeenranta, as well as in the coastal regions south of Vaasa. Thus, according to our results, there is limited or even negative catching-up between the productivity levels of the different regions in Finland due to the agglomeration of human capital.

Figure 2.9 TFP Growth

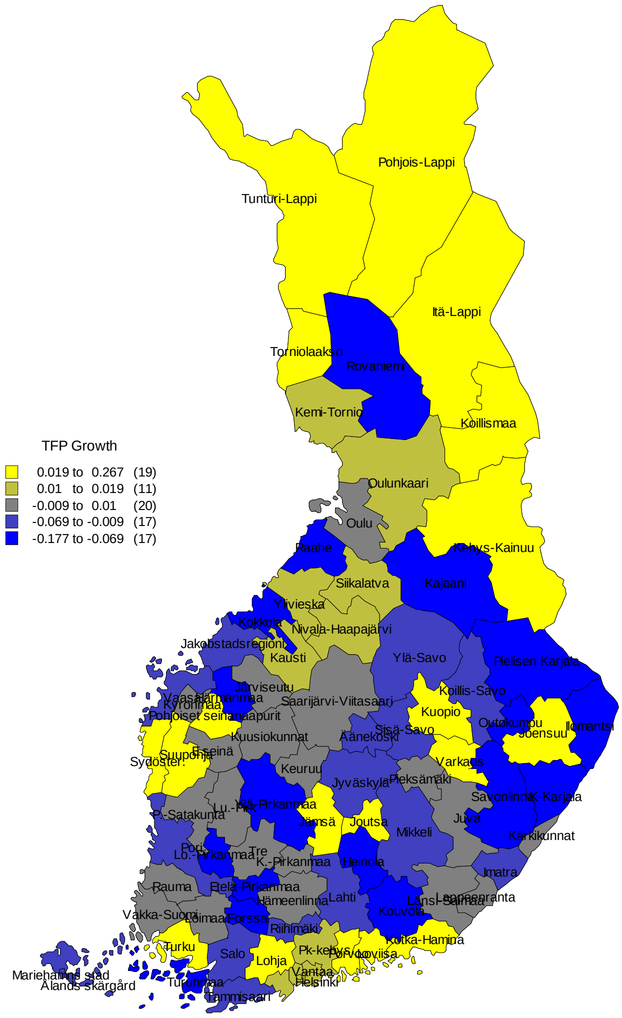
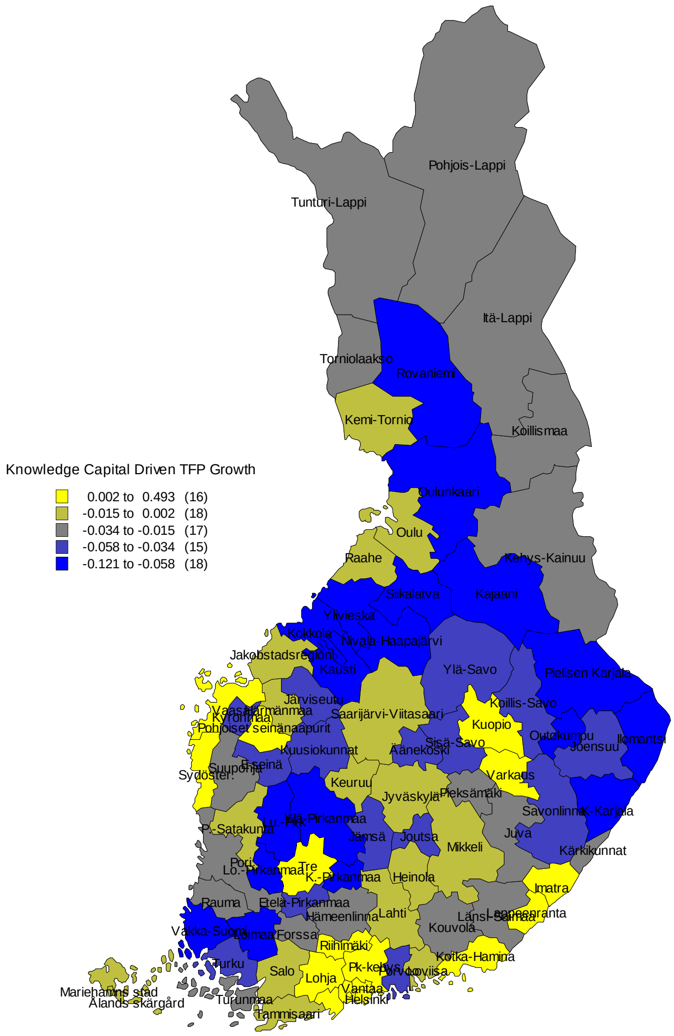


Figure 2.10 Knowledge Driven TFP Growth



2.6 Conclusions

This chapter has examined productivity growth driven by knowledge capital, which includes human capital of workers and intangible capital at company-level. Human capital is agglomerated, which explains no regional convergence. Educational and occupation human capital turned out to be the two cornerstones of productivity growth. The education human capital measure used takes into account both the share of highly educated workers and the educational premium. In line with Benhabib and Spiegel (1994, 2005) and Brunello and Comi (2004), education provides not only the initial labour market advantage but also a permanent advantage. Catching-up is stronger for companies located in human capital agglomerated areas. Agglomeration of education human capital is also useful in the imitation process and contributes to catching-up especially when the company is near the frontier in productivity.

Education human capital alone plays a significant role for very advanced companies near the frontier. Occupation human capital is important in all companies. However, not all companies are abundant in education human capital and have highly paid professions because these are not positively correlated. Companies far from the frontier should possess unobserved human capital for catching-up to continue. This implies that firms should recruit high-wage workers, where the high level of wages is not solely explained by workers having long working career or high level of education. Occupation human capital, unobserved human capital and other intangible capital in the company can lead to logistic type growth. It is also noteworthy that knowledge capital rather than the workforce employed in R&D explains the divergence in growth. This is somewhat surprising, since Kafouros (2005) finds that in the UK growth has since 1995 been particularly R&D driven.

The heterogeneity of experience-based human capital explains why the overall effects on total factor productivity can be unclear. Experience-based human capital as a whole does not indicate stronger growth, while companies may find it beneficial to have both young and experienced workers. We also observe companies with high seniority to have somewhat lower productivity growth.

We can see that growth is concentrated in restricted regions, such as Espoo, Salo and Oulu, where the biggest mobile phone manufacturer Nokia Corporation has important facilities. Finland has experienced agglomeration and divergence in productivity growth at the regional level since 1995. One reason is that the catching-up process is faster for low-productivity companies in education capital abundant, high-productivity areas. It is evident that it is important for specific clusters of regions to have access to a regional pool of education human capital. Substantial labour mobility within countries compared to between countries can be also argued to explain the regional dispersion in growth, see Ottaviano and Pinelle (2002). However, the mobility of workers across regions has not been very high in Finland.

Traditional geography models since Krugman (1991) consider labour mobility to be the key in core-periphery models. However, convergence in productivity should occur, because human capital mobility and agglomeration tend to equalise profitability across regions. Evidence in recent history does not support this hypothesis because insufficient knowledge capital forms a major impediment for all regions to grow. Human capital agglomeration explains no regional convergence.

Many studies, including, for example, Baldwin and Martin (2005), show that R&D research benefiting from local knowledge capital leads to increased spatial inequality. This is not a catastrophe as long as all companies can buy the particular R&D research knowledge from another region. Keller (2002) also argues that decreased localisation of technology diffusion may be explained by reduced transport costs for high-technology goods or by increased direct foreign investment.

Appendix 2A. Construction of Spillover Effects

Spatial weights w are based on a negative exponential function with distance decay parameter β_{E_r}. Following Funke and Niebuhr (2000) and Tanel and Angelis (1998), spillovers from the regional stock of knowledge capital X_z are measured by

$$SPIL_{r,t} = \sum_{z=1}^{R} X_z w_{rz} = X_r w_{rr} + \sum_{\substack{z=1 \\ z \neq r}}^{R} X_z w_{rz}$$

$$= x_r \int_0^{c_r} 2\pi \tilde{c} \exp(-\beta_{E_r} \tilde{c})\, d\tilde{c} + \sum_{\substack{z=1 \\ z \neq r}}^{R} X_z \exp(-\beta_{E_r} d_{rz}) . \qquad \text{(A.1)}$$

Knowledge capital utilisation in the region (first term) is assumed to be evenly distributed in the area of the region, F_r, with the corresponding radius $c_r = \sqrt{F_r / \pi}$. The density of knowledge capital utilisation is $x_r = X_r / F_r$. In the surrounding regions (second term), d_{rz} shows the distance between the region r and other regions z. β_{E_r} includes the decay parameter γ_E through

$$\beta_{E_r} = -[\ln(1-\gamma_E)] / \bar{D}_{MIN} . \qquad \text{(A.2)}$$

$\bar{D}_{MIN}$ shows the average distance between adjacent neighbouring regions. The parameter γ_E $(0 < \gamma_E < 1)$ measures the percentage decrease of the spatial interaction, a higher value of which represents geographical impediments. Knowledge capital declines with increasing "half-distance" $d_E = \ln 2 / \beta_{Er}$, which is the distance that reduces the spatial interaction by one-half. The half-decay distance is set, on average, at 122 km for education human capital. This optimal distance was identified from the variation of the productivity growth effects. Half-life distance is less than that obtained for R&D international spillovers in Keller (2002), where it ranges from 162 to 1,200 km. Note that these half-life distances vary from one region to another, and are greater when neighbouring regions are remote (e.g. 250 km for the Oulu region in Northern Finland).

Appendix 2B. Description of the Linked Employer-Employee Data

The data with 3,096,771 observations, cover all workers (excluding top management) who have worked for at least one year during 1996-2002 in companies that belong to the Confederation of Finnish Industry and Employers. After some adjustment for relevant observations, the estimation sample for observations with a company code is 2,755,716 (20,796 observations discarded for having no education classification, 3,157 omitted for no information on seniority, 181,048 dropped for missing hourly wages, 118,243 omitted for log wages deviating more than five standard deviations from the predicted value using experience up to the fourth potency, gender and 22 education classes and 17,811 observations dropped for lacking company codes). This number decreases to 2,096,523 when only employees with an estimable company effect are included.

Following the method developed by Baldwin *et al.* (1992), company births and deaths are considered a mere transfer of the company in instances where people employed either at the old company at date t–1 or at the new company at date t constitute more than 40% of all employees working in these companies at dates t–1 and t. Thus 43,744 individuals are in (many) small companies that are linked to a large company by giving them the same company code and 16,756 individuals are in large companies that divide into (many) small companies with the same company code since satisfying this 40% criterion. These unnatural births and deaths account for approximately 3% of all company births and deaths. Many of the old or new companies are large and, therefore, recoding will affect 9% of employees. The deflator used is the producer price index at the two-digit level in manufacturing and three-digit level in other industries, yielding 58 industries.

Regional dummies

The merged regions are Vakka-Suomi (Vakka-Suomi and Loimaa), Luoteis-Pirkanmaa (Luoteis-Pirkanmaa and Kaakkois-Pirkanmaa), Lounais-Pirkanmaa (Lounais-Pirkanmaa and Ylä-Pirkanmaa), Länsi-Saimaa (Länsi-Saimaa, Kärkikunnat, Juva, Pieksämäki), Ylä-Savo (Ylä-Savo, Koillis-Savo, Sisä-Savo), Outokumpu (Outokumpu, Ilomantsi, Keski-Karjala, Pielisen Karjala), Keuruu (Keuruu, Saarijärvi-Viitasaari), Jämsä (Jämsä, Joutsa), Seinäjoki Etelä (Seinäjoki Etelä, Kuusiokunnat, Järviseutu, Kyrönmaa), Kaustinen (Kaustinen, Oulunkaari, Siikalatva, Nivala-Haapajärvi, Ylivieska), Koillismaa (Koillismaa, Kehys-Kainuu, Torniolaakso, Itä-Lappi, Tunturi-Lappi, Pohjois-Lappi), Maarianhamina (Maarianhamina, Ålands landsbygd, Ålands skärgård, set at average value).

Table 2A.1 Estimates of the Effects of Experience, Year, Individuals and Companies on the Log of Wages for 1996 to 2002 with Plant Dummies and Person Effect

	First-Stage Eq. (8)		Second-Stage Eq. (9)	
Variable	Coefficient	t-value	Coefficient	t-value
Experience/10	1.239	(67.7)***	1.272	(195.4)***
$Experience^2/100$	-0.438	(40.9)	-0.457	(116)***
$Experience^3$ / 1000	0.081	(23.2)***	0.088	(72.8)***
$Experience^4$ / 10000	-0.006	(15.2)	-0.006	(50.9)***
Seniority/1000	0.361	(5.2)***	0.214	(5.4)***
Seniority/10000	0.052	(6.6)***	0.028	(6)***
Performance Related Pay	0.023	(21.9)***	0.026	(70.9)***
R&D Work	-0.063	(2.6)	-0.016	(4.3)***
Blue-Collar Work	0.213	(27)***	0.233	(84)***
Other White-Collar Work	0.028	(3.6)***	0.036	(13.5)***
Management Accountancy	-0.008	(1.2)	-0.012	(4.9)***
Invoicing	-0.028	(3.8)	-0.019	(6.7)***
Secretarial	-0.016	(2.9)	-0.014	(6.8)***
Construction	0.072	(2.8)**	0.035	(8.1)***
Planning	-0.010	(1.6)	0.009	(3.8)***
Logistic	0.012	(3)**	0.008	(6.7)***
Customer Service	0.003	(1.4)	-0.006	(2.8)**
Marketing	0.004	(0.4)	0.013	(4.2)***
Information, Data Processing	-0.014	(1.7)	-0.003	(1.2)
Legislation 1	0.017	(3.6)***	0.025	(17.9)***
Legislation 2	-0.008	(0.9)	0.002	(0.6)
Office work 1	-0.005	(0.6)	0.009	(3)**
Office work 2	0.003	(0.3)	0.015	(4.9)***
Office work 3	-0.001	(0.2)	0.008	(2.7)**
Personnel Policy Work	-0.016	(1.6)	-0.006	(1.9)
Buyer	0.013	(1.3)	0.024	(6.9)***
Firm Effect			0.045	(27.2)***
Observations	285,730		2,096,523	
Chow test between (289,031 obs) movers and non-movers (1,919,171 obs) in Eq. (9)			F-value 12.180	Pr > F <0.0001
R squared	0.157		0.136	

Estimation includes 1,421 firm dummies and time dummies. * Significant at 95% level, ** Significant at 99% level, *** Significant at 99.9% level.

Table 2A.2 Education Effects

Variable	Coefficient	Standard Error
Intercept	-47.289	(69)***
Upper Secondary Level		
General	0.474	(183.2)***
Teacher	0.099	(20.1)***
Humanities, Arts	0.100	(21.9)***
Natural Science	0.196	(9.6)***
Technology	0.194	(106.6)***
Health, Services, Agriculture	0.211	(62.6)***
Lowest Level Tertiary	0.075	(8)***
General, Teacher		
Humanities, Arts	0.294	(100.1)***
Natural Science	0.585	(44.7)***
Technology	0.207	(69.1)***
Health, Services, Agriculture	0.332	(38.1)***
Lower Degree, University	0.265	(30.5)***
General, Teacher		
Humanities, Arts	0.621	(95.8)***
Natural Science	0.414	(18.1)***
Technology	0.554	(184.9)***
Health, Services, Agriculture	0.608	(30.8)***
Higher Degree, University	0.651	(80)***
General, Teacher		
Humanities, Arts	0.907	(163.2)***
Natural Science	0.772	(90.6)***
Technology	0.867	(231)***
Health, Services, Agriculture	0.893	(36.1)***
Doctoral Level	0.872	(78.2)***
Gender Effect	-0.191	(119.3)***
Number of Observations	142,810	
R-Squared	0.35	

* Significant at 95% level, ** Significant at 99% level, *** Significant at 99.9% level.

Table 2A.3 Total Factor Productivity Growth, Regional Effects

	TFP Growth	TFP Growth All Variables	TFP Level		TFP Growth	TFP Growth All Variables	TFP Level
Helsinki	0.011	0.070***	0.011	Savonlinna	-0.036	-0.097	-0.036
	[0.6]	[3.6]	[0.6]		[0.5]	[1.3]	[0.5]
Vantaa	0.013	-0.003	0.013	Ylä-Savo	0.013	-0.07	0.013
	[0.3]	[0.1]	[0.3]		[0.2]	[1.2]	[0.2]
Espoo	-0.045	0.06	-0.045	Kuopio	0.017	0.011	0.017
	[1.0]	[1.4]	[1.0]		[0.3]	[0.2]	[0.3]
Helsinki area neighbours	0.001	0.017	0.001	Varkaus	0.082	0.05	0.082
	[0.0]	[0.5]	[0.0]		[0.9]	[0.6]	[0.9]
Lohja	0.01	0.02	0.01	Outokumpu	-0.035	-0.124**	-0.035
	[0.2]	[0.4]	[0.2]		[0.6]	[2.1]	[0.6]
Tammisaari	-0.068	-0.110**	-0.068	Joensuu	0.095	0.042	0.095
	[1.2]	[2.0]	[1.2]		[1.4]	[0.7]	[1.4]
Turunmaa	-0.077	-0.07	-0.077	Jyväskylä	-0.033	-0.062	-0.033
	[0.8]	[0.7]	[0.8]		[0.8]	[1.5]	[0.8]
Salo	-0.046	-0.076	-0.046	Keuruu	0.007	-0.005	0.007
	[0.7]	[1.1]	[0.7]		[0.1]	[0.1]	[0.1]
Turku	0.055*	0.004	0.055*	Jämsä	0.116	0.077	0.116
	[1.7]	[0.1]	[1.7]		[1.2]	[0.8]	[1.2]
Vakka-Suomi	0.068	-0.038	0.068	Äänekoski	0.038	-0.04	0.038
	[1.3]	[0.8]	[1.3]		[0.3]	[0.4]	[0.3]
Rauma	0.037	0.011	0.037	Suupohja	0.295**	0.263*	0.295**
	[0.7]	[0.2]	[0.7]		[2.0]	[1.9]	[2.0]
Pori	-0.009	-0.049	-0.009	Seinäjoki pohjo	0.117	0.137*	0.117
	[0.2]	[1.1]	[0.2]		[1.5]	[1.8]	[1.5]
Pohjois-Satakunta	0.007	-0.038	0.007	Seinäjoki etelä	0.042	-0.038	0.042
	[0.1]	[0.4]	[0.1]		[0.6]	[0.6]	[0.6]
Hämeenlinna	0.033	-0.015	0.033	Härmänmaa	-0.064	-0.124	-0.064
	[0.6]	[0.3]	[0.6]		[0.8]	[1.6]	[0.8]
Riihimäki	-0.036	-0.033	-0.036	Vaasa	-0.02	-0.021	-0.02
	[0.6]	[0.6]	[0.6]		[0.3]	[0.4]	[0.3]
Forssa	-0.051	-0.101	-0.051	Sydösterbotten	-0.244	0.023	-0.244
	[0.6]	[1.3]	[0.6]		[0.9]	[0.1]	[0.9]
Luoteis-Pirkanmaa	0.049	-0.02	0.049	Pietarsaari	-0.018	-0.079	-0.018
	[0.6]	[0.3]	[0.6]		[0.3]	[1.2]	[0.3]
Etelä-Pohjanmaa	-0.06	-0.153*	-0.06	Kaustinen	0.076	0.005	0.076
	[0.7]	[1.9]	[0.7]		[1.3]	[0.1]	[1.3]
Tampere	-0.012	-0.016	-0.012	Kokkola	-0.004	-0.116*	-0.004
	[0.5]	[0.6]	[0.5]		[0.1]	[1.7]	[0.1]
Lounais-Pirkanmaa	-0.057	-0.138***	-0.057	Oulu	0.001	-0.037	0.001
	[1.0]	[2.6]	[1.0]		[0.0]	[0.8]	[0.0]
Lahti	-0.003	-0.033	-0.003	Raahe	-0.176*	-0.212**	-0.176*
	[0.1]	[1.0]	[0.1]		[1.8]	[2.3]	[1.8]
Heinola	-0.092	-0.149*	-0.092	Koillismaa	0.06	0.047	0.06
	[1.1]	[1.9]	[1.1]		[0.9]	[0.7]	[0.9]
Kouvola	-0.049	-0.085	-0.049	Kajaani	-0.024	-0.102	-0.024
	[0.9]	[1.6]	[0.9]		[0.2]	[1.1]	[0.2]
Kotka-Hamina	0.024	0.026	0.024	Rovaniemi	-0.017	-0.109	-0.017
	[0.4]	[0.5]	[0.4]		[0.2]	[1.3]	[0.2]
Lappeenranta	-0.044	-0.018	-0.044	Kemi-Tornio	0.013	-0.018	0.013
	[0.8]	[0.3]	[0.8]		[0.2]	[0.2]	[0.2]
Länsi-Saimaa	0.025	-0.044	0.025	Porvoo	0.154**	0.095	0.154**
	[0.3]	[0.5]	[0.3]		[2.2]	[1.4]	[2.2]
Imatra	-0.025	-0.029	-0.025	Loviisa	0.057	0.047	0.057
	[0.4]	[0.4]	[0.4]		[0.5]	[0.4]	[0.5]
Mikkeli	-0.06	-0.07	-0.06	Maarianhamina	-2.19	-21.733	-2.19
	[0.9]	[1.1]	[0.9]		[0.1]	[0.9]	[0.1]
Observations	6788	6788	6788				

Absolute value of z statistics in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. First columns 1,4 include only industry, regional and year dummies and interactions to year and industry dummies.

3. Public Funding of R&D and Growth

3.1 Introduction

This study explains growth in productivity and employment generated by public R&D subsidies. Overall public R&D expenditure is distributed over the country more equally than private R&D expenditures, where over 80% take place in Uusimaa, Varsinais-Suomi, Pohjois-Pohjanmaa (Oulu) and Kanta-Häme. This is explained by the distribution of universities and polytechnics. The Greater Helsinki region is still responsible for about 50% of all public R&D expenditure. Around 50% of R&D subsidies by the National Technology Agency (Tekes) go to the Greater Helsinki region.

Regional distribution is hard to evaluate, since often the subsidies are awarded to the headquarters although R&D takes place elsewhere (see, however, later Figure 3.1). The public subsidies are used to foster innovation and growth in the area, which, in turn, is often presumed to have a positive impact on employment. We use linked employer-employee data for Finland. Linked data is extensively used in the study of human capital formation, starting with Abowd *et al.* (1999). The data allow the estimation of returns on knowledge capital, which can be divided into that specific to the individual and to the company. Company-specific innovations and knowledge, worker-specific knowledge and the catching-up process are the major determinants of growth. We analyse how public subsidies are integrated into the knowledge capital of companies to produce growth. We adapt Jones' (1995) framework to separate innovation and imitation, and Benhabib and Spiegel (2005) to include in the model the catching-up process.

The rate of return on private R&D has increased over the decades, see Wieser (2005) and Kafouros (2005) for the UK. Wieser (2005) in his surveys also finds that the rates of return do not significantly differ between countries, whereas the estimated elasticities do because of the difference in R&D intensities. If public subsidies augment private R&D they can thus also enhance productivity growth. David *et al.* (2000) in their survey find mixed results on the substitutability between, or the complementarity of public subsidies and private R&D expenditure. Public funding is highly endogenous and later studies have controlled for this using instrumenting techniques. Wallsten (2000) finds that, after instrumenting similar to our study, the public R&D subsidies in the US have a strong crowding out effect on private investment and no effect on employment. Most of the other studies do not find complete crowding out. Busom (1999) in Spain and Czarnitzki and Fier (2002) and Hussinger (2003) in Germany find evidence that public funding has real effects on private innovations. Sorensen *et al*. (2003) in Denmark find that subsidies increase private R&D expenditures. Ebersberger (2004) in Finland utilises differences-in-differences techniques to analyse the innovation and labour demand effects of public R&D funding in Finland. The results suggest that subsidies have a positive impact on innovation output, and in the long run on employment, see also Lehto (2000). Ali-Yrkkö (2005) instead finds no employment effect other than the positive impact on the number of workers in R&D research.

Public subsidies by the National Technology Agency, Tekes, have been since 2004 publicly recorded. Tekes is responsible for about 80% of all public subsidies on R&D in Finland, the amount being 409 million euros in 2004. As regards large firms, public subsidy awards require a joint project with small firms. These projects usually take place long time, up to five years. Firm size is thus important to control. Small firms also participate less frequently in various support programmes and those that participate can be more easily the most technologically advanced. Small firms can also have a higher cost for alternative external finance. We pay particular attention to the instrumentation of public subsidies using the information available or R&D subsidies in each industry and region. The main finding in our study is that public subsidies have a positive effect on productivity growth in small- and medium-sized firms and improve employment in companies with highly-paid R&D workers and in small and medium-sized companies from large companies. The rest of the chapter is structured as follows: Section 3.2 describes the model and Section 3.3 the data. Section 3.4 presents the results of the estimation. Section 3.5 concludes.

3.2 The Model

This chapter analyses the effectiveness of public funding in R&D in promoting productivity and employment growth. We rely on Jones (1995) in the modelling of subsidies to generate long-run growth. Knowledge capital (including private R&D) relates to public R&D subsidies in log-linear form

$$KC_t = Y_t^{\theta} G_t^{\zeta} X_{KCt}, \qquad (1)$$

Where Y_t is the quantity of final goods sold, G_t is public subsidies on KC (especially for R&D) and X_{KCt} is other determinants of knowledge capital and private R&D. If KC is scale invariant, $\theta + \zeta = 1$, eq. (1) can be expressed in intensity terms KC_t/Y_t , G_t/Y_t. The production technology for new knowledge is specified as

$$I_{t+1} - I_t = KC_t^{\lambda} \vartheta I_t^{\phi} - \delta I_t , \tag{2}$$

where I_t indicates knowledge and δ is the depreciation rate of knowledge. The parameter ϕ indicates spillovers from existing knowledge, ϑ is the arrival rate and λ indicates the decrease in marginal productivity when new and less innovative scientists enter the R&D work. The arrival rate of innovations, ϑ, can exceed unity explaining continuous growth. The neoclassical model assumes no knowledge spillovers $\vartheta = 1, \phi = 0$, and no decreasing returns in marginal productivity, $\lambda = 1$. The semi-endogenous growth model by Jones (1995) takes $0 < \lambda < 1$, $\vartheta > 0, \phi < 1$. Knowledge exhibits decreasing returns, $\phi < 1$, under the assumption that the most productive knowledge is invented first. Most qualified scientists are also hired first so that $0 < \lambda < 1$. The steady state growth rate of knowledge is given by

$$\frac{\dot{I}}{I} = \vartheta \frac{KC^{\lambda}}{I^{1-\phi}} - \delta . \tag{3}$$

For no scale effects, an increase in the marginal return on new scientists in knowledge capital (λ goes up) should be accompanied by a lower return for existing knowledge (ϕ goes down) so that the change in KC^{λ} is paralleled by a change in $I^{1-\phi}$. In the opposite case, with an improvement in both the marginal return on new scientists and existing knowledge, scale effects exist. Earlier literature, starting with the Romer (1990) and Grossman and Helpman (1991) models, takes this to the extreme, $\vartheta = \phi = 1$, so that productivity growth is directly proportional to the number of R&D workers. We, however, proceed in intensive form. We thus assume that subsidies are not proportionally more efficient in companies with many scientists. We also produce some indirect evidence that the scale effects are not very large.

The steady state level of innovation activity I_t^* can be expressed as a function of the steady state level of output and other determinants by substituting (1) with (3) (with $\dot{I}/I = \delta$)

$$I^* = \vartheta G^{*\lambda\zeta/(1-\phi)} Y^{*\theta\lambda/(1-\phi)} KC^{1/(1-\phi)}. \qquad (4)$$

The elasticities with respect to public subsidies $\lambda\zeta/(1-\phi)$ and output $\theta\lambda/(1-\phi)$ simplify to λ and θ with a neoclassical production function. If scale invariance $\theta + \zeta = 1$ prevails, this can be rewritten in intensity form as

$$\frac{I^*}{Y^*} = \vartheta Y^{*\frac{\lambda+\phi-1}{1-\phi}} \left(\frac{G^*}{Y^*}\right)^{\lambda\zeta/(1-\phi)} KC^{1/(1-\phi)}. \qquad (5)$$

Knowledge accumulation as explained by public subsidies depends on the inefficiency of public subsidies, ζ, and on the decreasing returns either in the recruitment of new scientists, $0 < \lambda < 1$, or in the use of existing knowledge, $0 < \phi < 1$. The release of the scale invariance in knowledge accumulation, $\lambda + \phi > 1$, leads the innovation rate to be positively dependent on output. Following Benhabib and Spiegel's (2005) framework, we explain by the level of knowledge the impetus for growth. This assumes that knowledge capital has important long-run effects that are not captured by difference estimation.

3.3 Data

The labour data are from the Confederation of Finnish Industry and Employers, where 75% of the companies are in the manufacturing sector. The original data with 3.09 million individual-year observations cover 1996-2002 and include both blue- and white-collar employees. The data include a rich set of variables covering compensation, education and profession. The white-collar employees receive salaries and the blue-collar workers receive an hourly wage. Employee data are linked to publicly available financial statistics data provided by the Balance of Consulting and Suomen Asiakastieto, to include information on profits, value added and capital intensity (fixed assets). We have no information on R&D expenditures at the company level, but have information on white-collar workers in R&D work.

Knowledge Capital

Using the linked employer-employee data analysis starting with Abowd *et al.* (1999), we divide knowledge capital into that relating to, respectively, individual and company heterogeneity. The estimation of these, as done in Chapter 2 in this volume, is briefly described also in the next section. Worker-specific knowledge does not depend on the company's assets, and the worker can transfer this knowledge to the use of other companies in job transfers. We can argue imitation to work here, which includes returns to scale opportunities. In the Benhabib and Spiegel (2005) framework catching-up also plays an important role. The most important part of individual heterogeneity is the returns on education. The remaining part of the person-specific fixed effect is the part of the compensations that cannot be explained by observed characteristics (to the econometrician). We refer to this knowledge capital as unobserved human capital.

Knowledge important in innovations is considered to be company-specific. The higher share of scientists, the access of R&D in surrounding companies, intangible capital and also the organisation of work (here performance-related pay) are all company-specific and can be thought of as generating an innovative base. Unobserved company-specific knowledge capital is captured by company dummies.

Based on our theoretical model we divide firm-specific and person-specific knowledge capital. The division follows from the separation of company-level human capital (occupation, company effect, seniority (length of stay in the company), performance-related pay PRP) and individual human capital (education, unobserved, experience). The estimation of these is described in Chapter 2 and briefly in the next section. This leads to the following categories:

Table 3.1 Knowledge Capital: Firm-Specific, Worker-Specific

Knowledge Capital: Firm-Specific
Share of White-Collar Workers in R&D Work
R&D Agglomeration
Occupation Capital
Occupation Capital, Education Human Capital Interaction
Knowledge Capital: Worker-Specific
Education Human Capital
Workers Above 75% for Unobserved H.C.
Workers Below 25%, Workers Above 75% for Experience H.C. Interaction

The shares 25%, 75% use as the reference the overall distribution across firms over the period.

It is clear that education human capital also plays an important part in the innovative process, but is transferable in nature and not embodied in the company similarly to R&D work and occupation human capital.

Econometric Method

Compensations for skills and work are used to evaluate knowledge capital. Abowd *et al.* (2002) develop a numerical solution to deal with the large set of company dummies in the Least Squares Dummy Variables Estimator. Chapter 2 uses the two-step method suggested by Andrews *et al.* (2004).

The estimation includes dummy variables for the company that are estimated at the first step in data covering only individuals that move from one company to another and sweep out the worker heterogeneity by taking deviations from individual means. This is first expressed as a function of individual heterogeneity, company heterogeneity and measured time-varying characteristics for movers as a deviation from individual means. After checks for real births and deaths of companies, the original data included 2,359 companies and the firm-effect could be identified for 1,421 companies with at least 30 job transferees. Employees with one or more job transferees (286,000) account for 13% of all observations in the 1,421 companies. These companies, at the same time, cover most of the employee-year observations, 2.09 million out of 2.76 million. The second step estimation, with the same explanatory variables amended by the estimated company effect, covers all workers in the sample of companies for which the company effects were identifiable.

$$\ln(y_{it}) - \mu_{yi} = \beta(x_{it} - \mu_{xi}) + \gamma(w_{it} - \mu_{wi}) + \delta(\hat{\psi}_{j(i,t)} - \mu_{\psi i}) + e_{ijt} , \quad (6)$$

where $\beta(x_{it} - \mu_{xi})$ shows the compensation for time-varying human capital stated as a deviation from the individual mean human capital; hence it contains time dummies and experience expressed up to the fourth power. $\gamma(w_{it} - \mu_{wi})$ shows the respective time-demeaning for all company-specific variables: occupations, seniority, R&D work and performance-related pay, θ_i is the compensation for time invariant human capital (individual fixed effect) and $\mu_{\psi i}$ is the individual mean of the company effect $\hat{\psi}_{j(i,t)}$. The person fixed effect is the person average using the second-step estimation results: $\theta_i = \mu_{yi} - \hat{\beta}\mu_{xi} - \hat{\gamma}\mu_{wi} - \mu_{\psi i}$, where $\hat{\beta}$ and $\hat{\gamma}$ are the estimated values of the coefficients. The person effect θ_i is then regressed against all education-level dummies and gender. Unobserved human capital is the unexplained part of the person fixed effect. Estimation results are shown in Chapter 2 in this volume.

R&D and Public Subsidies

We use the publicly available information on public subsidies by the National Technology Agency, Tekes, including also information provided by Tekes on companies that have applied for subsidies and annual information on actual imbursement. The subsidies are measured in the year when granted and not when paid, as the distribution of payments can be arbitrary. In Finland subsidies for innovation activities are concentrated in Tekes with a budget of 400 million euros in 2004 and 2,000 projects annually. The data from the Confederation of Finnish Industries cover well, in particular, all large companies getting public funding as part of their investment. Nearly one fourth of the companies recorded in the data from the Confederation of Finnish Industries have applied for public funding. The following figures show the regional distribution of R&D workers and Tekes funding granted. The Regional distribution of subsidies granted for each company is based on the employment shares of companies, while subsidies are often granted to the region, where the headquarter is situated.

It is seen that Tekes funding of R&D is spatially distributed similarly to the share of workers engaged in R&D in the companies. Both indicate a line of heavy R&D investment extending from Helsinki in the direction of the Jyväskylä NUTS 4 -region.

An ideal instrument for R&D subsidies reflects the potentially available subsidies for the company (see Lichtenberg, (1988)). The Tekes funding has clear industry variation as the share of risk taking and innovative companies, the target group, is likely to vary from one industry to another. The potentially available subsidies, the Tekes budget for each industry, can also be said to be independent of the company's unobserved abilities in the industry. As an instrument for applicants with awards, Wallsten (2000) uses the sum of sector-level R&D total funding for the sectors where the companies have won public funding. The instrument for applicants with rejections is the sum of sector-level R&D total funding for the sectors where the company has applied for public funding. For the companies that have not applied for public R&D funds, he uses the sector-specific total funding multiplied by the probability of receiving them, which is awards per application in the sector. His data cover 367 companies with awards, 90 rejected companies and 22 companies that have not applied chosen from the Compustat database to represent this group.

We analyse Tekes funding in 26 industries further divided into 6 regions: Helsinki region, city, provincial centre, industrial region, countryside, periphery. Public awards are allocated unevenly across industries with an emphasis on the technology industry. Thus, it is likely that the potential for (knowledge capital intensive) companies to apply for or receive subsidies is lower outside the technology industry. The Tekes administration has also a regional dimension. Companies situated closer to the regional centres or in manufacturing intensive areas may have better opportunities to apply for Tekes funding than companies far away. Tekes funding is deliberately used to strengthen the growth sectors/areas in the economy.

Figure 3.1 shows the regional distribution of Tekes funding per Sales and Figure 3.2 shows the share of salaried workers. It is seen that R&D work is concentrated in Greater Helsinki region and in a direction to Jyväskylä. Tekes funding has much wider regional distribution. Uusimaa, Keski-Suomi and South Pohjanmaa appear to be the greatest beneficiaries of Tekes funding.

Figure 3.1 Average R&D Tekes Funding per Sale

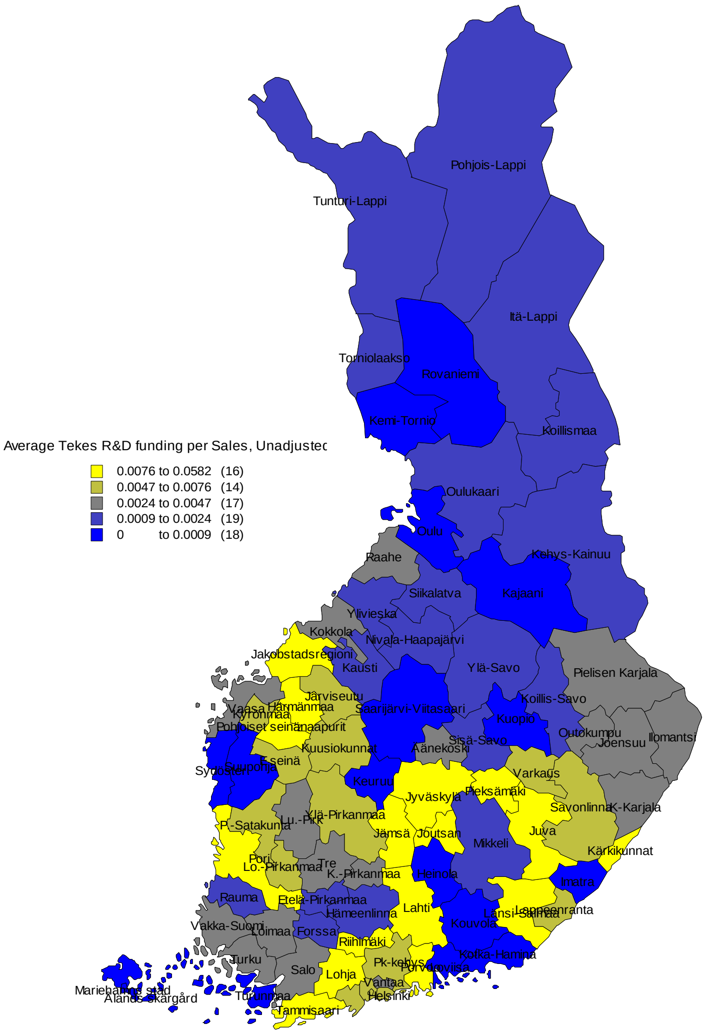
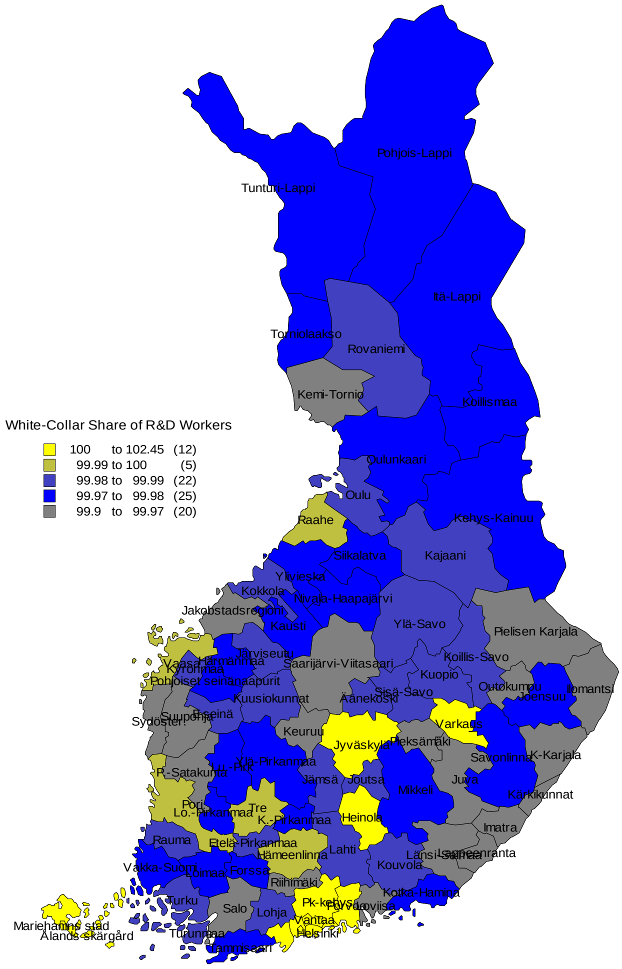


Figure 3.2 Share of R&D Workers in Salaried Workers



Nearly half of the firms have no R&D employees. The probability for applying for subsidies is twice as high for firms that have permanent R&D activities, see also Czarnitzki and Fier (2002) for evidence in Germany. Despite this, we use data for the 1,662 firms (or 1,428 firms in the estimation sample) and not just for the 836 firms that have had R&D workers in some years. We discuss robustness checks that also relate to the use of the partial data in Appendix 3A. For the companies with awarded public funding, the instrument we use is the employment weighted average of Tekes R&D funding per sales in the industry in the 6 regions. For the companies that have not applied for or have applied but not received public R&D funds, we use as a measure of potential public funding the same measure multiplied by the probability of applying for R&D subsidies in the industry/region. The probability is measured by the share of companies that have applied for funding from Tekes. The use of this probability also for the companies that have applied for but not received subsidies differs from Wallsten (2000) and Ali-Yrkkö (2005), but only slightly changes the estimation results. 377 companies have received Tekes funding in some years and 557 companies have not received subsidies. In the latter group 79 companies have applied for Tekes funding.

The estimation results in the previous chapter (Chapter 2) indicate that white-collar workers engaged in R&D are not highly paid as the wage level is lower than the average of white-collar workers after controlling for experience, profit-sharing and firm effects. We also measure the share of R&D workers from all white-collar workers who earn above the median level in the overall distribution of R&D pay. Compared to other companies with an overall high share of R&D workers, these companies are relatively large and profitable.

We refer to a company with an average workforce below the median average workforce of 161 workers as a small and medium-sized firm (SME). It is noteworthy that the estimation results would have been the same if the limit for the SME category had been the usual limit of 250 employees. It is useful to show the correlations of growth, white-collar shares in R&D, Tekes funding and potential Tekes funding in each industry and region (our instrument).

Table 3.2 Descriptive Statistics and Correlations of Growth, R&D Work and Tekes Funding

	Mean	Standard Deviation	Mean SME	Standard Deviation SME	Mean Large	Standard Deviation Large
Average Employment	570	2600	59	44	1451	4147
Total Factor Productivity Growth	-0.014	0.566	-0.015	0.591	-0.013	0.521
Employment Growth	0.068	0.521	0.065	0.539	0.072	0.492
Tekes R&D Funds (per Sales)	0.010	0.062	0.010	0.071	0.009	0.042
R&D Intensity	0.085	0.150	0.061	0.149	0.126	0.143
R&D Agglomeration	0.011	0.020	0.009	0.019	0.013	0.021
Catching Up Frontier Firm	4.511	1.642	4.694	1.648	4.195	1.584
Occupation Human Capital	0.155	0.072	0.159	0.076	0.147	0.064
Education Human Capital	0.093	0.108	0.081	0.110	0.112	0.100
Workers Above 75% for Unobserved H.C.	0.215	0.221	0.201	0.222	0.239	0.217
Workers Below 25%, Above 75% for Experience H.C.	0.047	0.029	0.044	0.032	0.053	0.021

Correlations	TFP Growth	Labour Growth	White-Collar in R&D	White-Collar in High-Paid R&D	Tekes Funding / Sales	Potential Subsidies / Sales
Labour Growth	0.17	1	0.00	-0.03	0.00	-0.01
White-Collar in R&D	0.02	0.00	1	0.57	0.17	0.20
White-Collar in High-Paid R&D	0.00	-0.03	0.57	1	0.07	0.09
Subsidies/Sales	0.06	0.00	0.17	0.07	1	0.53
Potential Subsidies/Sales	0.05	-0.01	0.20	0.09	0.53	1.00

It is seen that the average Tekes funding per sales is closely the same in SMEs and large firms in the estimation sample. It is seen that large firms have twice as high R&D intensity and are located in regions agglomerated with R&D. Large firms have more highly educated workers, while small firms are more intensive in occupation human capital. It is seen that Tekes funding per sales is weakly positively correlated with the share of R&D workers but has little correlation with the share of white-collar workers in skill intensive R&D work. It can be said that Tekes funding is more frequent in companies that have a more innovative investment base. The instrument for Tekes, Tekes subsidies per sale in each industry, correlates highly with the subsidies granted at company level but fairly little with growth, satisfying the requirement of an ideal instrument.

The white-collar worker share in R&D work is very non-linearly distributed. The distribution of the white-collar share in R&D, white-collar share in highly-paid R&D and subsidies per sales are given in Table 3.3.

Table 3.3 Distribution of R&D Activity and Subsidies

Percentiles	White-Collar Share in R&D Work	White-Collar Share in Highly-Paid R&D Work	R&D Subsidy per Sales
1 %	0	0	0
5 %	0	0	0
10 %	0	0	0
25 %	0	0	0
50 %	0.354	0.054	0
75 %	0.917	0.111	0
90 %	0.000	0.182	0.021
95 %	0.000	0.250	0.060
99 %	0.000	0.768	0.243
Mean	0.144	0.084	0.013
Std. Dev.	0.172	0.123	0.075
Skewness	2.192	4.189	15.774

It is seen that the R&D intensity of 14.5% (the average white-collar worker share in R&D work) is fairly high. There have been no R&D workers in over 25% of the years. We find it appropriate to use the second potency of the share of white-collar workers to account for the non-linearity. It is seen that subsidies are given on average around 10% of the firm-year observations and the average compensation is 1.3% of sales. The median change in R&D subsidies per sales is 3.3%. The magnitude of R&D per sales when first granted is 6.9% for SMEs and only 1.8% for large firms.

3.4 Estimation

We explain company-level productivity growth by the knowledge capital variables shown in Table 3.1 using the dynamic framework described in equation (5). As a productivity measure we use the multilateral productivity index described by Caves (1982). Productivity is compared relative to the average in 19 industries. The index has the advantage of being based on a translog production function thus being a second-order approximation of the true but unknown production function.

The knowledge capital variables have been described in the previous chapter and these are further listed in Appendix 3A. Other explanatory variables include average seniority, firm size (log employment), five region dummies, year dummies and 19 industry dummies. A high value of average seniority is also a sign of a mature company. We also measure spillovers from the agglomeration of R&D workers. The average R&D intensity is evaluated in each region at the NUTS 4-level assuming an average half decay parameter of 289 km. The decay parameter depends on the average distance between regional centres. In all estimations, we only use companies that have been engaged in R&D activity in some years.

3.4.1 Productivity and Employment Growth

This part explains growth in productivity and employment when not using a separate equation to describe the creation of knowledge in R&D work. Following Benhabib and Spiegel's (2005) framework, we explain by the knowledge intensity the impetus for growth. We do not use difference estimation that would ignore the important long-run effects. Growth in productivity is here first explained both by private R&D and by public subsidies on R&D.

$$d\ln A_{jt} = \beta_0 + \beta_1 \ln\frac{G_{jt}}{Y_{jt}} + \beta_{2l}\ln\frac{I_{jt}}{Y_{jt}} + \beta_3 \ln X_{jt} + \beta_3 \ln \overline{Y}_j + \beta_4 \ln\frac{A_{Mt}}{A_{jt}} + \varepsilon_j \text{,(7)}$$

where $d\ln A_{jt}$ represents the growth rate in log TFP of firm *j* in year *t*, $\ln G_{jt} / Y_{jt}$ is the R&D subsidy intensity (up to second potency), $\ln I_{ljt} / Y_{ljt}$ is knowledge capital (firm-specific includes the R&D white-collar share up to the second potency), X_{jt} is other firm characteristics, $\ln \overline{Y}_j$ is average firm size (log of average employment) to capture scale size effects and $\ln A_{Mt} / A_{jt}$ is the productivity gap with the leading firm *M* in the industry. All estimations also include industry, region and year dummies.

Table 3.4 shows the estimation results in explaining total factor productivity. Column 1 reports the OLS estimation for total factor productivity and employment growth, respectively. The remaining columns report instrument variable estimation results. We pay most attention to the instrumental variable estimates. In column 3 subsidies are also interacted with the interaction of occupation and education human capital. The latter captures education human capital in highly-paid occupations.

Columns 4 and 5 show the effectiveness of subsidies in SMEs and large firms and columns 6 and 7 in firms far from and near the leading firm in productivity in the industry. This division is based on the median value of the productivity gap in each of the 19 industries.

The Davidson and MacKinnon (1993) test indicates that the instruments are jointly significant in all estimations. In this test, the predicted values for the endogenous variables, here public subsidies, are first estimated using the instruments and control variables. At the second stage, the predicted values together with original values are used in the same regression. Instruments are valid if the predicted values are of significance, as is found to be the case.

Table 3.4 Tekes Funding and Total Factor Productivity Growth

	OLS	IV No Interaction	IV	IV SMEs	IV Large Firms	IV Far from Leaders	IV Close to Leaders
Tekes R&D Funds	0.591***	2.044***	0.669	2.039***	0.728	0.935	2.512***
	[2.8]	[4.6]	[0.8]	[4.2]	[0.6]	[1.1]	[3.0]
Tekes R&D Funds^2	-0.656***	-1.702***	-1.707***	-1.676***	-0.907	-1.344	-1.932***
	[4.2]	[6.9]	[7.4]	[6.4]	[0.6]	[1.2]	[4.8]
Tekes R&D Funds, Education H.C.,			8.062*				
Occupation H.C.*10 Interactions			[1.8]				
White-Collar in R&D	-0.317**	-0.347**	-0.510***	-0.259	-0.809***	-0.1	-0.847***
	[2.5]	[2.2]	[3.6]	[1.4]	[3.7]	[0.6]	[3.8]
White-Collar in R&D^2	0.436**	0.549***	0.707***	0.361	1.173***	0.127	1.260***
	[2.5]	[2.6]	[3.7]	[1.5]	[3.4]	[0.5]	[4.4]
R&D Agglomeration	0.793*	0.615	0.789*	0.712	1.047*	0.657	0.582
	[1.9]	[1.1]	[1.8]	[1.3]	[1.7]	[1.2]	[0.9]
Catching Up Frontier Firm	0.202***	0.190***	0.205***	0.239***	0.201***	0.247***	0.282***
	[22.5]	[15.8]	[21.4]	[18.6]	[12.3]	[17.4]	[18.1]
Occupation Human Capital	0.902***	0.475*	0.908***	0.716***	0.853**	0.904***	0.752***
	[5.4]	[1.8]	[5.1]	[3.4]	[2.5]	[4.0]	[2.8]
Knowledge: Worker-Specific							
Education H.C., Occupation H.C.*10	0.308**	0.532***	0.239	0.325*	0.680***	0.803***	-0.05
Interaction	[2.3]	[2.8]	[1.6]	[1.8]	[2.8]	[4.2]	[0.2]
Education Human Capital	0.245*	0.011	0.268*	0.077	0.401	-0.284	0.455**
	[1.9]	[0.1]	[1.9]	[0.4]	[1.6]	[1.4]	[2.3]
Workers Above 75% for Unobserved H.C.	-0.046	-0.05	-0.022	0.004	-0.023	-0.059	-0.03
	[1.5]	[1.1]	[0.7]	[0.1]	[0.4]	[1.4]	[0.6]
Workers Below 25%, Above 75%	0.102	1.258***	0.178	0.153	0.612	-0.411	0.793**
for Experience H.C. Interaction	[0.4]	[3.0]	[0.7]	[0.5]	[1.0]	[1.2]	[2.0]
Observations	6557	3348	5654	3579	2075	2740	2914
R-squared	0.113	0.121	0.116	0.127	0.125	0.158	0.145

Absolute value of z statistics in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. Estimation includes seniority, seniority squared, firm-size, 5 area, 19 industry and year dummies.

Our focus of study is the coefficients for private R&D accumulation and R&D subsidies that are here assumed to have independent effects. It is seen in Table 3.4 from column 2 that the private R&D worker share has a non-linear effect with the estimate for the first potency coefficient being negative and that of the second potency positive. Productivity growth is thus strongest in high-technology firms. It appears from column 2 that public subsidies raise productivity growth at a decreasing rate. Subsidies have fared better in supporting marginal investment rather than when being a large share of sales (non-linearity is, however, not very large, see later Monte Carlo experiment). The productivity effects are clearest for SMEs in column 4, while absent for large firms in column 5.

R&D workers are part of the firm-specific knowledge capital. Other knowledge capital listed in Table 3.1 has similar productivity growth effects as those reported in Chapter 2 in this volume. Education human capital has in general a direct positive effect on growth and most clearly so in firms with well-paid occupations. Chapter 2 indicated that blue-collar workers have more occupational human capital (after controls for education and other). The interaction with education human capital then deals with occupation human capital of white-collar workers, in particular. We interact this with R&D subsidies in column 3, which thus has a significant positive sign. R&D subsidies allocated to high-wage-occupation and high-education firms generate stronger growth.

It is noteworthy that large firms are on average 22% more productive than the average benchmark firm in the industry; whereas SMEs are on average 10% less productive (the productivity growth rates were the same in Table 3.2). One argument to explain the small gains from subsidies in large firms could be that they already belong to the productivity frontier. Columns 5 and 6 in Table 3.4 explain the effectiveness of subsidies in firms far away from and near the leaders in productivity. It is seen that subsidies are most effective in firms close to the leaders. It thus appears that the small productivity improvement in large firms is not explained by them already being near the frontier. It was also stated earlier that the productivity growth effects of R&D intensity are stronger in firms intensive in R&D irrespective of firm size. Finally, catching-up (coefficient for the difference between the TFP and the most productive firm in 19 industries) is not a more important driving force for SMEs than for large firms.

Table 3.5 shows the employment growth effects. In the employment growth analysis, we interact subsidies with R&D intensity.

Table 3.5 Tekes Funding and Employment Growth

	OLS	IV
R&D Intensity	-0.41	-0.256
	[1.2]	[0.4]
R&D Intensity^2	0.196	0
	[0.5]	[.]
R&D Intensity, White-Collar in R&D	0.978	1.005
	[0.4]	[0.2]
R&D Intensity, White-Collar in R&D^2	0.049	1.013
	[0.0]	[0.2]
White-Collar in R&D	-0.112	-0.098
	[0.8]	[0.6]
White-Collar in R&D^2	0.131	0.113
	[0.7]	[0.5]
R&D Agglomeration	0.840**	0.816**
	[2.1]	[2.0]
Catching Up Frontier Firm	0.084***	0.074***
	[9.2]	[7.5]
Occupation Human Capital	0.242	0.241
	[1.4]	[1.3]
Knowledge: Worker-Specific		
Education H.C., Occupation H.C.*10	0.847***	0.875***
	[6.1]	[5.9]
Education Human Capital	-0.513***	-0.555***
	[3.7]	[3.7]
Workers Above 75% for Unobserved H.C.	0.025	0.019
	[0.8]	[0.6]
Workers below 25%, Above 75% for Experience	0.644**	0.906***
	[2.5]	[3.2]
Observations	5564	4791
R-squared	0.075	0.078

Absolute value of z statistics in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. Estimation includes seniority, seniority squared, firm size, 5 area, 19 industry and year dummies.

Comparing Tables 3.4 and 3.5 it is seen that firms improving in productivity are on average growing in size so that productivity and employment growth effects of knowledge capital usually go in the same direction. However, R&D subsidies have no employment growth effects. The interaction term to the share engaged in R&D work is also insignificant. R&D spillovers are instead positively related to employment growth. Following Chapter 2 growth is concentrated in knowledge capital intensive areas.

3.4.2 Productivity Growth and R&D Work as a System

This section examines productivity growth taking into account the possible crowding out of private R&D by R&D subsidies. We thus use two-stage-estimates, which include a separate equation to explain the private R&D worker share by Tekes subsidies controlling for year, region and industry. The empirical testable specifications may be written as

$$\begin{aligned} d\ln A_{jt} &= \beta_0 + \beta_{1l} \ln \frac{I_{ljt}}{Y_{ljt}} + \beta_2 \ln X_{jt} \\ &+ \beta_3 \ln \overline{Y}_j + \beta_4 \ln \frac{A_{Mt}}{A_{jt}} + \varepsilon_{1j} \end{aligned}, \tag{8}$$

$$\ln \frac{I_{jt}}{Y_{jt}} = \beta_5 + \beta_6 \ln \frac{G_{jt}}{Y_{jt}} + \varepsilon_{2j}, \tag{9}$$

where the explanatory variables are the same as before with the Z_{jt} variables including the productivity gap to the frontier and firm size. Both equations thus include industry, region and year dummies. The R&D subsidy intensity and its square are instrumented by potential R&D subsidies in the industry and its square, as explained before. Estimation results are reported in Table 3.6.

The 2SLS estimation explains productivity growth as driven by R&D work. Compared with the earlier estimation results reported in Table 3.4, the coefficients for R&D intensity are of a reversed sign. The first-potency coefficient is positive and the second-potency one negative. The explanation for this is that R&D workers are also considered as a channel for the productivity growth created by the R&D subsidies. Subsidies raise the R&D worker share (and growth), but not at very high level of them. The complementarity/substitutability dilemma is complicated by the non-linear effects.

Table 3.6 Two-Stage Least Squares Estimation of Total Factor Productivity Growth and White-Collar Workers Engaged in R&D

	TFP Growth	White-Collar Share in Skilled R&D	TFP Growth SMEs	White-Collar Share in Skilled R&D	TFP Growth Large Firms	White-Collar Share in Skilled R&D
Constant	-1.588***	-0.028*	-1.659***	0.022	-8.267	-0.035
	[6.5]	[1.7]	[5.5]	[1.0]	[0.0]	[1.1]
R&D Intensity		0.995***		0.594***		3.189***
		[10.1]		[5.2]		[9.5]
R&D Intensity^2		-0.275***		-0.083		-2.888***
		[4.9]		[1.4]		[7.1]
White-Collar in R&D	2.389		3.038		-68.016	
	[1.4]		[1.1]		[0.0]	
White-Collar in R&D^2	-7.601***		-7.923***		177.968	
	[4.0]		[2.9]		[0.0]	
R&D Agglomeration	1.494*		1.502		-22.793	
	[1.8]		[1.4]		[0.0]	
Catching Up Frontier Firm	0.172***	-0.002	0.243***	0.003	2.296	-0.010***
	[7.4]	[0.9]	[8.2]	[1.1]	[0.0]	[3.1]
Occupation Human Capital	2.590***		2.144***		-39.08	
Knowledge: Worker-Specific	[7.2]		[5.5]		[0.0]	
Education H.C., Occupation H.C.*10	-0.158		-0.42		4.034	
	[0.3]		[0.8]		[0.0]	
Education Human Capital	2.655***		2.349***		-33.543	
	[5.3]		[3.6]		[0.0]	
Workers Above 75% for Unobserved H.C.	-0.123***		-0.083		1.792	
	[2.6]		[1.4]		[0.0]	
Workers below 25%, Above 75% for Experience H.C.	-0.094		0.048		14.616	
	[0.3]		[0.1]		[0.0]	
Observations	5654	5654	3579	3579	2075	2075
"R Squared"	-0.627	0.225	-1.147	0.294	-0.034	0.315

Absolute value of z statistics in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. All estimations include seniority, seniority squared, firm size, 5 area, 19 industry and year dummies as controls. Instruments include the control variables and potential Tekes budget in the industry.

Columns 3 and 5 reveal that the productivity effects of the share of white-collar workers in R&D are positive for the SME sub-sample but not for large firms. Public subsidies do raise R&D intensity in large firms even more than in small firms. However, the productivity effects of private R&D workers are insignificant.

Monte Carlo Simulation

We use the Monte Carlo simulation to determine the magnitude of the productivity effects depending on the subsidy intensity for SMEs and large firms (see King *et al.*). We use the predicted values of subsidies given the same instruments as before. The coefficients are almost the same as before, but the standard deviation of the predicted values is one-third lower. Thus the true confidence intervals are likely to be higher. We ran 10,000 simulations, and the quantitative effects are estimated from the average of each variable. The X-axis in Figure 3.3 is set to reflect the actual distribution of R&D subsidies per sales from the 1st percentile (0%) to the 99th percentile (18%). We show the estimation results separately for SMEs here.

Figure 3.3 Public Subsidies by Tekes and Productivity Growth in SMEs

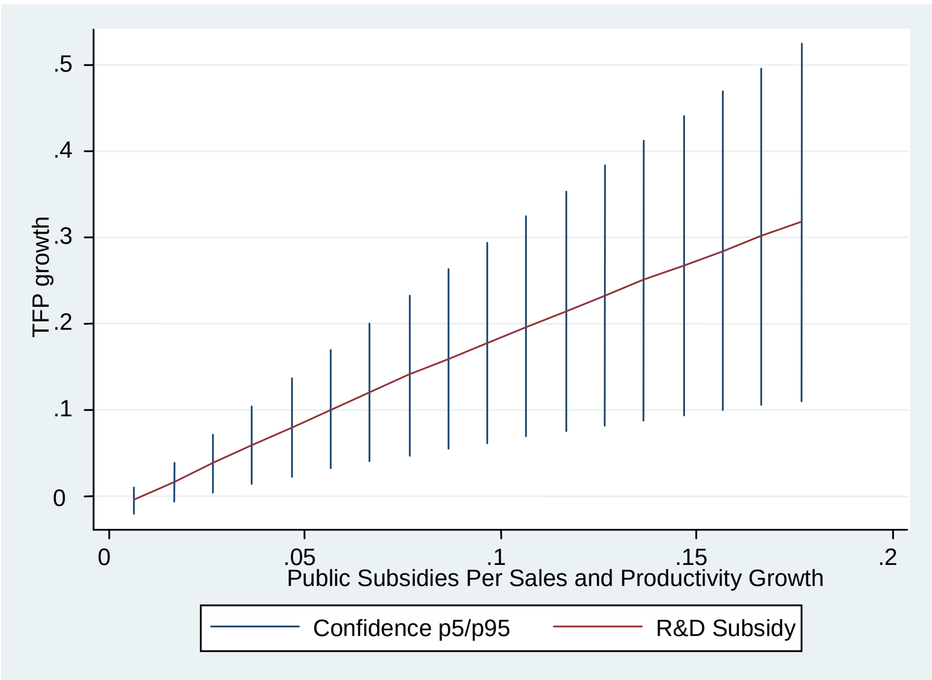


Figure 3.3 shows that the productivity effects for SMEs are around 0.12 log points when subsidies are 7% of sales, as is usual when first received. The productivity effects are reasonable given the 0.57 standard deviation of productivity growth. The confidence interval is, however, fairly wide ranging from 0.01 to 0.22.

The basic conclusion is that public subsidies have contributed to productivity growth in SMEs. Subsidies have important direct effects on productivity growth that are independent of them being substitutes or complements to private R&D work. It is noteworthy that the productivity effects would have remained the same when dropping the private white-collar share in R&D work (and its square) in the estimation of (7).

3.5 Conclusions

We find significant impacts of R&D funding on productivity growth for small and medium-sized firms. Subsidies have important direct effects and complement company-financed R&D. Similarly to Ali-Yrkkö (2005a) subsidies increase the share of workers engaged in R&D work. The complementarity/substitutability dilemma is, however, complicated by non-linearity. Firms use subsidies to raise R&D employment at a decreasing rate. The complementarity is strongest in large firms, while having a negligible effect on productivity growth.

The chapter offers some insights to assess the public subsidy policy by Tekes. The primary aim of Tekes subsidies is to encourage companies to improve their ability to develop and implement new technologies. Activities are targeted at new technology based firms and SMEs in particular, as well as new businesses and international cooperation (see www.tekes.fi). The target of improving productivity growth is well met in the financing of high-productivity firms. Public subsidies have the clearest positive effect on productivity growth in firms near the leaders in productivity. As discussed, stimulating imitation for firms far from the productivity frontier can instead lower the incentives for successful innovation by making it more short-lived and less profitable.

Tekes subsidies are granted to SMEs in short-term projects that last one or two years and we can clearly observe productivity improvements. We find instead little evidence that subsidies improve employment, which differs from the importance of knowledge capital as an engine for growth in general. One reason can be that subsidies are used to raise the wage-level rather than employment in firms that have low-paid R&D

workers. Alternatively, this suggests a long delay from R&D to pilot production. Other knowledge capital is possibly more used in the stage of process innovations, when new products enter the market.

We find important R&D spillovers in productivity growth. Growth is concentrated in areas rich in knowledge capital including R&D. This is not to say that subsidies do not promote growth in areas not intensive in R&D. Many studies, including, for example, Baldwin and Martin (2005), show that although R&D research, which benefits from local knowledge capital, leads to increased spatial inequality, it is not a catastrophe as long as all firms can buy the particular R&D research knowledge from another region (see, however, Aiello and Cardamone, (2005)). However, R&D subsidies appear not to be very effective for any regional policy aiming at creating new jobs.

Public subsidies overall fail to augment growth in large firms. One reason can be that public subsidy awards require a joint project with small firms. These projects are usually long-term, up to five years. Productivity effects are unclear and the effects on the small firm partner are hard to judge. Admittedly, one reason for meagre productivity long-term effects can also be the short time period of seven years in the data used. The productivity effects in the long-term projects are reaped after a considerable time, if at all. But long-term financing can also lead to too low a level of initial funding. Subsidies per sales at the start of the project (but not necessarily yet distributed) are twice as high, 7%, for SMEs compared to large firms.

Large firms with the most promising projects may also be reluctant to participate in research consortia, as argued by Branstetter and Sakakibara (1998). There is, therefore, a significant role for new independent public subsidies targeted at the most innovative large firms. SMEs may gain a significant reputation in being accepted for the subsidy programme, while such an objective appears to be absent for large firms. Another reason for the productivity gains of SMEs already at the start of the project is that SMEs have to undertake significant preparatory R&D in order to qualify for grants and thus the productivity effects may occur at an early stage.

Finally, Tekes subsidies interact surprisingly little with other knowledge capital. We find the only important link to be the share of highly-educated workers in highly-paid occupations. This hints at R&D subsidies being too narrowly used to cover the development of new technology that does not take advantage of the full potential of knowledge capital.

Appendix 3A. Robustness Check

The results are sensitive to the regional aspects in the choice of instruments. Using industry-level potential Tekes funding without the regional division would yield qualitatively similar but insignificant productivity effects. One line of reasoning for this difference is that the probability of applying and receiving for Tekes funding varies in different areas. Probit estimates, after controlling for the industry, indicate that, relatively to the Greater Helsinki region, the probability of applying for Tekes funding is 12% higher in manufacturing regions and 25% lower in the countryside and periphery.

The estimations included all firms with 5,654 firm-year observations, whereas firms with some R&D workers in some years include only 3,348 observations. The coefficients are somewhat lower but of the same sign and standard errors are higher if those firms with only R&D workers in some years are included in the analysis. OLS estimations were also done including those with no R&D workers with very similar results.

One line of reasoning for the insignificant positive effect in SMEs is that low-profit firms are liquidity constrained and cannot finance innovative activity. The profitability of the firm (log of net profits before extraordinary items and appropriations) relates positively but insignificantly to the productivity in SMEs and negatively to the productivity in large firms. We find no significant effects from interacting subsidies with profitability. Thus, the liquidity constraint argument cannot be used to defend the effectiveness of public subsidies awarded to SMEs. Our results are similar to Ali-Yrkkö (2005) but contrast with those of Toivanen and Niininen (2000) for all firms. Toivanen and Niininen apply a simultaneous equations approach and find evidence that public subsidies foster R&D expenditure in Finnish firms with only a moderate cash flow. They also find public and private R&Ds to be substitutes in large firms, which differs from our results.

We also experimented with interacting subsidies with the agglomeration and found this to be unimportant. Thus subsidies have not been less efficient in areas, where there is little R&D activity.

4. Competitiveness and Human Capital in Finnish Regions

4.1 Introduction

Regional disparities are a major policy concern in the European Union and in the U.S., see Tondl and Vuksic (2003) and Porter (2003).[1] Migration has lead to concentration of the population in urban regions and big cities. Agglomeration creates congestion costs, draws public resources to deprived areas and leads to inefficient use of resources when the labour force in rural areas is underutilised. The cohesion funds for 2000-2006 in the European Union are around 210 billion euros and close to the same as the funds in agricultural policies. The fiscal burden on rich countries is likely to be considerable unless the enlargement of the EU to 25 countries is not followed by a rapid reduction of income differences.

Earlier literature suggests a convergence between countries (and between regions) at an average rate of 2% per year, see Barro and Sala-i-Martin (1992) and Mankiw *et al.* (1992). The convergence is likely to be even stronger than this if the spatial and temporal variation in the pattern of technological change is controlled. However, in recent decades growth between regions shows little convergence. The European Commission (1999) shows that inequality across countries has declined since the middle 1980s but between 1986 and 1996 regional disparities in per capita GDP have decreased only within Portugal and the UK. Boldrin and Canova (2001) find no evidence of systematic catching-up in Europe in 1980-1996 including also many of the richest countries such as Germany, France and Benelux countries. Quah (1997) finds that among the Cohesion countries Spain and Portugal have grown most rapidly converging towards the rest of Europe, but have also experienced divergence in growth between regions.

Finland is ranked as the most competitive country in the Global Competitiveness Reports 2004-2005 and 2005-2006 by WEF (WEF 2004; 2005) (www.weforum.org/gcr). Finland has also stayed among the eight most competitive nations since 1997 in the alternative world competitiveness index by IMD (2005), that also gives some weight to the

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[1] Regional growth factors have been analysed in the EU area by Fagerberg *et al.* (1996), Vandhout *et al.* (2000), Badinger and Tondl (2002), and Griffith *et al.* (2003).

population size. The very high ranking is largely attributed to the sophistication and adoption of technology and to the high tertiary enrolment. The average GDP growth of 2.5% in 1980-2004 exceeding the average of 2.2% in the euro area has been accompanied by rapid growth (3.6%) since 1996.

Growth driven by knowledge capital has also lead to regional divergence in growth rates in Finland, see Chapter 2 in this volume. Figure 1.1 in Chapter 1 showed GDP per capita growth in NUTS 4-level areas in 1996-2002. It was seen that the Finnish regions exhibit no clear tendency of income convergence over the period under consideration. Large cities such as Espoo (6.6%) and Helsinki (4.8%) have grown rapidly, while the average growth rate is 3.6%. Loikkanen and Susiluoto (2002) have very similar findings. Ottaviano and Pinelli (2004) also find a negative convergence of GDP growth among the Finnish regions since 1994, while they find clear convergence before this.

Agglomeration of human capital can play an important role in explaining continued higher growth in the most competitive areas since 1990. Skilled workers move to agglomerated areas, see Baldwin and Martin (2005). Non-convergence can also be explained by high fixed costs, increasing returns to scale and other external effects, see Krugman and Venables (1995), Romer (1990), Grossman and Helpman (1994) and Canova (2002). Globalised companies invest in particular regions. Rugman and Verbeke (2004) still assert that in the downstream activities (sales/marketing) of companies most multinationals sell their products in their home region. However, the regional distribution of downstream activities within a country, such as large retail and shopping centres, may be narrower than before.

Finally, a public policy of improving knowledge capital, such as public R&D funds, may have had spatially undesirable consequences. Human capital can have a particular role in a small open economy with a regulated labour market. Bassanini and Ernst (2001) argue that countries with coordinated industrial-relations systems and strict employment protection tend to specialise in industries with a cumulative knowledge base. Chapter 3 in this volume shows that public funding by the National Technology Agency, Tekes, has contributed to productivity growth in small and medium-sized firms, while having had little effect on employment growth. It is clear that funding is allocated especially to growth areas, although funding is more regionally dispersed than R&D activity in general.

In this chapter the factors of competitiveness are examined in 2002 for 80 NUTS 4-level Finnish regions. This regional division meets the Porter *et al.* (2004) criteria for relevant regional entity fairly well. Jobs and workers are fairly well located in the same regions using NUTS 4-level and most of the regions also contain an urban centre. Higher than NUTS 4-level comparison is more suitable in between country comparisons. The European Commission has chosen NUTS 2 and NUTS 3-levels as the appropriate independent areas for inequality comparisons.[2]

In order to approach human capital and agglomeration from different perspectives, we apply three alternative ways to construct a competitiveness index from the 20 sub-indices used. These are the average approach, principal component analyses and hedonic analysis. In the hedonic approach each sub-index is given the weight according to how it has explained recent growth in GDP and employment. We also explain by sub-indices the productivity growth measured by the multilateral total factor productivity index (TFP), see Caves (1982).

TFP growth is the best measure of performance. Since the aggregate measure of human capital failed to explain productivity growth at the company level in Chapter 2 in this volume, it is also worthwile to include sub-indices for education and occupation human capital and their interaction. The human capital and TFP measures are, moreover, based on the same set of manufacturing company data, for which reason TFP growth estimates are naturally the most reliable. Finally, GDP growth per capita only partly takes into account productivity per capita and much of the cyclical GDP growth is due to a better utilisation rate of existing inputs, see, for example, Ryan (2000).

The TFP index is measured relative to the representative company in the industry and should not be dependent on the cyclical variation in the utilisation rate of inputs. The TFP measure also gives lower weight to catching-up, since productivity is measured within industries; thus separately for low and high productivity industries. Catching-up applies to the diffusion of technology within industries, with the firm leading in total factor productivity representing the technological frontier. Governmental policy to stimulate only catching-up and imitation can lower the incentives for successful innovations by making them more short-lived and less profitable. Davidsson and Segerstrom (1998) argue that only innovative R&D subsidies lead to faster economic growth.

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2 The population in each area in a NUTS 2-level division may still vary from a few hundred thousand to over ten million.

We thus apply cluster analyses, as outlined by Porter (2003), by measuring relative human capital and productivity within the same industry. This meets the criteria that rural areas should not imitate the industrial structure of metropolitan areas, but concentrate on industry where they have a comparative advantage. We argue that traditional competitiveness indices may give arbitrary weight to (the) sub-components that are also highly correlated. Average values also emphasise size economy very highly. Big cities usually have the largest share of educated labour and this is correlated not only with agglomeration but also with many other factors.

Rouvinen (2005) argues that the competitiveness index by WEF for 1996 has explained past GDP growth but fairly little of future growth in 50 countries. We aim to avoid this dilemma by excluding any survey opinion that is potentially related to past success. Chapter 2 in this volume also finds that productivity growth since 1995 has been driven by unique factors and by knowledge capital in particular, which is given high emphasis here.

We build our competitiveness indices of the Finnish regions by taking as our premises the three basic hypotheses derived in the earlier chapters in this volume: (i) education human capital and the right mix of young and old workers, and occupational human capital contribute to regional GDP and productivity growth although firm heterogeneity can be important, (ii) innovativeness of the region and R&D work enhance the performance of the company but have also many global spillovers and (iii) agglomeration of human capital is potentially very important but highly correlated with all other sub-indices. Therefore, alternative competitiveness indices should be used.

The rest of the chapter is structured as follows. Section 4.2 describes the construction of competitiveness indices. Section 4.3 shows the average competitiveness index, Section 4.4. the principal component competitiveness index and Section 4.5 hedonic competitiveness index. Section 4.6 shows the regional distribution of human capital and innovativeness. Section 4.7 concludes.

4.2 Competitiveness Indices

The global competitiveness report by WEF (2005), where Finland ranked at the top in 2004 – 2005, uses both hard data and an executive opinion survey. The three component indices relate to technology, institutions and the macroeconomic environment. The first innovation sub-index includes a survey question on the technological position relative to the rest of the world.[3] We do not use any survey questions, since they may correlate with past success rather than indicate the potential for future growth. We also exclude from our measures the efficiency of the public sector and economic stability, which are less relevant in comparisons between regions. The highly volatile growth in the number of companies and unemployment – used by the Institute for Strategy and Competitiveness, Harvard Business School – is also not considered.[4] Our competitiveness index stresses human capital (education, experience-based and occupation human capital) and technology usage (salaried employees engaged in R&D). The competitiveness index also covers measures on innovativeness and accessibility similarly to Huovari *et al.* (2002), which have not been taken into account in earlier competitiveness studies. (See Ovaskainen (1998) for a study of NUTS-III regions and Pikkarainen (1996) for a study of urban regions in Finland.)

This section describes sub-indices divided into major indices on frontier human capital (at worker and company level), regional human capital, innovativeness, agglomeration and accessibility following Huovari *et al.* (2002). Kangasharju and Pekkala (2001) show that manufacturing industries are the most important segment explaining the increase in regional disparities in Finland. Manufacturing is also at the core of rural development. Agriculture even in rural areas represents only a minor part of regional value added (1.6% of value added in the whole country or 2% when excluding the most heavily populated areas Uusimaa, Varsinais-Suomi, Satakunta, Pirkanmaa, Kanta-Häme). Rural regions also tend to have a relatively stronger position in traditional manufacturing than in advanced services, see, for example, Porter (2003). Our micro data consists of companies, which are members of the Confederation of Finnish Industries. 75% of the companies belong to the manufacturing sector, thus representing the leading industries in productivity growth.

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3 Innovation hard data includes US utility patents and the tertiary enrolment rate. Technological transfer is assessed based on the importance of direct foreign investments and foreign technological licensing, both of which are likely to be more common in a small export-orientated country.

4 The Institute for Strategy and Competitiveness lists these relating to *current economic performance*: employment/employment growth, workforce participation, unemployment rate, average wages/wage growth, cost of living, poverty rate, gross regional product per employee, regional export level, inward business investment, and to *innovation performance*: patents/patent growth, venture capital investments, new establishments/new establishment growth, fast growth companies, initial public offering proceeds per 1,000 companies.

We analyse frontier human capital based on linked employee-employer manufacturing data in 1996-2002 using the estimates of human capital described in Appendix 4A and in greater detail in Chapter 2 of this volume. Frontier human capital is estimated controlling for the average human capital and the average growth of human capital in the industry, see below the description of sub-indices.

This frontier human capital is evaluated using the methodology starting with Abowd *et al.* (1999), where wage compensations are divided into those explained by non-time varying person effect and by time-varying person-related characteristics such as experience and occupation. Returns on time-varying characteristics are obtained from a difference form estimation (where all variables are deviations from individual means). The person effect can be further divided into that explained by the educational level and unobserved human capital, see Appendix 4A. Overall human capital is defined as the sum of time-varying experience-based human capital and the person effect (the sum of education and unobserved human capital). Following the two-step method suggested by Andrews *et al.* (2004) the estimation also includes firm effects which are obtained from a separate estimation in the data that includes only workers who switch between companies.

The explicit definitions of the sub-indices are in Appendix 4B. All sub-indices are further standardised around 100 so that 100 is added to the variable after first dividing by the standard deviation and multiplying by 10. We use information from 77 subregions at the NUTS 4-level. Three regions in Ahvenanmaa are ignored.

Frontier Worker Human Capital Indices

The regional distribution of human capital is examined within industries. Towards this aim, we explain the human capital of each worker by region dummies at the NUTS 4-level controlling for 19 industries, time dummies and the interaction between time and region dummies in 1996-2002 (using 2002 as the reference). The regression estimates of region dummies indicate the relative human capital compared with the average human capital in the industry and the average growth rate.

The share of employees in plants located in the Greater Helsinki region is about 20%, while allocating all employees to the headquarters' region would imply that 50% of all employees would belong to the Greater Helsinki region. Region dummies are constructed by locating a company not only to the headquarter's region, but also according to the location of its plants. Thus, the human capital in each company is reallocated to regions depending on the employees in plants belonging to this company in this region. The regional dummies of the company are constructed to add up to unity. Finally, we use constrained regression, where each region is weighted according to its relative population size. Thus region dummies show frontier human capital relative to that of a typical worker within the industry.

We use as one sub-index the average of overall human capital (the average of the sum of experience-based human capital and the person effect). Education human capital is additionally measured in efficiency units. Each educational level is valued according to its relative rate of return. The sum of the education human capital of highly educated workers is divided by total number of workers in the company (see Appendix 4B). This measure is used at both the person-level (the same as weighted average over companies) and the company-level (unweighted average, i.e. the same weight irrespective of company size).

Frontier Company Human Capital Indices

Frontier human capital is here considered as an unweighted average over the companies instead of over the workers as in the worker-level indices, thus weighting small and large companies equally. Siebert (2000) notes that the companies compete for market shares. The relative competitive position of the large company may rather deteriorate than improve the chances of other firms to expand. Siebert also notes that regions compete against each other for mobile factors. The skill composition of the largest firms may differ from the desired skill composition of the workforce in general.

Chapter 2 in this volume found occupation human capital (returns from shifting from one job to another) to have important effects on productivity. One sub-index used is the company-level averages of the interaction of occupational human capital with educational human capital. This captures education human capital in highly-paid occupations. We also found that a high share of both new and experienced workers in a company enhances productivity growth. Thus companies with both young and old workers have higher productivity growth. Another sub-index used is therefore the interaction between the share of workers in a company below the 25^{th} and above the 75^{th} percentile of the overall experience-based human capital distribution across companies.

Regional Human Capital Indices

The regional-level human capital indices are mostly from Statistics Finland. They include the share of the working age population, the labour participation rate, the share of the highly educated, the share of students, and students in technical fields, see Appendix 4B.

Innovation, Agglomeration and Accessibility Indices

The innovativeness index includes detailed hard data mostly from Statistics Finland: information on R&D expenditures, the share of innovative companies and the value added of the high technology sector in the region (using linked employer-employee data). Agglomeration effects include population density, spillovers and co-operation in innovative companies. Spillovers encompass those created by education human capital. The importance of this is assumed to decay depending on the distance (see Appendix 4B). The decay parameter varies also depending on the size of regions so that the decay is lower in Northern Finland, where distances are large (average half decay is 288 km). Accessibility is measured by the share of exporting or importing companies and by air traffic connections.

We use three alternate competitiveness indices: unweighted average of sub-indices, sub-indices weighted according to principal component analysis and sub-indices weighted following a hedonic approach.

4.3 Average of Sub-indices

Huovari *et al.* (2001), (2002) measure competitiveness as an average of the 14 sub-indices other than frontier capital that are closely similar to those listed in Appendix 4B and discussed above. The major difference to our competitiveness index is that the frontier human capital estimates are ignored and only those measured at the regional level are included. We also use a measure of education human capital agglomeration and co-operation in innovative firms instead of agglomerative sectors, supporting sectors and specialization and no measure for road accessibility of markets. The indices are compared to the growth of GDP, employment and total factor productivity in 1996-2002 in the following Table 4.1.

Table 4.1 Competitiveness Index

	Huovari et al. GDP Growth 95-99	GDP Growth 97-02	Employment Growth 97-02	TFP Growth 97-02
Competitiveness Index	**0.32**	**0.38**	**0.44**	**0.51**
Human Capital: Worker Level		**-0.07**	**0.13**	**0.39**
Overall Human Capital		0.03	0.06	0.21
Education Human Capital		-0.15	0.16	0.44
Human Capital: Company Level		**0.18**	**0.24**	**0.21**
Education Human Capital		0.12	0.12	0.01
Education H.C., Occupation H.C.		0.03	0.02	0.18
Experience H.C. Lowest, Highest Quartile		0.15	0.22	0.30
White-Collar Share in R&D		0.12	0.23	-0.10
Human Capital: Region	**0.24**	**0.39**	**0.51**	**0.50**
Working Age Population (15-64) Share	0.11	0.27	0.43	0.38
Participation Rate	0.25	0.30	0.40	0.30
Students	0.15	0.05	0.21	0.11
Technical Students	0.11	0.39	0.19	0.37
Highly Educated	0.29	0.14	0.26	0.28
Innovativeness	**0.45**	**0.36**	**0.18**	**0.30**
R&D Expenditures	0.48	0.78	0.39	0.30
Patents	0.44	0.19	0.30	0.37
Innovative Establishments	0.04	0.00	-0.10	0.10
High Technology Sector, Value Added %	0.50	0.30	0.23	0.07
Agglomeration	**0.26**	**0.21**	**0.23**	**0.43**
Population	0.29	0.32	0.54	0.35
Education H.C. Agglomeration		0.29	0.47	0.55
Co-operation in Innovative Firms		0.26	0.20	0.01
Accessibility	**0.19**	**0.26**	**0.26**	**0.54**
Air Accessibility	0.25	0.29	0.45	0.50
Establishments Engaged in Foreign Trade	-0.06	0.07	-0.10	0.27

Sub-indices are described in Appendix 4B. Correlations for 75 regions. Joutsa, Parikkala, Ålands landbygd, Ålands skärgård ja Mariehamns stad omitted due to low number of observations. Huovari *et al.* (2001) competitiveness index is calculated for 1995.

Table 4.1 shows that all four main categories – human capital, innovativeness, agglomeration and accessibility – correlate positively with GDP growth. The correlations in our analysis are similar to those in Huovari *et al.* (2001) shown in the first column. It is seen that the correlations are fairly similar with respect to GDP per capita and employment growth. Regions with high productivity growth were also able to raise employment (the correlation of TFP growth with employment growth is 0.34 and with GDP per capita growth 0.21). Loikkanen and Susiluoto (2002) also find that the efficiency of regions is highly correlated with employment growth. They also show that the innovativeness index, especially the number of patents, is an important determinant of efficiency. R&D expenditures are here equally important. We suspect that the very high correlation of R&D expenditures to GDP growth is explained by third factors (such as this being a good approximate for the Greater Helsinki area, where 40% of R&D expenditures take place). The weakest correlating indices to GDP and total factor productivity growth are the number of students and the share of innovative establishments in manufacturing. Similar weak correlations were found in Loikkanen and Susiluoto (2002).

We have argued that TFP growth is the best measure of performance. It is seen that the correlations are no less to TFP growth. The frontier human capital of manufacturing workers in the region (the sum of experience-based, educational and unobserved human capital) has a clear positive correlation with TFP growth. Since, the overall human capital – the sum of education human capital, experience human capital and unobserved human capital – failed to explain productivity growth at the company level in chapter 2 in this volume, it is also worthwhile to examine human capital also at a more disaggregate level. We also include sub-indices for education human capital at worker and company levels and the interaction of company level education human capital to occupation human capital. It is seen from Table 4.1 that frontier worker education capital is positively correlated with TFP growth but less so at the company-level.

We noticed before that regional-level measures of human capital show strong concentration to big cities. These factors appear to explain a lot of the regional growth and to play a key role in the hedonic approach, too. The student share alone is not a good indicator, though. The supply of a highly educated workforce in general and the share of the working age population are key indicators of where growth continues. Labour force participation and the share of the working age population are typically higher in the big cities. Therefore, all big cities are ranked on top when using the unweighted average of sub-indices, see later Figure 4.1. The ten most competitive regions are in decreasing order Greater Helsinki region, Tampere, Oulu, Turku, Jyväskylä, Salo, Vaasa, Porvoo, Imatra and Joensuu.

The sub-indices are highly correlated, as also noted by Huovari *et al.* For example, the share of the working age population has a correlation coefficient of at least 0.4 with *all* other sub-indices (except for the labour force participation rate, the share of the highly educated, the share of innovative plants and the share of exporting or importing plants). The labour force participation rate correlates by nearly 0.4 with other sub-indices (except for the share of students and the share of innovative plants). Finally, frontier worker education human capital has a correlation of 0.47 with the company level education and occupational human capital interaction term, 0.59 with the R&D white-collar share, 0.47 with the working age population share, 0.49 with technical students share, 0.54 with patents and around 0.5 with the agglomeration and accessibility indices. We consider the pair-wise correlations to be the most relevant as the standardized coefficients used in hedonic approach can be arbitrary. In the hedonic approach, we rely mainly on the standardized coefficients for the six major indices listed in Table 4.1.

Education human capital has important spillover/agglomeration effects, as shown in chapter 2 in this volume. Beyond this, education human capital had the clearest positive effect on growth in high-productivity companies. The correlations here are strong and of the expected sign, except for frontier company education human capital. This is not counterintuitive, as regions with a lot of frontier company-level human capital (in the manufacturing typical for the region) are not necessarily in other respects high-growth areas.

Innovativeness, agglomeration and accessibility are all important for GDP, employment and TFP growth. Innovativeness is a more significant factor for GDP and TFP growth than for employment growth. This is consistent with our earlier findings in Chapter 3 of this volume, where private R&D and public subsidies on R&D were found to be unrelated to employment growth. It is also seen that agglomeration and accessibility correlates most strongly with TFP growth. Thus agglomeration appears especially important in innovative productivity growth.

4.4 Principal Component Approach

Principal component analysis measures the independence of separate factors. Information from sub-indices is transformed into a new data set where the variables are pair-wise uncorrelated. The first principal component is a linear combination of original sub-indices with maximal variance, etc. Information from 77 regions and 20 sub-indices forms a matrix $X = \left[x_{ij} \right]$, i = 1,…,77, j = 1,…,20. This matrix is transformed into a new matrix

$$Z = XA, \tag{1}$$

where Z is the principal component matrix of X. Eigenvalues λ_j, j = 1,…,20, represent the variance of each principal component in a way that

$$Z'Z = A'X'XA = \begin{bmatrix} \lambda_1 & & & \\ & \cdot & & \\ & & \cdot & \\ & & & \lambda_{20} \end{bmatrix}. \tag{2}$$

The proportionate contributions of each of the principal components to the total variation in the X matrix is given by

$$P_j \equiv \frac{\lambda_j}{\sum \lambda_j}. \tag{3}$$

Each principal component can now be used as an independent index. In the principal component analysis that we report in Table 4.2, the four most important factors explain 61% of the total variation in the data (see last column cumulative value).

The first five factors are labeled "Competitive environment", "Regional human capital", "High technology concentration", "R&D intensive industry" and "Manufacturing human capital". The first factor has fairly large eigenvalues for all attributes (in column 1) and explains 34% of the total variation in the data (cumulative value). The second most important factor "Regional human capital" has large eigenvalues for the working age population and the number of students. It explains 11% of the total variation. The third factor "High technology concentration" emphasises the size of the high technology sector and co-operation in innovative companies and explains 9% of the total variation. The low eigenvalues for R&D expenditures and patents are due to measurement at a fairly aggregate level so that they correlate strongly with the competitive environment in general. The fourth factor "R&D intensive industry" relates to R&D expenditures but little to frontier human capital and especially to the R&D worker share. The fifth factor "Manufacturing human capital" relates to the location of heavy manufacturing industry with skilled workers in less populated areas with little agglomeration or necessary good flight connections.

We apply the eigenvalues of these five most important factors as weights when constructing the competitiveness index. The second to the last column shows the average weights. These differ substantially from the equal weights of 0.05 for each sub-index in the average competitiveness index.

Table 4.2 Principal Components of Sub-indices

Component	Eigen-value	Diffe-rence	Propor-tion	Cumu-lative			
1 "Competitive Environment"	6.81	4.61	0.34	0.34			
2 "Regional Human Capital"	2.20	0.39	0.11	0.45			
3 "High Technology Concentration"	1.81	0.45	0.09	0.54			
4 "R&D Intensive Industry"	1.36	0.19	0.07	0.61			
5 "Manufacturing Human Capital"	1.17	0.12	0.06	0.67			**Not**
Eigenvectors	1	2	3	4	5	**Average**	**explained**
Frontier Worker Human Capital							
Overall Human Capital	0.178	-0.167	-0.145	-0.289	0.521	0.020	0.254
Education Human Capital	0.270	0.178	-0.083	-0.403	0.084	0.009	0.192
Frontier Company Human Capital							
Education Human Capital	0.124	-0.142	-0.293	0.090	0.364	0.028	0.530
Education H.C., Occupation H.C.	0.192	0.015	0.235	-0.423	-0.041	-0.004	0.402
Experience H.C. Lowest, Highest Quartile	0.219	-0.411	-0.011	-0.097	-0.041	-0.068	0.286
R&D White-Collar Worker Share	0.217	0.188	0.084	-0.373	0.104	0.044	0.388
Regional Human Capital							
Working Age Population (15-64) Share	0.261	0.286	0.022	0.171	0.175	0.183	0.279
Participation Rate	0.224	-0.367	-0.224	0.127	-0.119	-0.072	0.231
Students	0.004	0.516	0.095	0.186	0.362	0.233	0.196
Technical Students	0.304	-0.038	0.148	0.154	0.173	0.148	0.262
Highly Educated	0.115	0.165	-0.143	0.029	-0.019	0.029	0.811
Innovativeness							
R&D Expenditures	0.249	0.094	0.104	0.458	-0.069	0.167	0.247
Patents	0.294	0.024	-0.010	0.146	-0.030	0.085	0.380
Innovative Establishments	0.037	-0.025	0.194	0.158	0.227	0.118	0.826
High Technology Sector, Value Added	0.248	-0.068	0.458	-0.004	-0.212	0.084	0.141
Agglomeration							
Population Density	0.330	0.052	-0.194	0.147	-0.126	0.042	0.135
Education H.C. Agglomeration	0.200	0.193	-0.350	-0.086	-0.369	-0.082	0.250
Co-operation in Innovative Firms	0.228	-0.053	0.472	-0.035	-0.132	0.096	0.210
Accessibility							
Air Accessibility	0.258	0.214	-0.284	-0.045	-0.243	-0.020	0.227
Establishments Engaged in Foreign Trade	0.214	-0.317	-0.021	0.161	0.195	0.046	0.386

It is seen that frontier human capital is in general given very low weight and that the emphasis is on regional human capital and innovativeness. Thus the competitiveness index using principal component analysis largely ignores all variation in frontier human capital. Principal component analysis thus says less on the human capital relative to other companies in the industry. We later find the principal component analysis to place the Greater Helsinki region at no more a competitive position relative to the rest of the country than other indices (see Table 4.4). The reason is that accessibility and agglomeration are not weighted more than in other indices due to the last factor “Manufacturing human capital”.

4.5 Hedonic Approach

In the hedonic approach the sub-indices are weighted by regression coefficients. These are obtained from explaining the regional performance by sub-indices. The measures of performance ($\dot{Y}$) – GDP per capita growth, employment growth and total factor productivity growth – are regressed against the various sub-indices $\beta_i, i = 1,...,20$.

$$\dot{Y} \equiv \beta_0 + \sum \beta_i Ind_i + \varepsilon \,, \tag{4}$$

where ε is the residual of the estimation. The coefficient estimates β_i in normalised form can be used as weights in constructing the aggregate competitiveness index.

We give each sub-index a weight depending on its relation to the average effect on GDP, employment and total factor productivity growth. The estimation results are given in Table 4.3. The estimation is done separately with sub-indices and major sub-indices (middle part of the table) used as regressors. The table also includes the weights given to each sub-index (last column) and the correlations of the three competitiveness indices (lowest part of the table).

As discussed before, the sub-indices are highly correlated and measure much the same thing. We do not put much emphasis on the standardized coefficients for any single sub-index. We pay most of our attention to the standardized coefficients for the 6 major indices: frontier worker human capital, frontier company human capital, regional human capital, innovativeness, agglomeration and accessibility. It is seen that all the coefficients, except for human capital at worker level and agglomeration, are positively related to GDP growth and TFP growth.

In the construction of the competitiveness index, the weights used are the average of the coefficients obtained over the three growth factors. The last column shows these. The competitiveness index based on the hedonic approach gives a relatively high value to frontier company human capital, regional human capital and innovativeness. It is seen that frontier worker human capital and agglomeration even receive a negative weight. We can conclude that the hedonic competitiveness index captures much of the human capital and innovativeness that is not necessarily strongly related to agglomeration or firms being at the frontier in productivity and human capital. We can, however, see later that the hedonic index also values unique smaller regions with frontier company human capital. The largest weight is given to regional human capital, which puts much emphasis on the availability of skilled workers.

Table 4.3 Hedonic Model

	GDP Growth 97-02	Employment Growth 97-02	TFP Growth 97-02	Average
Coefficients for Sub-indices				
Frontier Worker Human Capital	-0.918***	-0.230*	0.018	-0.377
Overall Human Capital	*0.271*	*0.022*	*-0.025*	*0.089*
Education Human Capital	*-0.842****	*-0.148*	*-0.013*	*-0.334*
Frontier Company Human Capital	0.801***	0.580***	0.126**	0.502
Education Human Capital	*-0.424*	*-0.563***	*0.019*	*-0.323*
Education H.C., Occupation H.C.	*0.116*	*0.082*	*-0.022*	*0.059*
Experience H.C. Lowest and Highest Quartile	*0.125*	*-0.009*	*0.066*	*0.061*
R&D White-Collar Worker Share	*-3.653*	*0.407*	*0.841*	*-0.802*
Regional Human Capital	0.606**	0.174	-0.048	0.244
Working Age Population (15-64) Share	*-0.107*	*-0.016*	*0.071*	*-0.017*
Participation Rate	*0.489*	*0.552****	*0.044*	*0.380*
Students	*0.243*	*0.415****	*0.036*	*0.231*
Technical Students	*0.057*	*-0.228*	*0.083*	*-0.029*
Highly Educated	*0.054*	*0.009*	*0.056*	*0.040*
Innovativeness	1.191***	-0.184	-0.103	0.301
R&D Expenditures	*1.880****	*0.132*	*-0.032*	*0.660*
Patents	*-0.251*	*0.046*	*-0.008*	*-0.071*
Innovative Establishments	*0.047*	*0.206*	*0.015*	*0.089*
High Technology Sector, Value Added	*0.22*	*-0.024*	*0.006*	*0.067*
Agglomeration	-0.771	0.282	0.107	-0.127
Population	*-0.448*	*0.484**	*-0.008*	*0.009*
Education H.C. Agglomeration	*0.335*	*0.011*	*0.062*	*0.136*
Co-operation in Innovative Firms	*-0.127*	*0.035*	*-0.124*	*-0.072*
Accessibility	0.133	-0.102	0.193**	0.075
Air Accessibility	*0.187*	*0.089*	*0.125*	*0.134*
Establishments Engaged in Foreign Trade	*-0.303*	*-0.249**	*0.025*	*-0.176*
R-Squared for Major Indices	0.772	0.572	0.480	
Average Competitiveness Index	0.378	0.440	0.511	
Principal Component Competitiveness Index	0.373	0.458	0.478	
Hedonic Competitiveness Index (Major Indices)	0.557	0.511	0.304	

* significant at 10%; ** significant at 5%; *** significant at 1%.

Finally, the bottom rows in Table 4.3 show how the three competitiveness indices correlate to the three growth factors. Recall that the average measure puts relatively high emphasis on accessibility and agglomeration but also on frontier human capital. Principal component analysis emphasizes the importance of regional human capital and innovativeness. Finally, the hedonic approach brings forth human capital and the presence of many competitive firms, as reflected by the frontier company human capital, and gives even negative weight to agglomeration. It is seen that all three competitiveness indices are fairly similarly related to economic growth. The hedonic index based on major indices also appears to perform well, but the ignorance of agglomeration and frontier worker human capital explains its low correlation with TFP growth. The following table shows the value of the alternative competitiveness indices in areas differing in the degree of urbanisation.

Table 4.4 Competitiveness in Regions of Different Urbanisation Level

	Frontier Worker Human Capital	Frontier Company Human Capital	Regional Human Capital
Greater Helsinki Region	116.1	104.6	108.4
City (Not Helsinki Region)	100.7	99.7	105.4
Provincial Centre	95.0	100.3	98.0
Industrial Region	95.6	99.1	96.3
Countryside	90.5	97.4	91.2
Periphery	86.2	92.8	88.6

It is seen that all competitiveness indices are positively related to the degree of urbanisation. The Greater Helsinki region is 12 to 13.5% more competitive than the other regions, while the periphery is some 10% below the average. The principal component and hedonic approaches place the Greater Helsinki area below the competitiveness of other cities. The first reason for this is the lower weight on agglomeration and accessibility, where the Greater Helsinki area markedly differs from other areas. The Greater Helsinki area is around 30% more agglomerated and accessible than other areas. The second reason is that the principal component and hedonic approaches give a fairly low weight to frontier worker human capital, where the Greater Helsinki area is clearly superior to other regions. This appears later to be the greatest disadvantage of the hedonic approach, which does not explain well the difference in growth between the Greater Helsinki area and other large cities. Agglomeration effects can be captured by urbanisation dummies but part of the difference in growth rates is also explained by the fact that many of the companies located in the Greater Helsinki area are among the most abundant in frontier human capital.

Figure 4.1 shows the competitiveness index based on the average of sub-indices and on the hedonic approach using the major indices. The order of competitiveness across the regions from the 1st to the 77th position is in accordance with the average of sub-indices.[7] Figures 4.2 and 4.3 show the competitiveness position in the map of Finland based on, respectively, the average and the hedonic competitiveness index.

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[7] The competitiveness indices for the three regions in Ahvenanmaa include only a few sub-indices due to missing data on manufacturing and are not reported.

Figure 4.1 Rankings in Competitiveness Index: Average and Hedonic, Major Indices

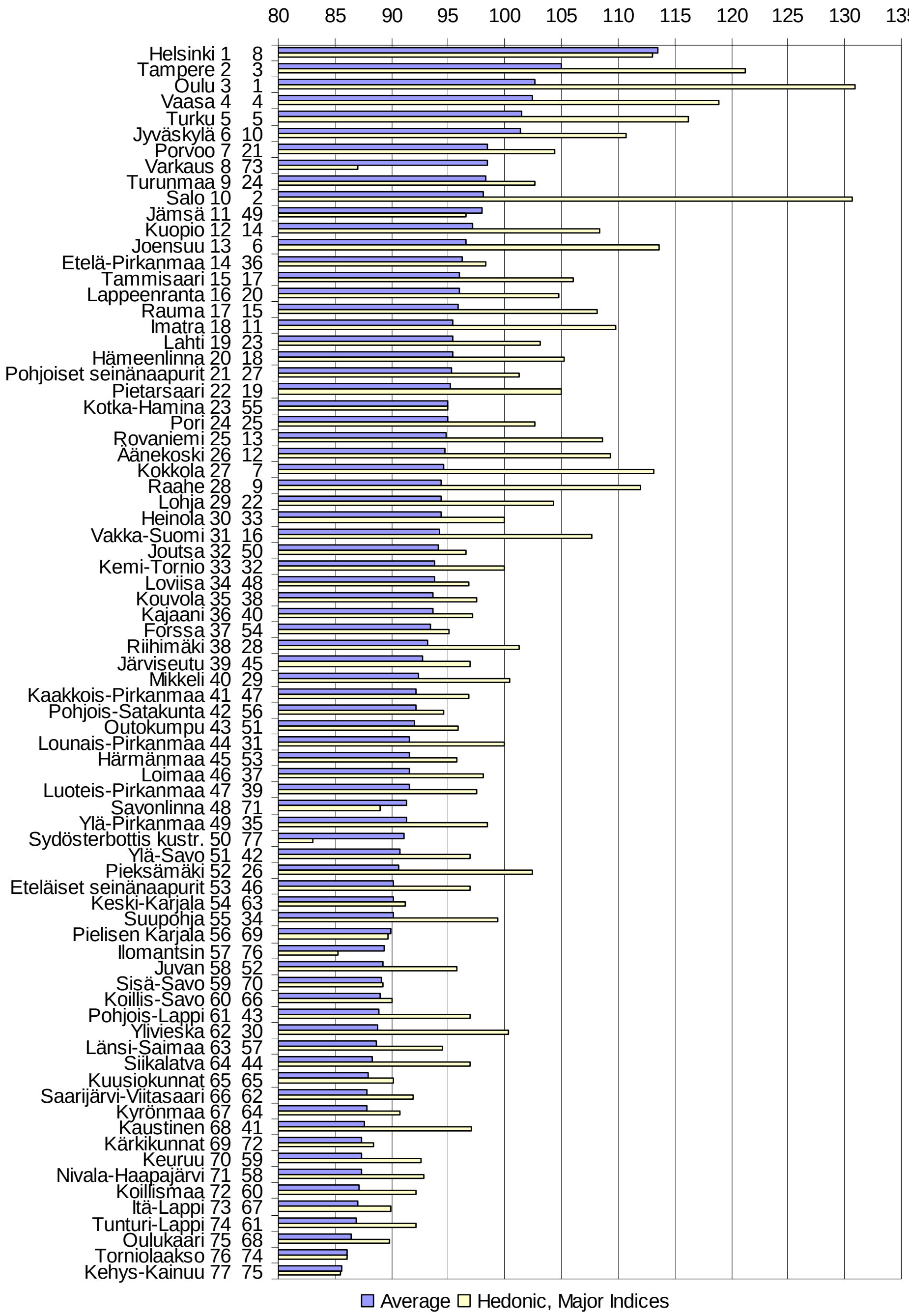


Figure 4.2 Average Competitiveness Index

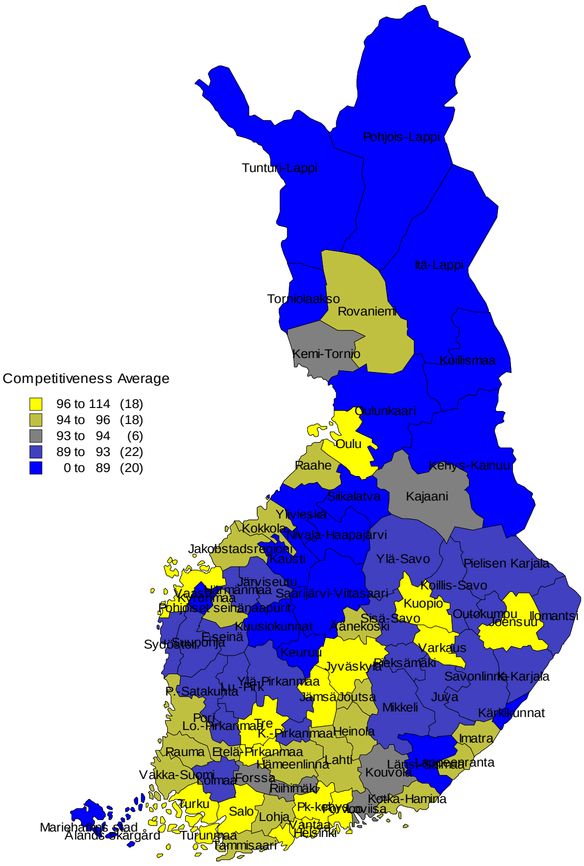
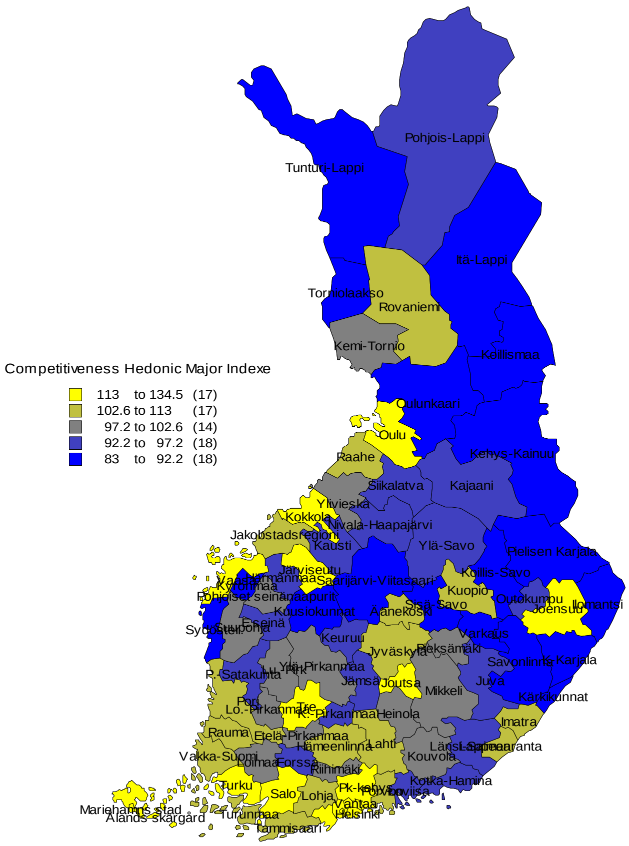


Figure 4.3 Hedonic Competitiveness Index



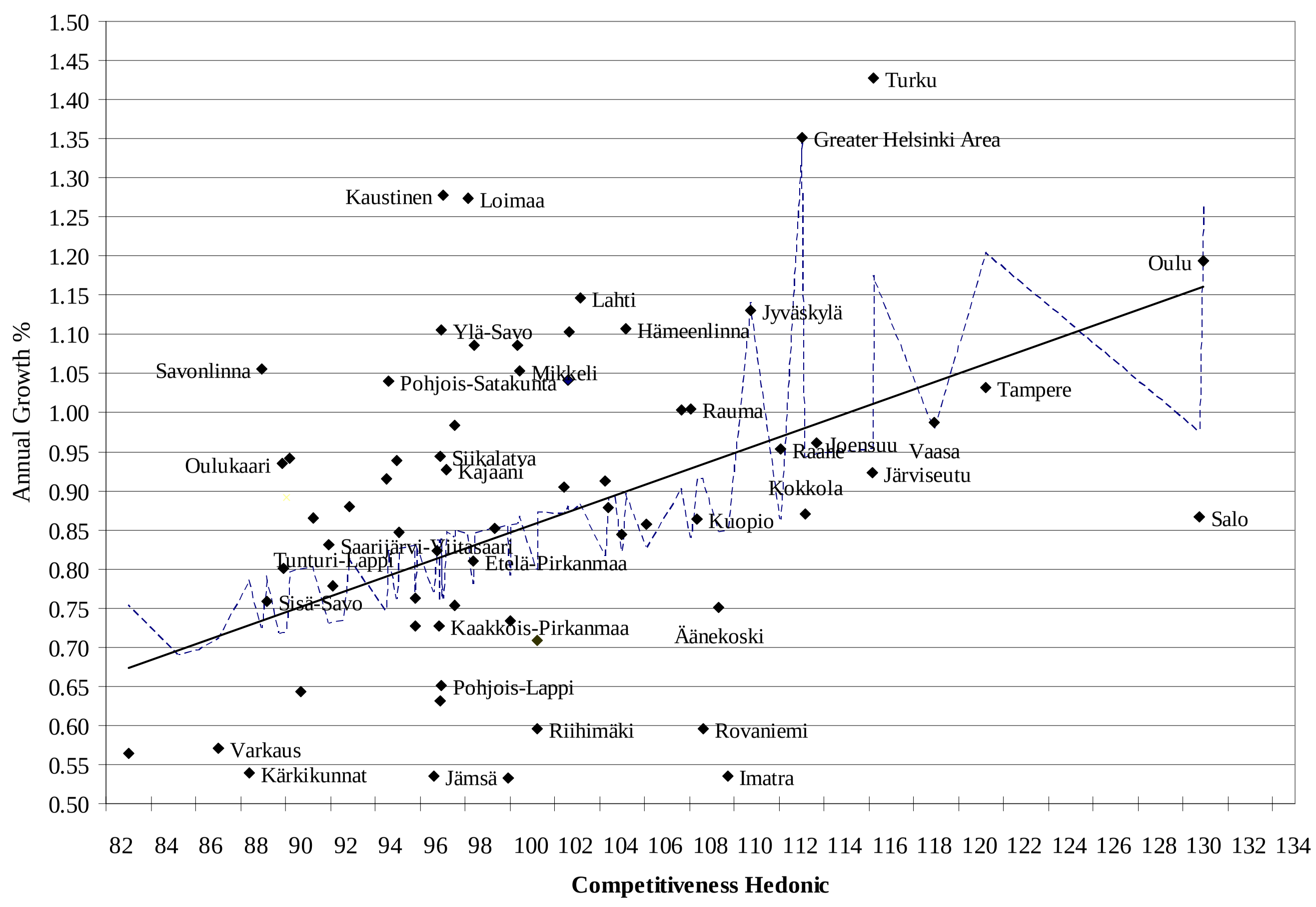
It is seen from Figures 4.1 and 4.2 that, using the average measure, the five most competitive regions are all areas with a high population density (except Vaasa with 88,385 inhabitants): Greater Helsinki region, Tampere, Oulu, Vaasa and Turku. The most competitive smaller regions at the NUTS 4-level, besides the Vaasa region, are Jyväskylä (142,869 inhabitants), Porvoo (72,294 inhabitants), Varkaus (35,590 inhabitants), Turunmaa (22,801 inhabitants). Using the hedonic approach, Oulu instead ranks number one and Salo (62,530 inhabitants) ranks as second (Tampere and Vaasa follow closely). This shows the availability of skilled workers and the abundance of regional human capital accompanied the location of some well-performing manufacturing firms in these areas (particularly the establishments of Nokia Corporation in Oulu and Salo).

It can be seen that the hedonic approach ranks higher some less heavily populated areas with IT manufacturing and high-productivity companies. These areas are not necessarily characterized by frontier companies in all industries as the hedonic index gives a low weight to frontier worker human capital. Recall also that agglomeration is given a negative weight in the hedonic approach (after controlling for all other human capital factors). The high position in the hedonic approach, hence, also indicates the presence of many skill intensive firms but also of some large firms that do not separate out as the most competitive ones. It is also noteworthy that Helsinki ranks only 8th in the hedonic competitiveness index given the negative weight on agglomeration. However, none of the large cities are below the median level in any of the competitiveness comparisons.

All the top-ranked smaller regions listed above are intensive in manufacturing, which compensates for the small size and population density. In the hedonic approach, these areas are Varkaus, Jämsä, Porvoo, Etelä-Pirkanmaa, Jyväskylä and Salo. It is also noteworthy that the service sector has been growing in these areas so that current growth relies less on the expansion of manufacturing. Kotka-Hamina, Hämeenlinna and Savonlinna are rich in human capital but are still not at the frontier in competitiveness. Finally, Figures 4.3 and 4.4 show that the most competitive regions are located very similarly around large cities irrespective of the approach used.

Similarly to Huovari *et al.* (2002) we also evaluate how competitiveness explains future growth (they calculated the index for 1995 and evaluated growth in 1996-1999). It is evident already from Figure 4.2 that the variation in the average competitiveness index is fairly low. Most of the regions are in the narrow range, where competitiveness is 3 to 8% below the average. We only report in Figure 4.4 the plot of the

Figure 4.4 Hedonic Competitiveness Index and Sales Growth in 2003-2004



hedonic competitiveness index against the sales growth in the regions in the years 2003 and 2004. The estimation of a trend line also includes 6 urbanisation dummies to capture the degree of urbanisation: Helsinki region, city, provincial centre, industrial region, countryside, periphery (using city as the reference). These control for the agglomeration effects that are otherwise given low weight in the hedonic approach.

It is seen that a high number of regions are close to the trend line and especially when taking into account the urbanisation dummies (unsolid lines that deviate from the trend depending on the urbanisation dummies). The urbanisation dummies imply a 19% higher growth rate in the Greater Helsinki area relative to cities and some 40% higher growth relative to other areas. The difference between the Greater Helsinki area and other cities attributes largely to a higher level of total factor productivity, since controlling for this would narrow the difference from 19% to 4%. The explanatory power is 27.7% after controlling for the degree of urbanization.[8] Outliers can also be explained by the volatile growth in some areas with only few large firms as major actors. The large firm industries include shipyard in Turku, metal industry in Loimaa, steel and paper and pulp industries in Imatra and paper and pulp industry in Jämsä. It is also noteworthy that the hedonic competitiveness index explains 44.0% (11.9%) of the variation in logarithmic GDP (logarithm of sales per employee) in 2002 (these figures are closely the same as in the average approach). We expect that the explanatory power of the model would have been much higher, had data on productivity growth been available.

4.6 Regional Distribution of Human Capital and Innovativeness

The following figures show the value of various sub-indices analysed above. We concentrate on human capital and regional innovativeness. These are given the highest weight in the hedonic approach.

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[8] In a simple regression without regional dummies, the hedonic index explains 18.3% of the variation in sales growth. The average competitive index explains 15.7% of the variation.

Human Capital

Figure 4.5 presents the regional distribution of highest education in Finland based on data about the share of the highly educated amongst the entire working age population (16-64 years of age) obtained from Statistics Finland. Figure 4.6 shows the distribution of the frontier education human capital estimates used here. Figure 4.7 shows frontier occupation human capital and Figure 4.8 the interactions of the shares belonging to the highest or lowest overall experience human capital.

Badinger and Tondl (2002) show that Finnish regions exhibit a clear growth in higher level educational attainment relative to the rest of Europe (at the NUTS 2-level). It is seen that the education human capital abundant regions include all the big cities: Helsinki, Tampere, Turku, Pori, Lahti, Jyväskylä, as well as some smaller towns: Kemi-Tornio, Vaasa, and Varkaus region. It is seen that the regional distributions when using highly educated workers in all industries (Figure 4.5) and education human capital estimates for manufacturing companies (Figure 4.6) are fairly similar. Education human capital is not just concentrated in university regions. Some cities with university level education have a remarkably low level of manufacturing with skilled labour: Turku, Joensuu, Kuopio and Rovaniemi. On the other hand, some skill-intensive manufacturing regions, such as Vaasa, Kärkikunnat and Savonlinna, are rich in education human capital.

Chapter 2 of this volume found that occupation human capital and experience human capital interact positively with productivity growth. It is seen that occupational capital-intensive areas are located outside the big cities. This is explained by the fact that human capital is measured mainly in manufacturing and that high-wage traditional manufacturing is located outside the biggest cities. We see that

- Education human capital is concentrated in West Finland and Helsinki including the direction of Tampere and Jyväskylä.
- Occupation human capital intensive regions are: Turku region (excluding Turku itself), Pirkanmaa, Eastern Finland, Kemi-Tornio.
- Regions intensive in interaction between highest and lowest experience human capital are Ylä- and Keski-Pirkanmaa, Äänekoski, Mikkeli, Kokkola.

Figure 4.5 Highly Educated Share in Working Age Population

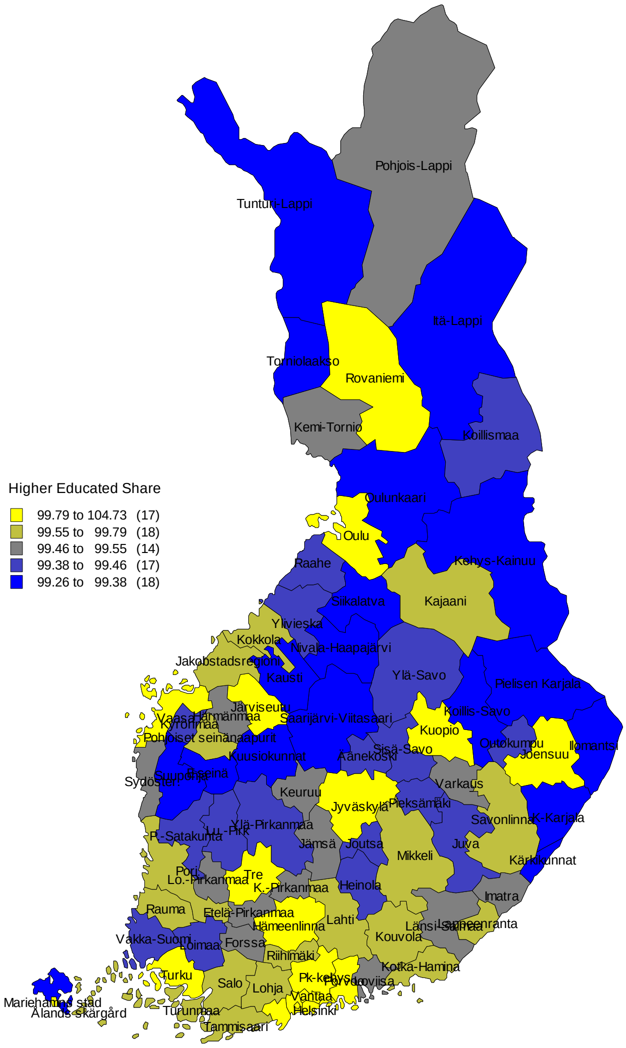


Figure 4.6 Education Human Capital

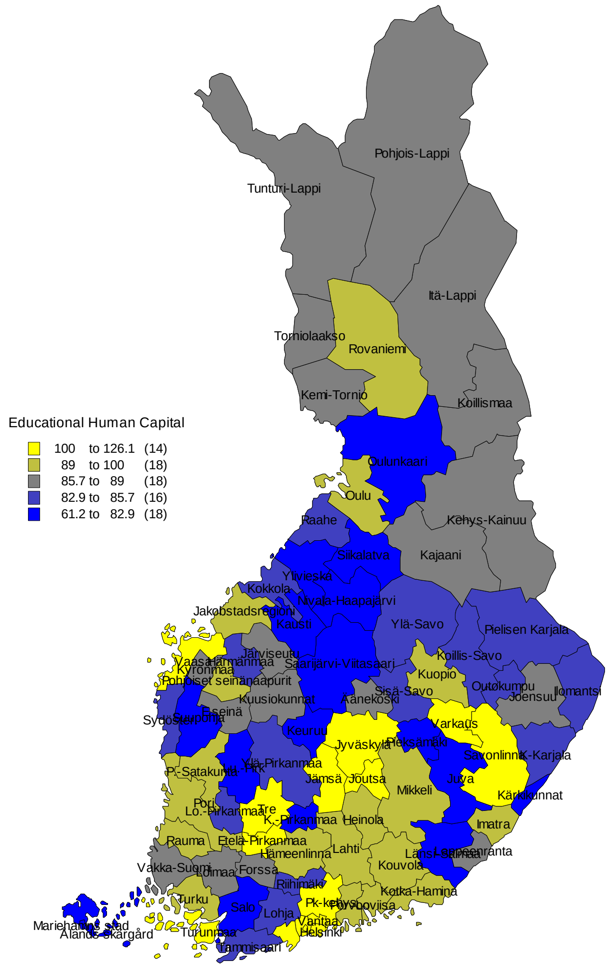


Figure 4.7 Occupation Human Capital

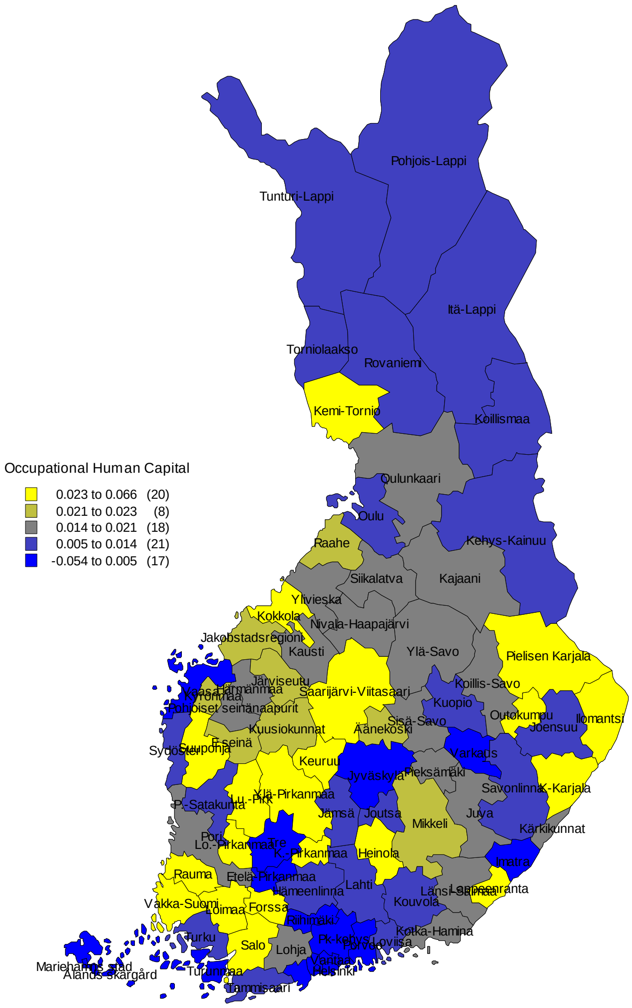


Figure 4.8 Experience H.C. Interaction

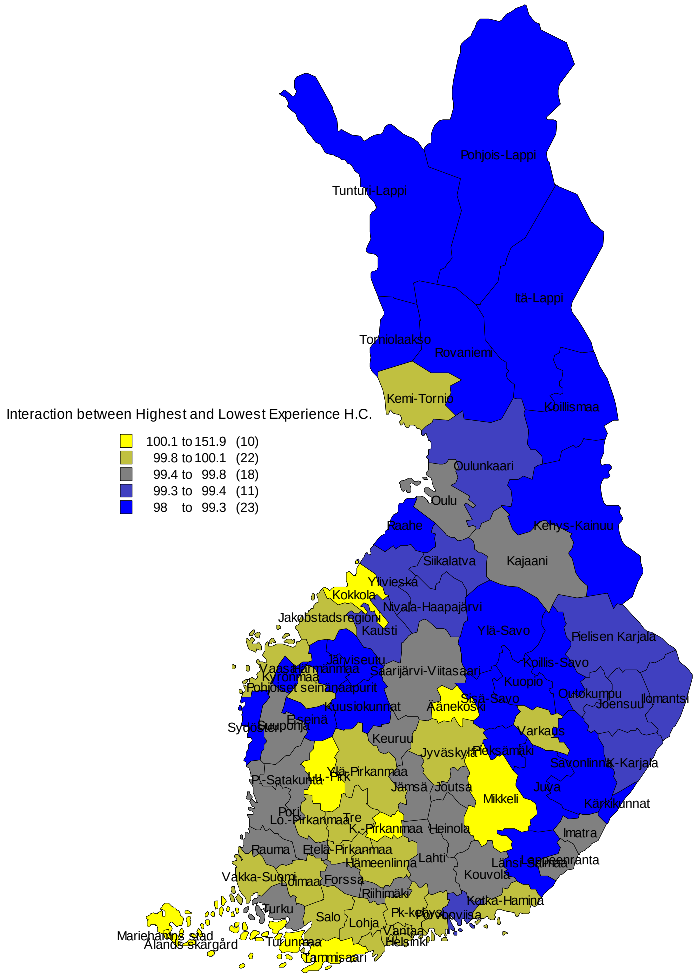


Figure 4.9 Innovativeness Index

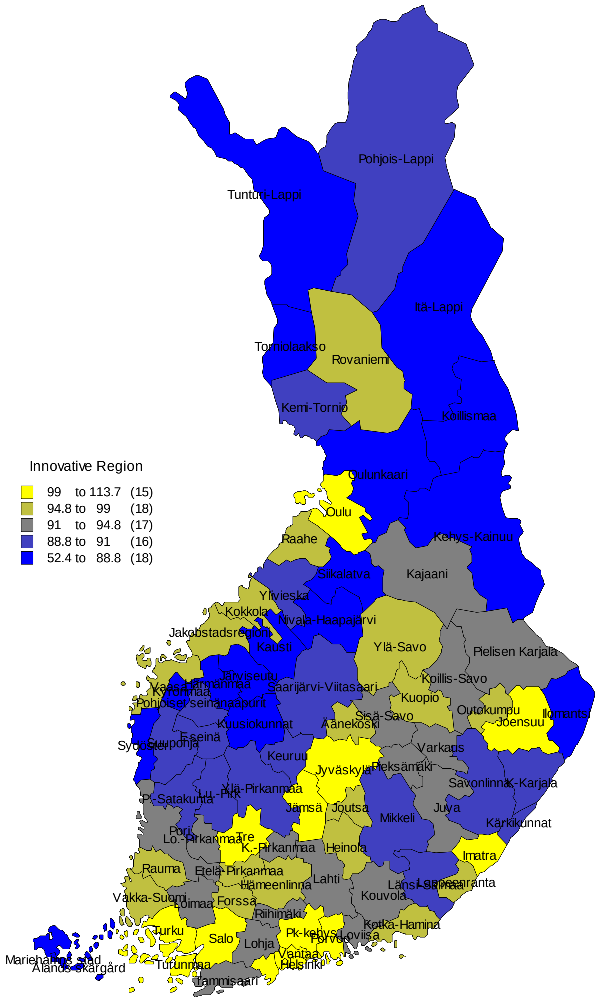
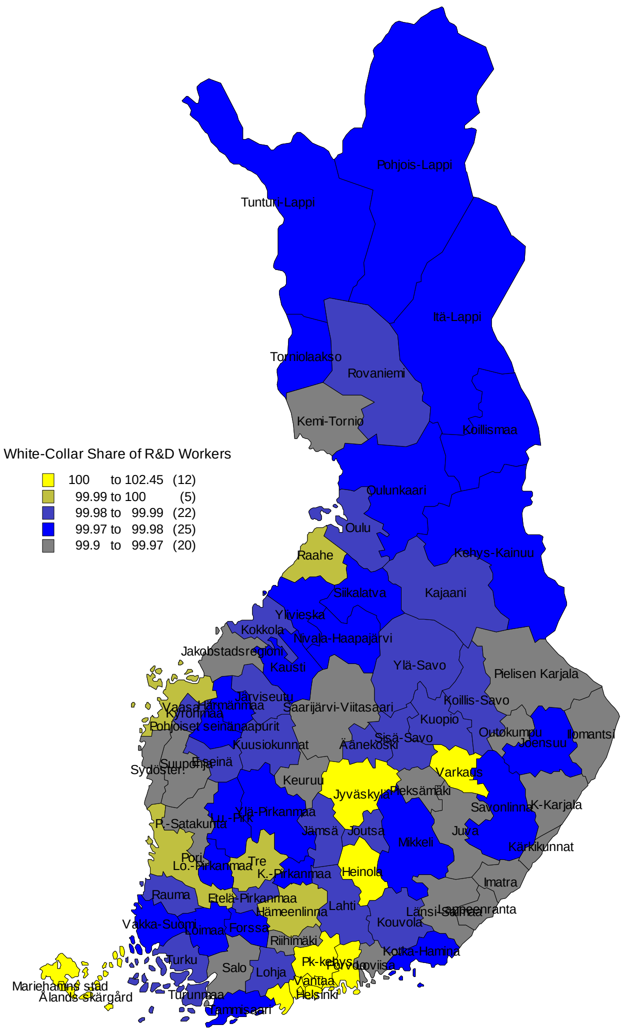


Figure 4.10 Share of R&D Workers in Salaried Workers



Regional Innovativeness

Figure 4.9 shows the innovativeness index and Figure 4.10 the sub-index measuring the share of salaried employees engaged in R&D.

Figure 4.9 indicates the Greater Helsinki region to be above the average in innovativeness. Nevertheless, Salo and Oulu are far ahead in absolute level. Oulu and Salo also separate out in the sub-indices of the share of innovative companies and high technology firms (not shown here). It is seen from Figure 4.10 that R&D workers are concentrated in the Greater Helsinki region, Jyväskylä, Varkaus and Heinola. The line of innovative and R&D intensive research areas also runs from Helsinki via the Lahti motorway in the direction of both Jyväskylä (with the exception of Lahti and Joutsa) and Tampere.

4.7 Conclusions

Competitive regions have competitive companies. Giving a significant role to frontier company-level knowledge also gives the independent variability needed to assess weaknesses and strengths in the NUTS 4-level regions. This is the core of this study, which uses manufacturing company-level information on education, experience-based and occupation human capital. It is also difficult to weight appropriately the importance of agglomeration and, thus, different approaches to tackle this problem are used. In regional competitiveness, a better innovative environment, a better research and easier accessibility are equally important, while infrastructure, suppliers and intensity of competition are not the focus here.

We have argued that Finland is a knowledge-based society indicated by the top position in international comparisons of competitiveness. Our study shows that the Greater Helsinki area is 12 to 13.5% more competitive than other areas. The competitive advantage of the Greater Helsinki area over the other cities is besides accessibility and agglomeration also explained by frontier worker human capital and high total factor productivity; that is, by the fact that many of the leading industry companies are situated in Helsinki. The hedonic approach, which gives high weight to frontier company human capital and innovativeness, approximates reasonably well future growth and outperforms the average approach that shows too much clustering of smaller regions to the same competitive level. The most competitive areas are IT intensive regions: Oulu and Salo. An additional factor to forecast future growth is the degree of urbanisation, which correlates highly with agglomeration effects.

It can be said that the competitiveness index measured as an average of sub-indices performs better in the ordering of current competitiveness, but is worse than the hedonic competitiveness index in predicting future growth. The principal component index does not perform well as it gives very low weight to frontier human capital. The major findings are:

1. The competitiveness index appears to catch reasonably well the high productivity and, especially, its growth in the Greater Helsinki region and surrounding regions, but the hedonic approach is able to pick up the competitive smaller regions.
2. The top ranking of Salo and Oulu in the hedonistic approach is explained by the frontier company human capital and by the high share of innovative manufacturing and co-operation among innovating companies. Helsinki did not appear to be the most technologically intensive region as it ranked 8th in the hedonic approach.
3. Human capital as a whole shows a strong regional concentration in an area in a radius of around 100 km from Helsinki and other big cities: Tampere, Turku and Oulu.
4. Education human capital has important agglomeration effects and gives a comparative advantage to large cities. The availability of skilled workers is here also captured by regional human capital.
5. R&D intensity correlates with agglomeration and accessibility and does not explain productivity growth very well compared to other knowledge capital. The line of the R&D intensive research area runs from Helsinki via the Lahti motorway in the direction of Jyväskylä. Some northern regions like Kemi-Tornio, Oulunkaari and Itä-Lappi present relatively high total factor productivity rates without a significantly high share of R&D workers. On the other hand, in regions like Kajaani, Raahe and Rovaniemi, R&D intensity is not associated with high total factor productivity.

Traditional manufacturing with heavy capital investment is loosing importance. Balanced economic growth over the areas is very challenging, since human capital is utilised better in urban areas. This is associated with a concentration of downstream industries (sales, marketing) in bigger units in populated areas, where the availability of a workforce and scale economics is important. The problem with the importance of human capital or education human capital linked to highly paid professions appears to be the resulting divergence in growth between regions. Porter *et al.* (2004) find four key recommendations for rural development. First, the unique strengths of the area should be emphasised rather than ameliorating general weaknesses. Second, adjacent urban centres are vital for economic development. Third, the efficient spatial distribution does not replicate urban economies. This is simply because rural areas will never match urban infrastructure, services and amenities. Finally, local authorities must be provided with sufficient tools and financing as simply subsidising rural regions through centralised decision-making only provides disincentives for improved competitiveness.

We emphasise the importance of many companies with human capital, irrespective of size. These companies require easy accessibility (flight connections), but the availability of a skilled workforce is most important. This does not always require very high agglomeration of R&D.

Siuruainen (2004) considers the role of the IT sector and R&D investment in regional growth in Finland. His report emphasises the strengthening of 34 urban regional centres (aluekeskus) so that they are able to take advantage of human capital and skills like the most competitive biggest cities. This requires co-operation between the educational and corporate sectors, incentives for entrepreneurial activity and proliferation of competitiveness in certain industries (with particular emphasis on pulp and paper, the IT sector and the metal industry). The 22 human capital centres located in these areas are already profiled in certain industries, which can be taken as the starting point. The rest of subregions are mostly rural areas that are suffering most severely from the ageing of the population, also due to emigration. Siuruainen (2004) also defends financing R&D activity in these areas taking tourism in Lapland as one good example.

It is also shown that the share of students in a region alone does not directly correlate much with GDP growth. Some cities with university level education have a relatively low level of manufacturing with skilled labour (Turku and Joensuu). It is instead less clear that the spread of heavily concentrated R&D expenditure always brings large local spillovers if these are not clearly connected to the industries, in which the region is profiled.

Appendix 4A. Human Capital

Human capital indices at the individual and company levels use data with 3,096,771 observations covering all workers (excluding top management) who have worked in the member companies of the Confederation of Finnish Industry and Employers at least one year in 1996-2002. Data include information on wages, performance-related pay PRP schemes, working hours, education and seniority. Employee data are linked to financial statistics data from Balance of Consulting and Suomen Asiakastieto, here only to include information on capital intensity (fixed assets). After some adjustment for relevant observations, the sample of observations with a company code is 2,755,716 (20,796 observations discarded for having no education classification, 3,157 omitted for no information on seniority, 181,048 dropped for missing hourly wages, 118,243 omitted for log wages deviating more than five standard deviations from the predicted value using experience up to the fourth potency, gender and 22 education classes and 17,811 observations dropped for lacking company codes). This number decreases to 2,096,523 when only employees with an estimable company effect are included.

Human capital is estimated by separating person and company-level components of the earnings $\ln(w_{\mathrm{ijt}})$ of a person *i* working in company *j*. Following the two-step method suggested by Andrews (2004), the dependent variable is expressed as a function of individual heterogeneity, company heterogeneity and measured time-varying characteristics:

$$\ln(w_{\mathrm{j(i,t)}})\text{-}\mu_{wi} \;=\; \beta(x_{it}-\mu_{xi})+\gamma(w_{it}-\mu_{wi})+\theta_i+\delta\hat{\psi}\;+e_{ijt}\;. \quad (4A.1)$$

θ_i is the time invariant compensation for human capital (individual fixed effect). The person effect is the person average of the original error: $\theta_i = mean_i(\ln(w_{it})-\hat{\beta}x_{it}-\hat{\gamma}w_{it}-\hat{\psi}_i)$, where $\hat{\beta}$ and $\hat{\gamma}$ are the estimated values of the coefficients and $\hat{\psi}_i$ is the person-average company effect. $\hat{\psi}$ is the first-stage estimate of $\psi_{j(i,t)}$ capturing the effect of unmeasured employer heterogeneity estimated first, where *j* indicates the employer of *i* at date *t* in company *j* (i.e. the first-stage estimate includes $\delta(\psi_{J(i,t)}\text{-}\mu_{Ji})$ showing the time-demeaning of company dummies). $\beta(x_{it}-\mu_x)$ shows compensations for time-varying human capital, experience, stated as a deviation from the individual mean. $\gamma(w_{it}-\mu_{wi})$ shows the time-demeaning of all company-specific variables. e_{ijt} represents a statistical error term. The estimation of the first-stage wage equation is shown in Chapter 2.

This includes 1,421 companies with an estimable firm effect covering 2.10 million employees

The decomposition of the person effect θ_i uses the least square estimates of

$$\theta_i = \alpha_i + u_1\eta_i + \varepsilon_i \ , \tag{4A.2}$$

where α_i is the intercept (unobserved human capital effect), η_i is the educational level and ε_i is the statistical error. Six educational grades are separated according to five fields: (i) general education, humanities, aesthetics, medical and health, field unknown, (ii) commercial and clerical work, law, social sciences, (iii) technology and natural sciences, (iv) transport and communication and (v) agriculture and forestry (no field for elementary and doctorate level education and also unspecified field for vocational education). Human capital consists of

$$Human_i = Experience_i + \alpha_i + u_1\eta_i \ , \tag{4A.3}$$

where $Experience_i$ is the return from experience (up to the fourth potency), α_i is unobserved human capital and $u_1\eta_i$ is the return on education.

Appendix 4B. List of Sub-indices

Frontier Worker Human Capital

Overall Human Capital

The average of education, experience and unobserved human capital in 1996-2002, see equation (4A.3) in Appendix 4A.

Education Human Capital

As a measure of education human capital we take into account both the share of highly educated and the relative rate of return in each highly educated group.

$$Educational\ HC_{j,t} = \sum_{i_t=1}^{I_t} z_{i_t \in H} u_H \eta_H / \sum_{i_t=1}^{I_t} i \,, \tag{4B.1}$$

where $z_{i \in H}$ indicates that the worker belongs to the highly educated group H (where the rates of return are given in Appendix 2B in this volume) and the denominator is all workers in the company. We also include non-technical lower-level tertiary degrees in the highly educated group.

Frontier Company Human Capital

Educational human capital: an average over the companies.

Occupational human capital: an average over the companies.

Interaction of experience-based human capital in the lowest and highest quartile: interaction of the average of the share of workers in the company below the 25th and above the 75th percentile of overall experience-based human capital.

The share of white-collar workers in R&D work

Human Capital: Region

Working Age Population (15-64)

$$\frac{\text{Working Age Population}_r / \text{Working Age Population}_{All}}{\text{Population}_r / \text{Population}_{All}} \tag{4B.2}$$

where subscript r is region and subscript *All* refers to the overall value in 2002.

Participation Rate

$$\frac{\text{Participation Rate}_r}{\text{Participation Rate}_{All}} \tag{4B.3}$$

Students

$$\frac{\text{Students}_r/\text{Students}_{All}}{\text{Population}_r/\text{Population}_{All}} \tag{4B.4}$$

Technical Students (Highly Educated with Technical Education in Manufacturing)

$$\frac{\text{High Education, Technical}_r/\text{High Education, Technical}_{All}}{\text{Population}_r/\text{Population}_{All}} \tag{4B.5}$$

Highly Educated

$$\frac{\text{Highly Educated}_r/\text{Highly Educated}_{All}}{\text{Population}_r/\text{Population}_{All}} \tag{4B.6}$$

Innovativeness

R&D Expenditures (in 2001 and 2002)

$$\frac{\text{R\&D Expenditures}_r/\text{R\&D Expenditures}_{All}}{\text{Population}_r/\text{Population}_{All}} \tag{4B.7}$$

Patents in 2003

$$\frac{\text{Patent Applications}_r/\text{Patent Applications}_{All}}{\text{Population}_r/\text{Population}_{All}} \tag{4B.8}$$

Innovative Establishments in Manufacturing

$$1/3 * \frac{\text{Innovative Establishments}_r}{\text{Establishments}_{Manufacturing}} + 1/3 * \frac{\text{Workers in Innovative Establishments}_r}{\text{Workers in Establishments}_{Manufacturing}} + 1/3 * \frac{\text{Sales Innovative Establishments}_r}{\text{Sales in Establishments}_{Manufacturing}} \tag{4B.9}$$

High Technology Sector, Value Added

$$\frac{\text{Personnel in High-Technology Manuf.}_r / \text{Personnel in Manuf.}_{\text{All}}}{\text{Population}_r / \text{Population}_{\text{All}}} \qquad (4B.10)$$

The high technology sector includes industries belonging to high-level technology and some belonging to middle-level technology according to the OECD classification:

- *High-Level Technology:* 30 Manufacture of office machinery and computers, 32 Manufacture of radio, television and communication equipment and apparatus, 72 Computer and related activities, 73 Research and development, 741 Other business activities, 742-743 Architectural and engineering activities and related technical consultancy, 748 Miscellaneous business activities.
- *Middle-Level Technology:* 241 Manufacture of basic chemical, 243 Manufacture of paints, varnishes and similar coatings, printing ink and mastic, 245 Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toiletries, 246 Manufacture of other chemical products, 247 Manufacture of man-made fibres, 29 Manufacture of machinery and equipment, 31 Manufacture of electrical machinery and apparatus, 34 Manufacture of motor vehicles, trailers and semi-trailers, 352 Manufacture of railway and tramway locomotives and rolling stock.

Agglomeration

Population Density

$$\log\left(\frac{\text{Population}_r / \text{Population}_{\text{All}}}{\text{Region Size}_r / \text{Region Size}_{\text{All}}} + 2.746 - 1\right) \qquad (4B.11)$$

Education Human Capital Agglomeration

The regional education human capital measure consists of the education human capital in region *r* as defined in (4B.1) and the influence of other regions. The decay parameter depending on the distance to neighbour regions is defined in Appendix 2A in Chapter 2 of this volume.

Co-operation in Innovative Companies

$$1/3*\frac{\text{Co-operating and Innovative Manuf. Plants}_{\text{r}}}{\text{Manufacturing Plants}_{\text{All}}} +1/3*\frac{\text{Workers in Co-operating and Innovative Manuf. Plants}_{\text{r}}}{\text{Workers in Manufacturing Plants}_{\text{All}}} +1/3*\frac{\text{Sales in Co-operating and Innovative Manuf. Plants}_{\text{r}}}{\text{Workers in Manufacturing Plants}_{\text{All}}} \quad (4B.12)$$

Accessibility

Air Accessibility

Distance is measured from region *i* to the region *j* which gives the easiest access to flights. Also the distance to Helsinki, and connecting flights from there, is taken into account.

$$Max_r\left(\frac{2*\text{Foreign Landings}_{\text{r}}+\text{Domestic Landings}_{\text{r}}}{\text{Distance}_{\text{r}}}\right) +\frac{2*\text{Foreign Landings in Helsinki}}{\text{Distance}_{\text{rR}}+\text{Distance to Helsinki}_{\text{rHelsinki}}} \quad (4B.13)$$

Establishments Engaged in Foreign Trade

$$1/3*\frac{\text{Exporting or Importing Manuf. Plants}_{\text{r}}}{\text{Manufacturing Plants}_{\text{All}}} +1/3*\frac{\text{Workers in Exporting or Importing Manuf. Plants}_{\text{r}}}{\text{Workers in Manufacturing Plants}_{\text{All}}} +1/3*\frac{\text{Sales in Exporting or Importing Manuf. Plants}_{\text{r}}}{\text{Workers in Manufacturing Plants}_{\text{All}}} \quad (4B.14)$$

Appendix 4C. Total Factor Productivity

Figure 4C.1 shows total factor productivity based on relative productivity to the average in 19 industries. Figure 4C.2 shows human capital at the individual level.

Figure 4C.1 suggests that total factor productivity is higher in the Helsinki region, in Pirkanmaa including Tampere and in the coastal region of Western Finland around Vaasa. Regions with pulp and paper or metal industries such as Lappeenranta and Kemi-Tornio also perform well in total factor productivity comparisons. Loikkanen and Susiluoto (2002) estimated efficiency scores using the Data Envelopment Analysis (DAE) method. They found similarly that all three big cities – Helsinki, Tampere and Oulu – were among the ten most efficient areas. All the ten biggest cities and university cities (with two exceptions) were also above the median. It is seen that in relative efficiency the top regions marked by the lightest colour are (in decreasing order): Espoo, Helsinki, Vaasa, Seinäjoki Pohjoinen, Vantaa, Mikkeli, Kotka-Hamina, Jämsä.

It is seen from Figure 4C.2 that the distribution of human capital is linked to that of total factor productivity. Regions with higher than average total factor productivity tend to also have more human capital. Human capital intensive regions include the Helsinki region and the major traffic connections from the Helsinki region to Tampere and Jyväskylä and the west coast around Vaasa.

Figure 4C.1 Total Factor Productivity

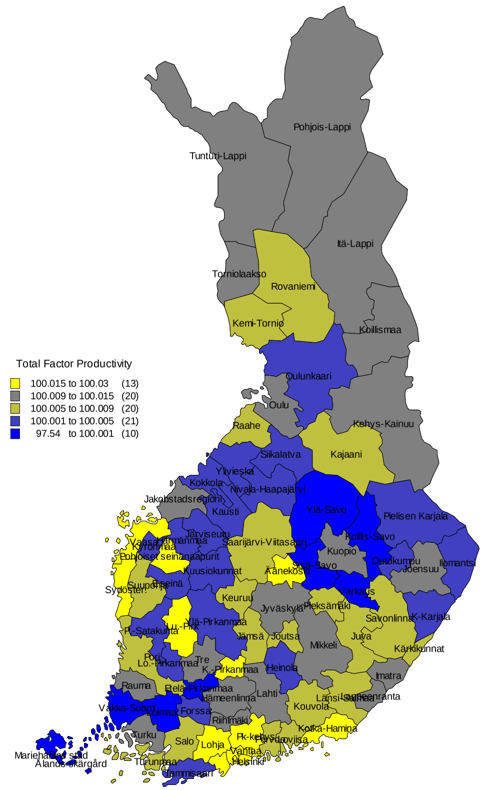
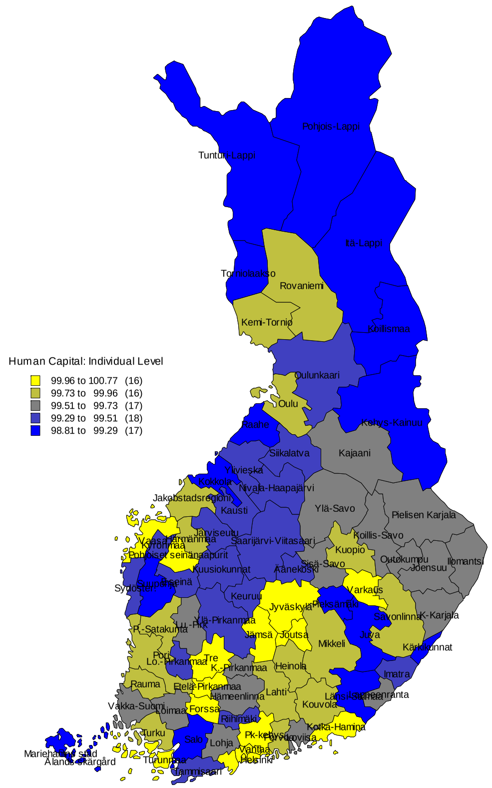


Figure 4C.2 Human Capital: Individual Level



5. Regional Evaluation of Competitiveness

5.1 Introduction

This section examines in greater detail competitiveness in Finnish regions using diagrams for each region. We showed in Chapters 2 and 4 of this volume that regional growth has diverged from 1999 to 2002, despite the economic recession after 2000, which hit the traditional growth areas of Uusimaa, Pirkanmaa, Varsinais-Suomi and Pohjois-Pohjanmaa more. In the ETLA forecast the regional disparities in growth are estimated to remain the same in the period 2003-2008. The investment activity in Eastern Finland will stay at a moderate level (Mäkitalo, (2004)). It is also clear that the recent recession hit many companies in the IT industry relatively severely, especially in Pohjois-Pohjanmaa and Keski-Suomi. The recovery in the IT sector is already taking place in the Pirkanmaa, Varsinais-Suomi, Pohjois-Savo and Pohjanmaa regions. Panu Uotila (Kauppalehti 2005) examined the growth of companies in Finnish regions picking up the most successful ones. Based on financial statements data collected by Balance Consulting, businesses in the Pohjanmaa regions (Keski-Pohjanmaa, Etelä-Pohjanmaa, Pohjois-Pohjanmaa) have been growing in 2004 at the fastest rate, around 7%. Pohjois-Savo (including Kuopio and Varkaus) and Pohjois-Karjala (including Joensuu) have also grown well in this list of the most well-performing 1,000 firms, most of which are small and medium-sized.

Siuruainen (2004) has considered the regional allocation of government technology funding. According to him the biggest university cities (Helsinki, Turku, Tampere, Oulu, Jyväskylä, Kuopio and Joensuu), as well as Lappeenranta, have developed human capital intensive clusters. All these areas grow in size and GDP per capita. The Ministry of Interior launched a programme of 34 regional centres in 2002, to extend the good performance of the big cities to other areas. This programme has, later on, been extended by programmes in the Greater Helsinki region, Middle Uusimaa, Lohja and Tammisaari.

In Chapter 2 we showed figures on total factor productivity growth in (Figure 2.9) and that explained by human capital (Figure 2.10). Figure 2.9 indicated strong total factor productivity growth also in many less populated areas. Figure 2.10, however, indicated a regional concentration of human capital explained growth in the area around the Greater Helsinki region. We showed that productivity growth explained by human capital has been highest in the Greater Helsinki region, especially in Espoo, and also in Lappeenranta and in the west coast regions around Vaasa. In Espoo the annual productivity growth explained by human capital is 11%. In the Greater Helsinki region the exception is Vantaa, which was not considered separately in the competitiveness index. In other areas the productivity growth explained by human capital is usually around 2.5% to 5% lower than the average. It is somewhat surprising that, despite being among the top ten in the competitiveness index, Turku and Oulu do not stand out particularly as areas of good performance driven by human capital. In Turku this can be explained by the human capital intensity, which is only average. In Oulu growth has taken place in the form of new enterprises in the IT sector rather than the traditional manufacturing doing well. The spillovers from the IT sector to the rest of the economy are other than those driven by human capital. However, Figure 4.5 in Chapter 4 shows that sales growth in companies located in Turku and Oulu has been rapid in recent years.

When measuring regional competitiveness we did not want to merely pick up the agglomeration effects. In the hedonic approach, frontier company human capital and innovativeness indicate growth opportunities also outside the agglomerated areas such as Salo.

Pikkarainen (1996) finds that the Tampere and Greater Helsinki regions lost regional growth of GDP in manufacturing and export-oriented production in the recession in 1990-1995. The Tampere and Turku regions are specialised in manufacturing, logistic services, and business and finance services. The public sector share is of the same order as the Finnish average. He also finds a divergence in growth between urban regions. The regions with telecommunication, pulp and paper, energy and basic metal industries have grown faster and improved their productivity.

The position in competitiveness of various regions when using the average (first number in the brackets) and the hedonic approach (second number in the brackets) is as follows. The high-growth regions in 1990-1995 include Raahe (28, 9), Salo (10, 2), Jämsä (11, 49), Kemi-Tornio (33, 32), Vaasa (4, 4), Äänekoski (26, 12), Porvoo (7, 21) and Pietarsaari (22, 19). Pikkarainen also finds a group of urban regions with poor growth in GDP in 1990-1995. These include Jyväskylä (6, 10), Hämeenlinna (20, 18), Tampere (2, 3), Kuopio (12, 14), Lahti (19, 23) and Turku (5, 5). It is evident that the GDP growth in the recession period tells fairly little about the subsequent competitiveness of the region. Many areas, such as Tampere and Jyväskylä, have succeeded relatively well since the recession, see Figure 4.5 in Chapter 4. As noted earlier it also took a relatively long time for the Greater Helsinki region to recover from the recession in the early 1990s although it is one of the leaders in competitiveness and also in current growth (especially in that explained by human capital).

Chapter 4 explained sales growth by hedonic competitiveness index. A high number of regions are close to the trend line in Figure 4.5 and especially when taking into account separately the degree of urbanisation (through the use of dummies). The urbanisation dummies imply a 19% higher growth rate in the Greater Helsinki area relative to cities and some 40% higher growth relative to other areas. The difference between the Greater Helsinki area and other cities attributes largely to a higher level of total factor productivity. We can hence argue that our competitiveness measures fare relatively well in predicting future growth.

Figure 4.2 in Chapter 4 showed the ranking of Finnish regions using 20 sub-indices for competitiveness. Here we use 10 sub-indices to describe the competitive positive of each regions. These are based on the four main criteria for competitiveness, which are human capital, innovativeness, industry structure and agglomeration. Human capital includes frontier human capital. This is human capital relative to the average in the industry, see previous Chapter 4. The competitiveness is mainly evaluated at the level of regional centres so that less attention is paid to rural areas.

5.2 Regional Competitiveness

The following table shows the evolution of industry shares since 1993. It is seen that manufacturing employs around 19% of all employed, being the second largest industry after social services. It is expected that the sales will continue to grow in all industries. However, the improvement in employment is concentrated in the service sector despite the surprisingly moderate decrease in manufacturing employment. This is especially so when taking into account that some 50,000 to 80,000 jobs have been externalised from manufacturing to the service sector since 1995, that is, around 2.5 to 3% of the total workforce.

Table 5.1 Industry Shares

Year	Agric. Forestry	Mining	Manuf.	Energy	Cons-truction	Trade, Hotel&Res-taurant	Transport, Telecom.	Finance, Estate	Social Services
1993	8.6 %	0.2 %	19.2 %	1.2 %	4.7 %	14.6 %	7.5 %	10.8 %	30.9 %
1994	8.0 %	0.2 %	19.9 %	1.2 %	4.8 %	14.4 %	7.4 %	11.0 %	30.5 %
1995	7.0 %	0.2 %	20.2 %	1.1 %	4.9 %	14.5 %	7.5 %	11.1 %	31.1 %
1996	6.7 %	0.2 %	19.9 %	1.1 %	5.0 %	14.4 %	7.3 %	11.2 %	32.1 %
1997	6.1 %	0.2 %	20.1 %	1.0 %	5.5 %	14.6 %	7.4 %	11.4 %	31.8 %
1998	5.6 %	0.2 %	20.0 %	1.0 %	5.6 %	15.0 %	7.6 %	12.1 %	31.1 %
1999	5.3 %	0.2 %	19.6 %	0.9 %	5.9 %	15.0 %	7.6 %	12.5 %	31.1 %
2000	5.1 %	0.2 %	19.7 %	0.8 %	6.0 %	14.9 %	7.5 %	13.0 %	31.2 %
2001	4.7 %	0.2 %	19.4 %	0.8 %	5.9 %	15.1 %	7.5 %	13.3 %	31.4 %
2002	4.3 %	0.2 %	18.9 %	0.8 %	5.8 %	15.2 %	7.4 %	13.4 %	32.0 %

Source: Statistics Finland

The following radar diagrams (Figures 5.1 to 5.12) show regional competitiveness sub-indices in 77 regions at the NUTS 4-level. The sub-indices are subsets of those used to construct the competitiveness index in Chapter 4. In addition, the organising of work measures the share of workers that has received performance-related pay. The effectiveness of incentives to motivate workers has been used as one sub-index in the competitiveness measure by World Economic Forum (WEF). Rouvinen (2005) finds it to be one of the most relevant sub-indices in explaining future growth.

It should be noted that the representative data in areas with very little manufacturing is not very good. Manufacturing employees are the major source of information when calculating human capital indices, organisation of work and the competitiveness index. We mainly analyse competitiveness at the level of regional centres so that less attention is paid to rural areas. The shortcoming then is that the competitiveness index relies heavily on information on frontier human capital that is available only for in companies that are members of the Confederation of Finnish Industry. We also show (in Appendix 5A) the share of employment by region relative to the average in the industries listed in Table 5.1.

Here, R&D expenditures, the working age population share, agglomeration and accessibility are directly from Statistics Finland data. In Appendix 5A we also show the relative share of nine main industries with respect to the average over all regions.

5.3 Pohjois-Pohjanmaa and Lapland

Rovaniemi region (also a regional centre) with 61,800 inhabitants ranks 25th in competitiveness, Kemi-Tornio region (also a regional centre) with 61,600 inhabitants ranks 33rd. Koillis-Suomi regional centre has 31,800 inhabitants (includes Itä-Lappi with 21,499 inhabitants).

Human Capital

It is seen that in Lapland as a whole, the share of the working age population is at the average in Finnish regions or above it. The working age population share is the average in Rovaniemi, whereas some 5%-points below the average in Kemi-Tornio. The population is fairly young in Oulu, but the opposite in the neighbours: the Southern Oulu regional centre, Ylivieska, Siikalatva and Nivala-Haapajärvi. Thus the regional centre of Oulu has absorbed the young population from the surrounding areas. In Northern Pohjanmaa the population is fairly aged.

The Rovaniemi region has a relatively high share of tertiary educated workers (25.2%, 28.6% in Rovaniemi city), especially when compared to Kemi-Tornio (19.1%, 20.2% in Kemi and 20.1% in Tornio) or to Koillis-Suomi (14.5%). Higher education institutes include the University of Lapland (Rovaniemi) and lower-level university institutes (polytechnics) in Kemi and Tornio. The Kemi-Tornio region has relatively more skilled labour in manufacturing than Rovaniemi. This is most apparent in large companies as seen from the frontier worker human capital.

Frontier company human capital, regional human capital and innovativeness were shown to be the driving forces for growth in the hedonic approach (Chapter 4 of this volume). Both in Kemi-Tornio and Rovaniemi, human capital can be said to be close to the average level in Finland. Innovativeness is 5%-points below the average in Rovaniemi and 10%-points below the average in Kemi/Tornio. The Oulu region is ranked the third most competitive region with a high share of highly educated workers, 28.6% (31.8% in Oulu city). The Southern Oulu regional centre has 84,800 inhabitants (Oulunkaari 27,059, Raahe 35,476, Koillismaa 22,263) with a much lower share of highly educated workers, 14.5%. Higher education institutes are Oulu University and lower university level polytechnics in Oulu, Ylivieska and Haapajärvi. Oulu is average in human capital at the company level.

Industry Structure

Kemi-Tornio has a large share of manufacturing employment (120%), see Figure 5A.1 in the appendix. In other words, compared to the average 18.9% manufacturing employment share in Finland (Table 5.1), manufacturing employment is 20%-points higher in Kemi. The Rovaniemi region has a very low share (40%) of manufacturing employment, whereas the energy and social service sectors are large. Manufacturing located in Rovaniemi and Kemi-Tornio profiles in almost average R&D expenditures and high technology. The Rovaniemi regional centre profiles in tourism, the Aurora Borealis technology centre in cold conditions, IT industry and service networks. The Kemi-Tornio regional centre profiles in many areas of technology and innovation. In the Oulu region employment is fairly similarly distributed over industries as in Finland on average. Manufacturing employment in Oulu is not relatively higher than the average and is not very human capital intensive, when measured in terms of educational, experience-based and unobserved human capital (the centre pieces of human capital at the individual level).

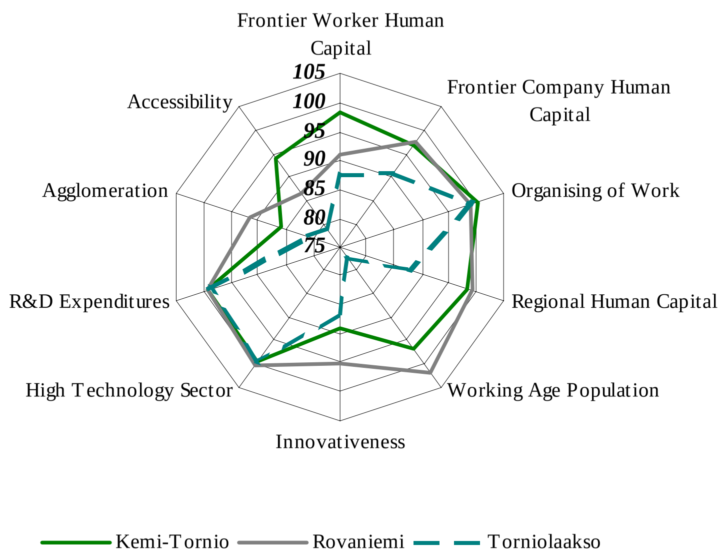
Innovativeness

In the Rovaniemi and Kemi-Tornio regions companies implement new organisation of work just as elsewhere, (here measured by the share of workers getting performance-related pay). Both regional centres have an average level of high technology companies and R&D expenditures.

The Oulu regional centre has a high concentration in the IT sector, which is shown as a high share of innovative companies. The specific industries include media, biotechnology and environmental clusters. Oulu is above average in regional human capital and one of the most innovative regions in Finland, 13% above the average. This indicates that Oulu has many small and innovative high productivity companies. The supply of skilled labour is also good given the large working age population share. However, many of the firms are not the most human capital intensive as measured by frontier human capital.

Overall it is seen that Northern Finland is at the average in R&D expenditures, as well as in the share of the high technology sector. Recall that the high technology sector includes industries belonging to high-level technology and some belonging to middle-level technology according to the OECD classification (such as manufacture of chemicals, man-made fibres and electrical machinery). High technology makes use of global, specified

Figure 5.1 Kemi-Tornio, Rovaniemi, Torniolaakso, Pohjois-Lappi (North Lapland), Tunturi-Lappi, Itä-Lappi



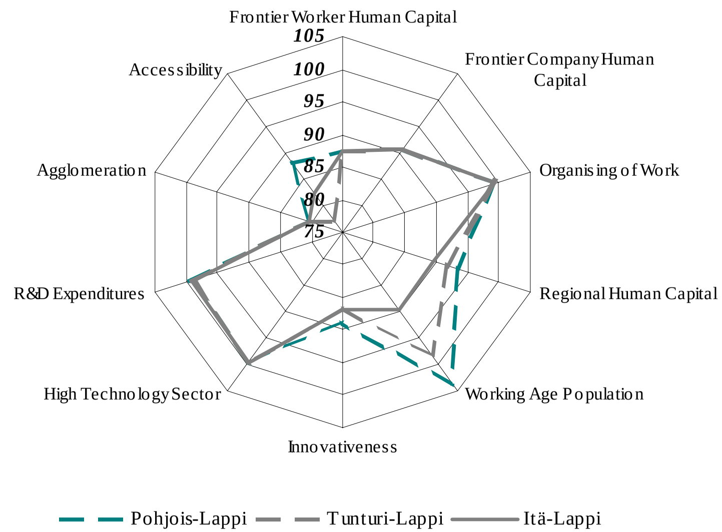
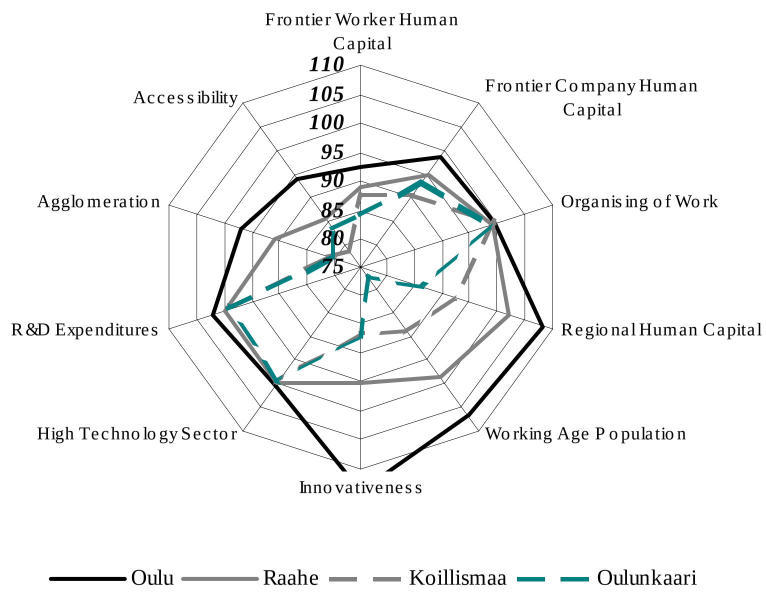
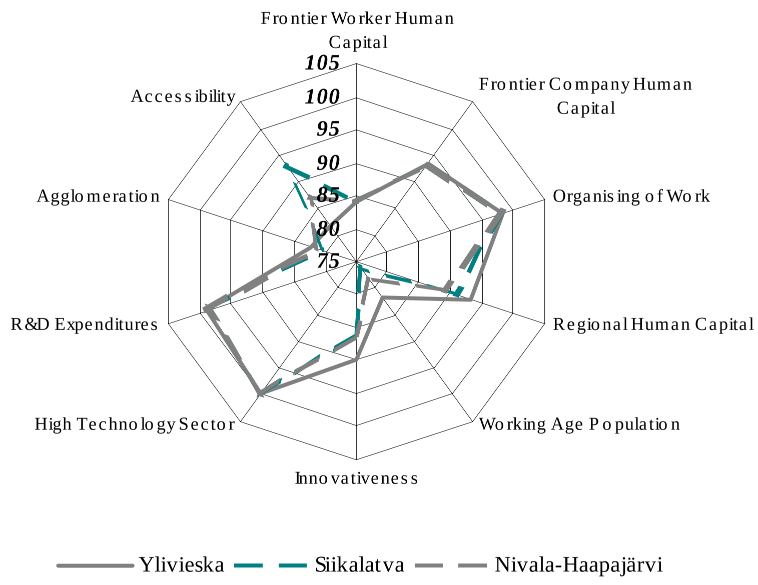


Figure 5.2 Oulu, Raahe, Koillismaa, Oulunkaari, Ylivieska, Siikalatva, Nivala-Haapajärvi





technology and is less reliant on downstream activity and close access to consumers. Oulu clearly shows the nucleus for future performance and for upgrading the general skill level, which is not above the Finnish average.

Other factors

Due to the long distances, accessibility is below average and population density is one of the lowest even in regional centres.

5.4 Pohjanmaa

Kokkola region with 52,300 inhabitants ranks 27th in competitiveness. Vaasa region with 88,500 inhabitants ranks 4th in competitiveness. Vaasa regional centre has a population of 105,700. Seinäjoki region (Pohjoiset seinänaapurit) with 64,000 inhabitants ranks 21st in competitiveness. Seinäjoki regional centre has 146,000 inhabitants.

Human Capital

In Kokkola and Seinäjoki the share of the working age population is average. In the Vaasa region the share of the working age population is below average and so is unemployment (the average unemployment rate is in Pohjanmaa 6.9% compared to the average 8.8% in 2004 in the whole country). Generally, the age structure in Pohjanmaa is not very good in rural areas. Eteläiset seinänaapurit and Suupohja have a very low share of the working age population. The Oulu, Vaasa and Seinäjoki regions absorb all the young population from the surrounding regions.

Keski-Pohjanmaa has a fairly low share of highly educated workers (19.4%) although the figure is around 4%-points higher than in Northern Finland (22.6% in Kokkola). Higher education is provided in Kokkola (52,252 in habitants) and Keski-Pohjanmaa polytechnics. The Pietarsaari regional centre has 48,300 inhabitants with very low unemployment (6.8%). In Etelä-Pohjanmaa the higher education institutions include Vaasa University, regional activity by Åbo Akademi, Svenska Handelshögskolan and University of Helsinki. Lower university level polytechnics (one for the Swedish-speaking population) are located in Vaasa and Keski-Pohjanmaa. In the Vaasa region the share of highly educated workers is 25% (29.5% in Vaasa city). Etelä-Pohjanmaa with the Seinäjoki region (Pohjoiset seinänaapurit) has a 19.8% share of highly educated workers (29.2% in Seinäjoki city) and average unemployment.

All the regional centres, Kokkola, Seinäjöki and Vaasa, rely on frontier company human capital. Thus Pohjanmaa contains many small skill intensive companies, but may lack large ones except for the Vaasa region where some large manufacturing industries (ABB, Wärtsilä Finland, Vacon, Vaasa Engineering, KWH-Yhtymä, Scott, Health Safety and Kemira) are located.

Industry Structure

In Keski-Pohjanmaa agriculture and energy industries are the cornerstones, although employment in manufacturing is also at the Finnish average level. The area has chemical industry and investment in R&D expenditures so that the high technology share is average. The service sector is underrepresented covering only 15% of total sales in Keski-Pohjanmaa (in the Kauppalehti (2005) study). Employment in the Vaasa region is fairly evenly distributed over all industry branches. Electronics, plastic and information technology stand out within manufacturing. In the Seinäjoki region (Pohjoiset seinänaapurit) all industries, except energy and finance, are fairly well represented, see Figure 5A.2 in the appendix. It is seen that Seinäjoki region has a very similar structure in competitiveness to the Vaasa region.

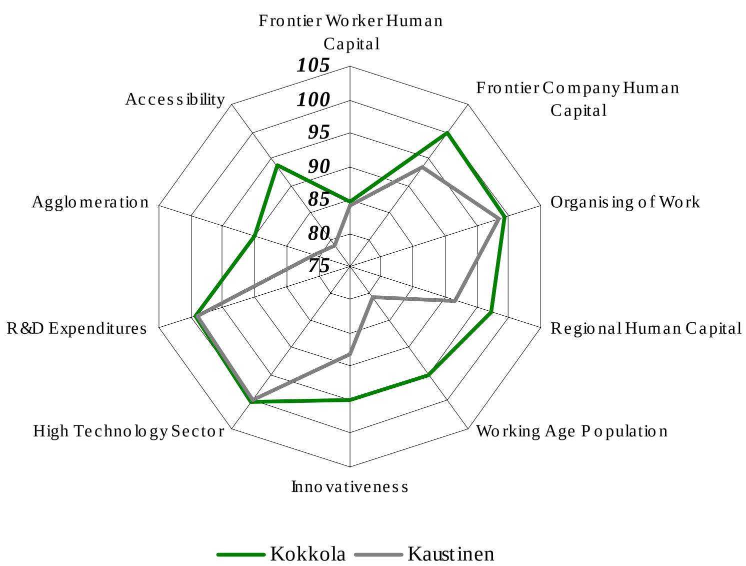
Innovativeness

Innovativeness is 5%-points below average in Kokkola and 10%-points in Seinäjoki, and average in Vaasa.

Other Factors

Kokkola's ranking would be higher than 27^{th} in competitiveness giving lower weight to the low scores in agglomeration, accessibility and frontier worker human capital. The Vaasa region is strong in every aspect except in agglomeration of population. The logistic position of Seinäjoki gives some advantages not shown in accessibility based on flight connections. In Pietarsaari accessibility is average. Accessibility is worse than in Vaasa due to less active air traffic. However, the good train connections are not taken into account here. In regions close to Seinäjoki region R&D investments and the share of high technology are close to the Finnish average.

Figure 5.3 Keski-Pohjanmaa (Central Ostrobotnia)



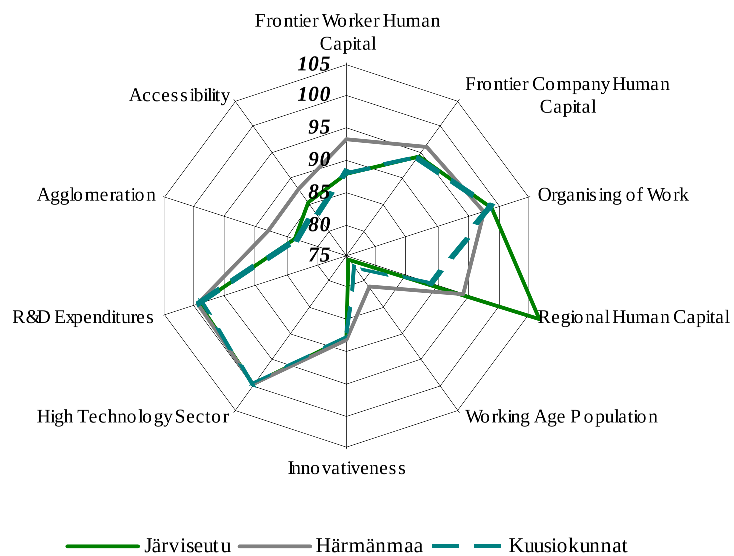
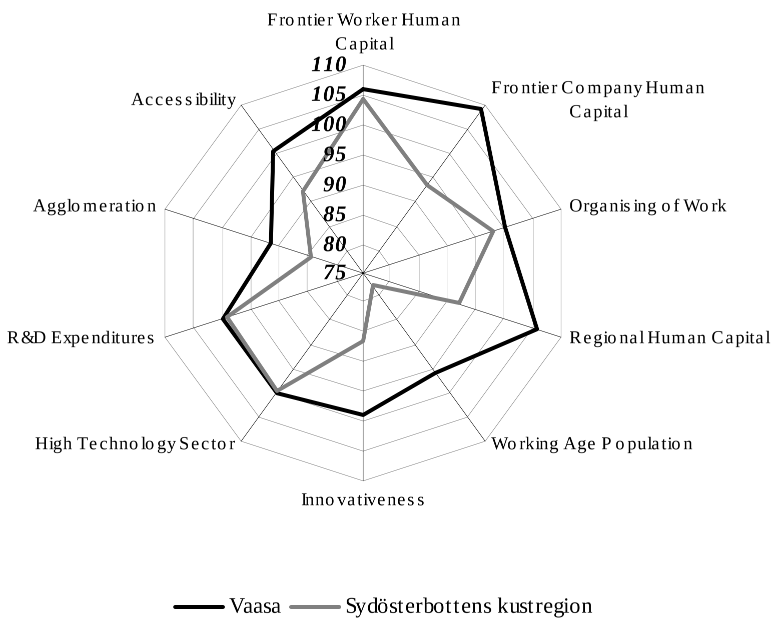
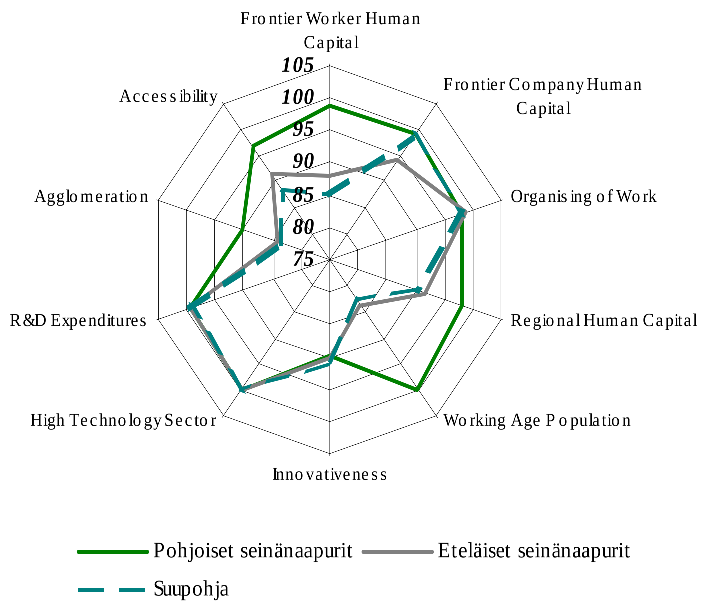


Figure 5.4 Etelä-Pohjanmaa (South Ostrobotnia)





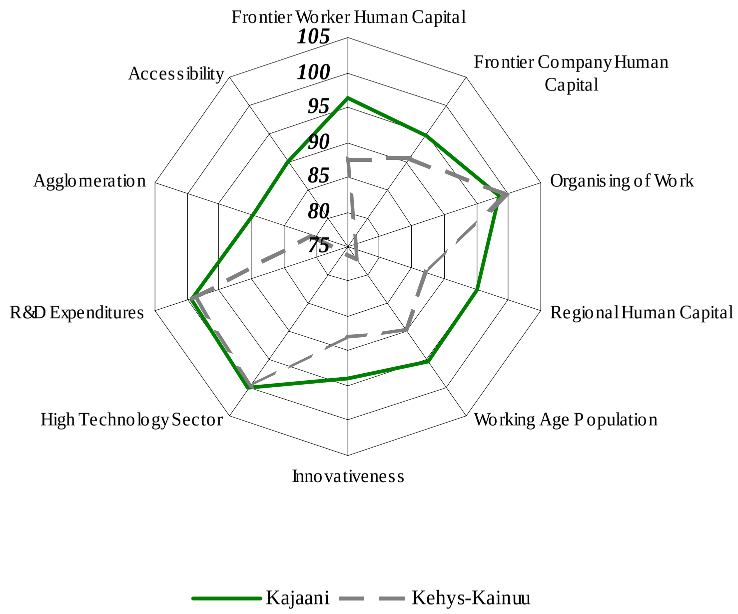
5.5 Kainuu, Pohjois-Karjala, Pohjois-Savo, Etelä-Savo

Kajaani region (the same as Kainuu regional centre) with 58,800 inhabitants ranks 36th in competitiveness. This region together with Kehys-Kainuu, 27,800 inhabitants, belongs to the less populated areas. Joensuu as the centre for Pohjois-Karjala with 93,100 inhabitants is ranked 13th in competitiveness and fares fairly well in all fields. Varkaus region with 35,400 inhabitants ranks 8th in competitiveness.

Human Capital

In the Kajaani region the working age population share is 80% of the Finnish average. Similarly to Kainuu and Lappi, the Kajaani region also suffers from high unemployment, 17.2% in 2003 (18.6% in Kainuu and 17.3% in Lappi). Joensuu has an above average share of the working age population. Somewhat similarly to Oulu the working age population share is low in the surrounding regions. Pohjois-Karjala has 169,100 inhabitants and ageing is severe outside Joensuu. In Varkaus the working age population share is 91% when related to the country average. In Kajaani human capital intensity is fairly low although the share of highly educated workers is 20.9% (25.1% in Kajaani). Higher education institutes include a unit of Oulu University and a polytechnic. Pohjois-Karjala has a relatively high share of highly educated workers, 21.8%. Joensuu has a 27.7% share of highly educated workers. Higher education institutes include Joensuu University and two polytechnics. Varkaus has a 22% share of highly educated workers and scores very well in all areas of human capital. The lack of skill intensive companies is indicated by frontier company human capital being at least 5% below average except in Varkaus and Kuopio.

Figure 5.5 Kainuu, Pohjois-Karjala (North Karelia)



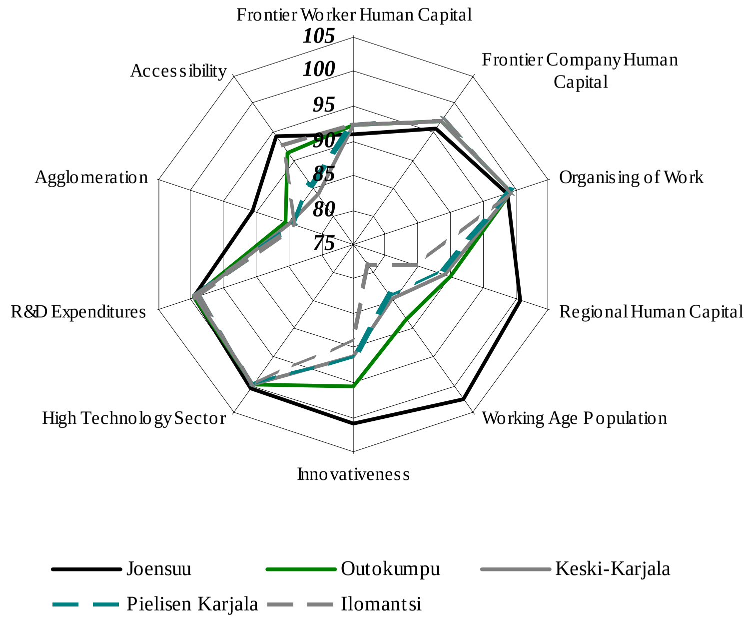
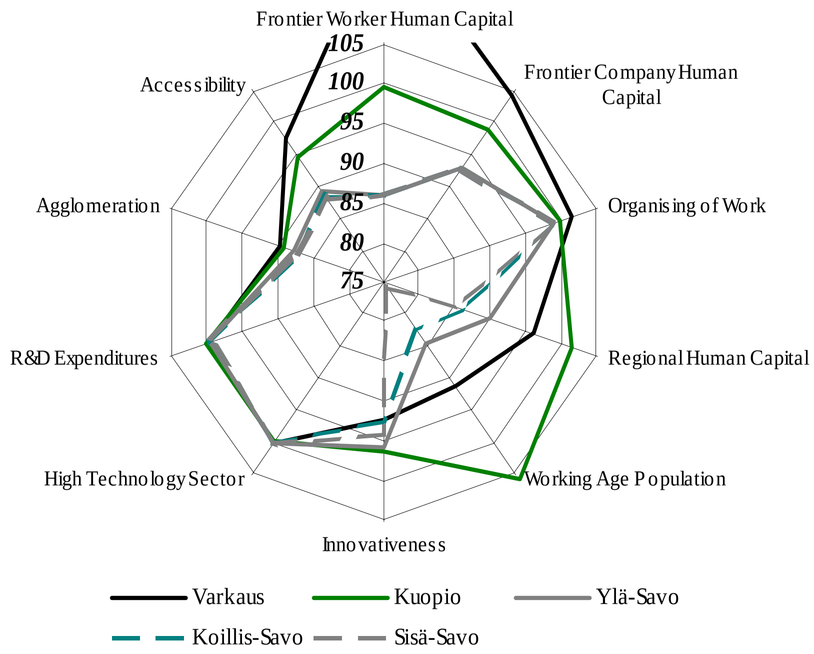
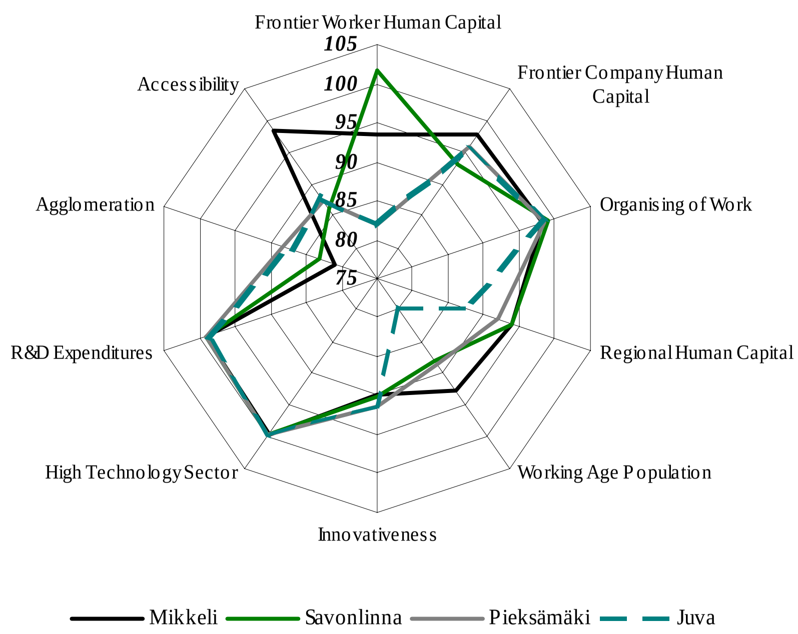


Figure 5.6 Pohjois-Savo, Etelä-Savo





Industry Structure

Lautanen and Saikkonen (2004) have listed the clusters in Eastern Finland (excluding Etelä Karjala) of a total employment of 169,907 as follows.

Table 5.2 Industrial Clusters in Eastern Finland in 2002

Industry	Employ-ment	Share of Employ-ment	Share of Value Added	Share of Value Added in Finland
Wellbeing	53, 729	17%	11%	15%
Agriculture	29, 553	9%	4%	14%
Paper, Pulp	27, 986	9%	17%	26%
Education	22, 646	7%	6%	15%
Metal, Chemical	19, 003	6%	7%	9%
Tourism	9, 318	3%	1%	11%
Mineral	4, 455	1%	2%	18%
IT	3, 217	1%	1%	2%

These clusters form 49% of value added and 54% of employment. These figures exceed the average share in Finland (cluster's average share of valued added is 47% in Finland). In Kajaani there are few manufacturing and finance sector companies. However, among the manufacturing companies Kainuu has many high technology companies and is not below average in R&D expenditures. The important clusters are around IT (also programming and tourism-related), pulp and paper, mining and cultural activities in Kuhmo. In Joensuu manufacturing and energy employment is roughly average. Agriculture and forestry employ less than the Finnish average, see Figure 5A.3 in the appendix. Joensuu is concentrated on plastic, metal and pulp and paper industries. An industry with increasing importance outside Joensuu is mining.

Innovativeness

Companies have average R&D investments in all the regional centers. Innovativeness is clearly below average except in Joensuu. Companies are also average level in organization of work. Manufacturing is thus healthy and uses R&D, but is not necessarily innovative. Manufacturing employment is also only 80% of the Finnish average. Varkaus is the clear exception, where manufacturing employment is 40% above average.

Varkaus went through radical and successful restructuring when one big Finnish company Ahlström Ltd started to internationalise and concentrate on certain industries. The process and the challenges of globalisation for a small city have been described in Jääskeläinen and Lovio (2003). For Ahlstrom the core business in the new environment located elsewhere than in Varkaus. The chemical pulp industry was sold to Enso-Gutzeit (now part of Stora Enso) at the end of the 1980s, automation technology (mainly related to the pulp and paper industry) was sold to Honeywell, the energy technology sector to Foster Wheeler in 1995 and the engineering sector to Andritz in 2001.

All the companies with new international owners have remained in Varkaus and the knowledge capital in the acquired company has been an important reason for the acquisition. Employment in manufacturing has not decreased substantially and this is explained by the substitution of employment in the basic metal and pulp and paper industries for employment in the engineering and automation industries. It is seen that the human capital intensity is one of the highest in Finland, which explains the ability of Varkaus to adapt to the new environment.

Many new companies have become established in Varkaus. In the future subcontracting also in the engineering industry is likely to increase and this offers small cities like Varkaus new opportunities for the establishment of small units that do not necessarily rely on innovativeness. Finally, Varkaus is an example of the length of human capital investment required. It took over 20 years before automation technology initiated by Ahlström Ltd was fully established. It is also noteworthy that the resistance to foreign ownership has not been strong. The foreign companies were usually the leaders in the industry and had a stronger international position.

Other Factors

All regional centres in Eastern Finland have airports and thus good accessibility. The exception is Kajaani with a low population density.

5.6 Keski-Suomi, Satakunta, Varsinais-Suomi

Jyväskylä region with 161,433 inhabitants is ranked the 6th most competitive area, Pori with 142,254 inhabitants ranks 24th, Rauma with 67,000 inhabitants is 17th and Turku regional centre with 295,600 inhabitants is 5th. Jämsä regional centre also fares well being the 11th most competitive area.

Figure 5.7 Jyväskylä, Äänekoski, Jämsä, Keuruu, Saarijärvi-Viitasaari, Joutsa

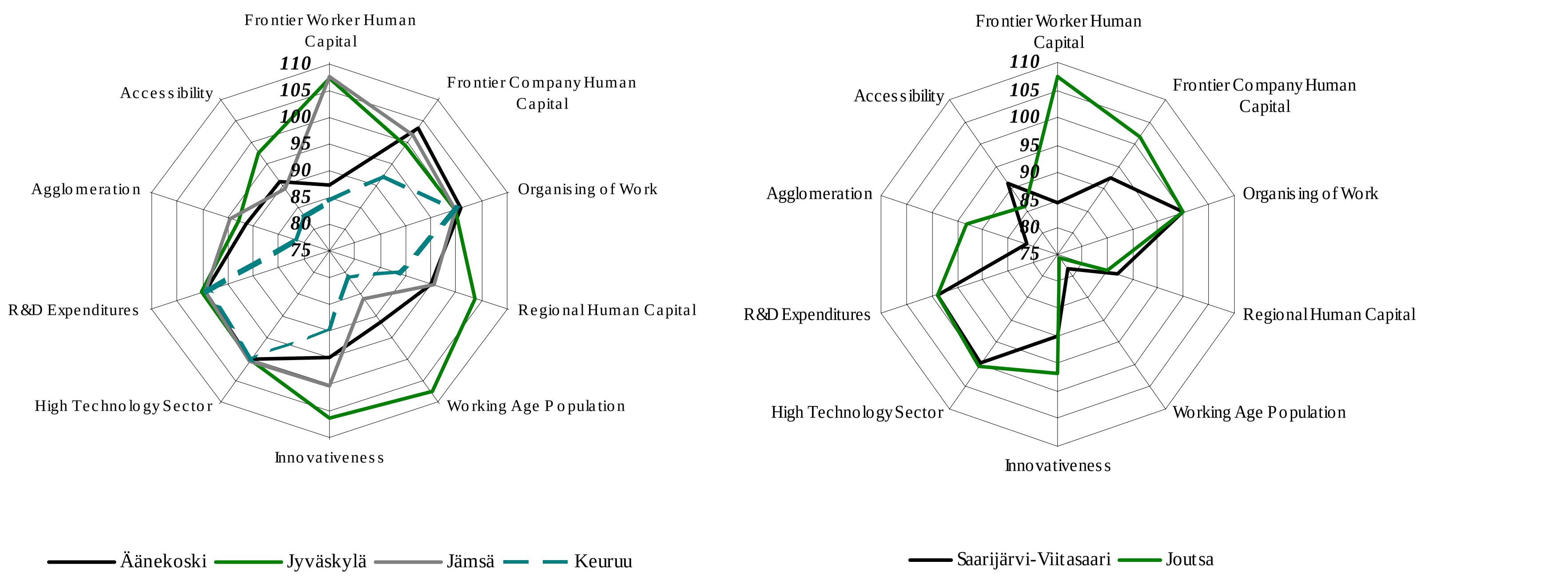
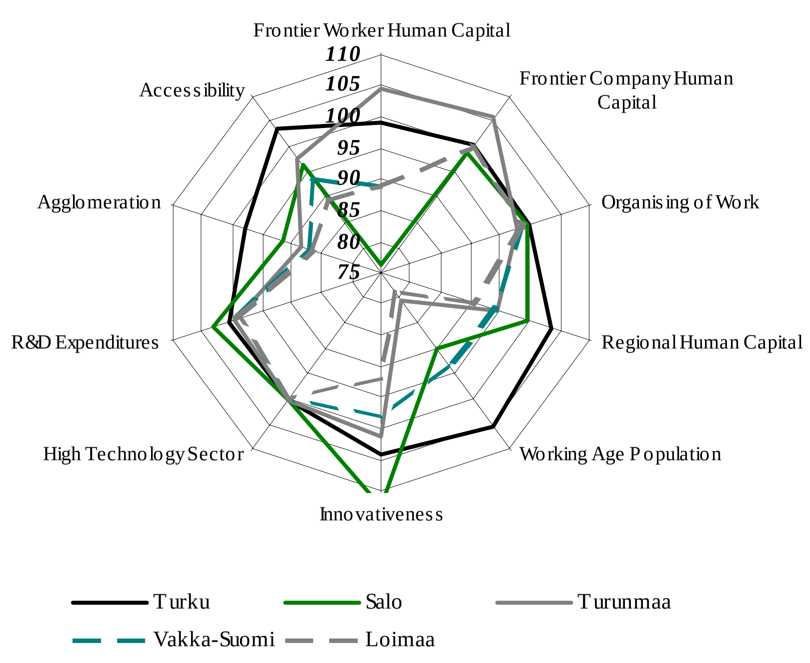
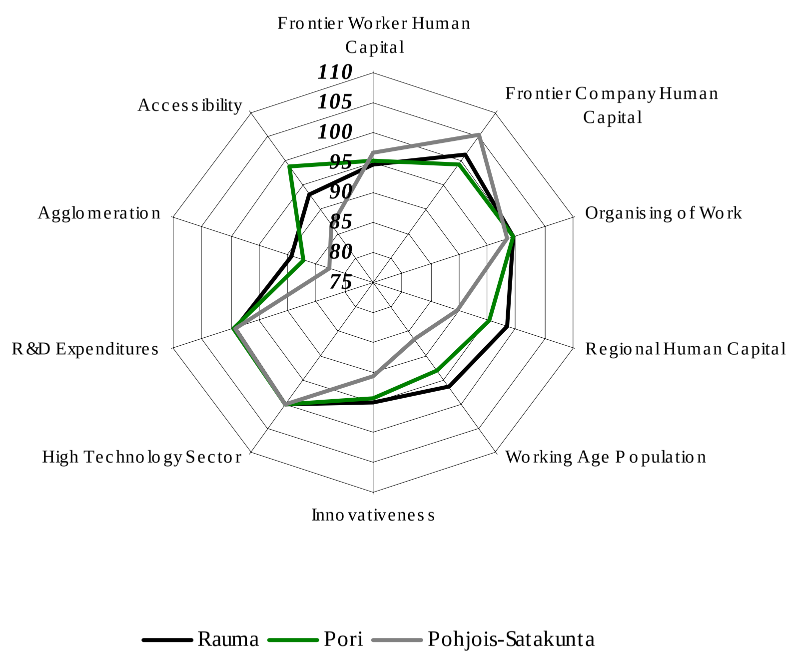


Figure 5.8 Turku, Salo, Turunmaa, Vakka-Suomi, Loimaa, Pori, Rauma, Pohjois-Satakunta





Human Capital

The working age population share is above average in Jyväskylä (107%) and in Turku (105%) and below average in all other areas. The Jyväskylä region has a high share of highly educated workers, 27.6% (31% in Jyväskylä city). Higher education institutes include University of Jyväskylä and polytechnic one. The Jämsä and Joutsa regions invest in human capital. This is explained by an experienced workforce (working age population share is also fairly low), while the share of highly educated workers is not very high (21% in Jämsä and 13.5% in Joutsa). In Pori city the share of highly educated workers is 21.9% and in Rauma 24.3%. Higher education institutes are a university unit in Pori and Rauma and two polytechnics: Satakunta polytechnic with ten units and Pori Diaconia Polytechnic. Rauma also ranks well in companies intensive in human capital.

The share of highly educated workers is 25.8% in the Turku regional centre (27.1% in Turku city). Vakka-Suomi regional centre has 40,400 inhabitants with a low share of highly educated workers (19.7% in Uusikaupunki). Higher education institutes include University of Turku, Åbo Akademi, Turku School of Economics and Business Administration and a polytechnics in Turku including Turku Diaconia Polytechnic. Salo regional centre has 62,500 inhabitants and the share of highly educated workers is 19.7% (24% in Salo city).

These southern and central parts of Finland have an average or above average level of human capital.

Industry Structure

Jyväskylä offers many jobs in finance and social services. A high share of educated workers in Jyväskylä does not mean a higher than average share of manufacturing employment. The Jyväskylä region profiles in metal, paper products, graphics, tourism, electronics and handicrafts. The Jyväskylä regional centre also specialises in information technology, design of pulp and paper machinery and environmental and energy technology. Pori has traditionally had a high share of manufacturing employment relative to the country average (120%). The employment in Rauma is heavily concentrated on manufacturing (160%), energy (220%) and construction (120%). In Pori and Rauma the metal industry employs half of the manufacturing workforce.

It is clear that in a large city like Turku, agriculture and mining are underrepresented and employment in manufacturing is average. Turku profiles in a marine cluster which includes shipbuilding, as well as metal and biotechnology industries. Other important clusters relate to culture and IT. In Salo the manufacturing employment share (170%) is high. Varsinais-Suomi also has industries related to health, logistics and food.

Innovativeness

All the regional centres are average in R&D expenditures and share the high technology industry. Jyväskylä has a high share of small and medium-sized companies and it appears that a big share of the large manufacturing companies is innovative. Turku as the 4th most competitive region also fares reasonably well in innovativeness. The close neighbouring region of Salo has, together with Tampere, one of the largest shares of innovative companies in Finland. This share rates 12% above the country average, which also explains why Salo is the second most competitive area after Oulu in the hedonic approach. In Salo 60% of the manufacturing companies are innovative. Jämsä and Joutsa (69%) are even more innovative, though. Imatra (74%) and Sydösterbottens kustregion (81%) rank at the top in the share of innovative companies.

Other Factors

Jämsä region could rank even higher than 11th if the population density were higher, since the region is substantially below average in agglomeration and accessibility. The accessibility index again ignores the fairly good train connections to Helsinki. Pori also has fairly good air connections. Turku is clearly most above average in accessibility. It is also noteworthy that Mäkitalo (2004) finds that in Varsinais-Suomi the share of small and medium-sized companies (SME) that aim at growth is below (4%) the Finnish average (7%). The share of SMEs considering international markets as the main target is also lower (3%) than the Finnish average (5%).

5.7 Pirkanmaa, Päijät-Häme, Kanta-Häme

Tampere region (Pirkanmaa) is the second most populated area outside the Greater Helsinki region with 309,600 inhabitants. Tampere ranks 2nd in competitiveness, which can be explained by the high share of innovative companies, working age population and regional human capital. For Lahti, Forssa and Hämeenlinna the ranks in competitiveness are, respectively, 19, 37 and 20.

Human Capital

The share of the working age population is average or above in these inland regions in Southern Finland. The exceptions are Lahti, Forssa and Hämeenlinna that have also not experienced substantial population growth since 1990 (between 1990 and 2003 5% in Lahti, -7% in Forssa and 8% in Hämeenlinna). In Pirkanmaa, the share of highly educated workers is 27% (29.1% in Tampere city) and close to the level in Jyväskylä but far behind the level in the Greater Helsinki region. In Lahti, Forssa and Hämeenlinna the shares of highly educated workers are, respectively, 22.8%, 19.4% and 28.4%. Human capital is average or above. Heinola and Hämeenlinna stand out by having many skill intensive companies, but only few of them are large companies.

Industry Structure

Tampere has very little agriculture, forestry and mining and an above average level of employment in manufacturing, see Figure 5A.5 in the appendix. Higher education institutes are University of Tampere, Tampere University of Technology, Department of Sound and Lighting Design in Theater Academy, Pirkanmaa polytechnic and Häme polytechnic in Valkeakoski. Pirkanmaa competes with Helsinki in offering a lower cost level as well as frontier human capital. Pirkanmaa profiles in machinery, automation, information technology, health, biotechnology and communications industry.

Innovativeness

Tampere has a 105% relative level of R&D investment and a high technology sector share and belongs to the top 10 regions in the share of innovative companies. The surrounding regions Ylä-Pirkanmaa, Lounais-Pirkanmaa and Hämeenlinna also have industries intensive in R&D expenditures and high technology. According to Mäkitalo (2004) 4% of SMEs in Pirkanmaa and 8% of SMEs in Häme are orientated towards growth (the average in Finland is 7%). All the other areas are average in innovativeness.

Other Factors

Tampere is well situated with good flight connections and agglomeration. All other areas near Pirkanmaa, also including Lahti and Heinola, do not stand out as having very good flight connections and/or share of exporting or importing companies. 19% of SMEs in the Häme region export, which is close to the Finnish average (20%).

Figure 5.9 Tampere, Ylä-, Lounais-, Etelä-, Luoteis-, Kaakkois-Pirkanmaa

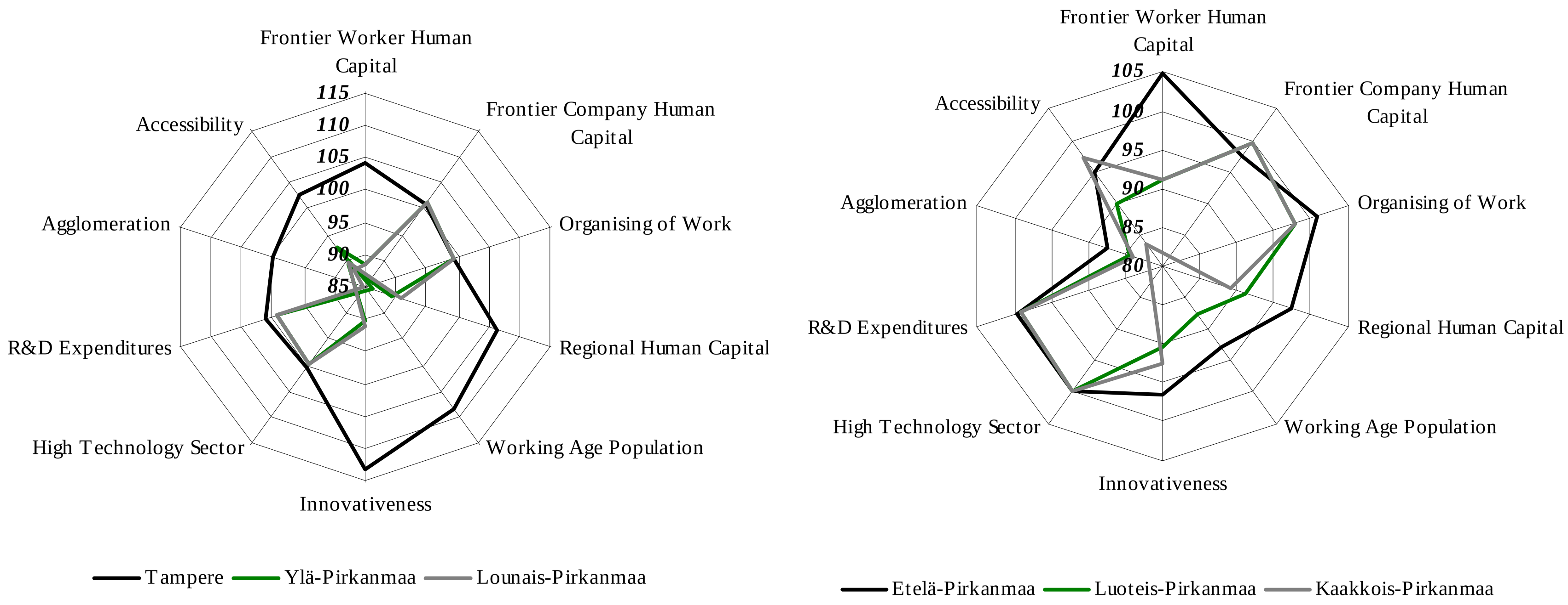
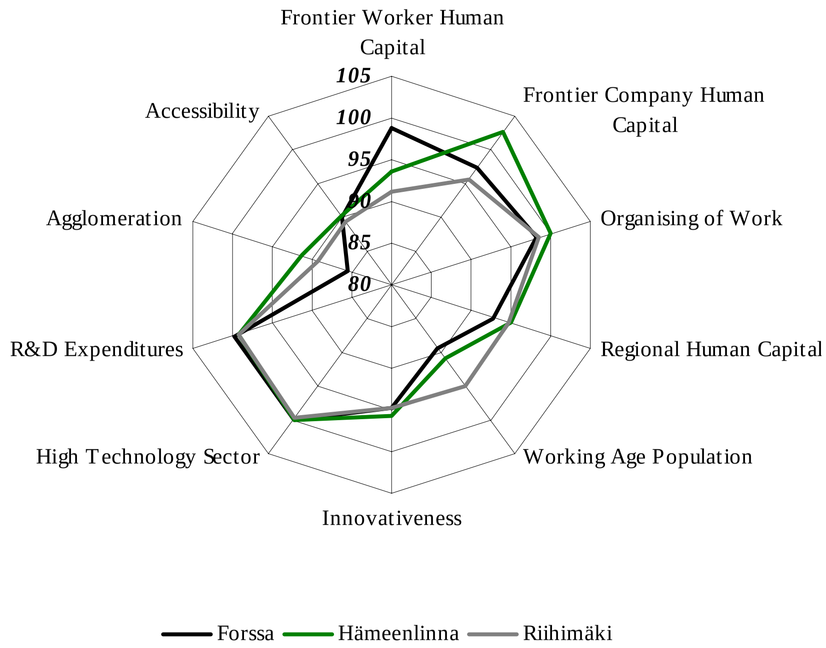


Figure 5.10 Forssa, Hämeenlinna, Riihimäki, Lahti, Heinola



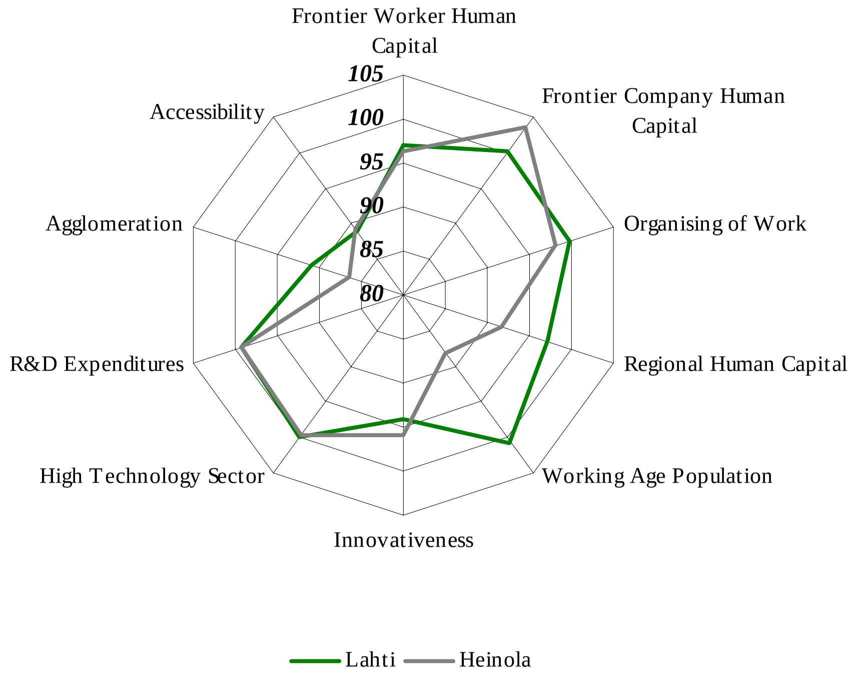
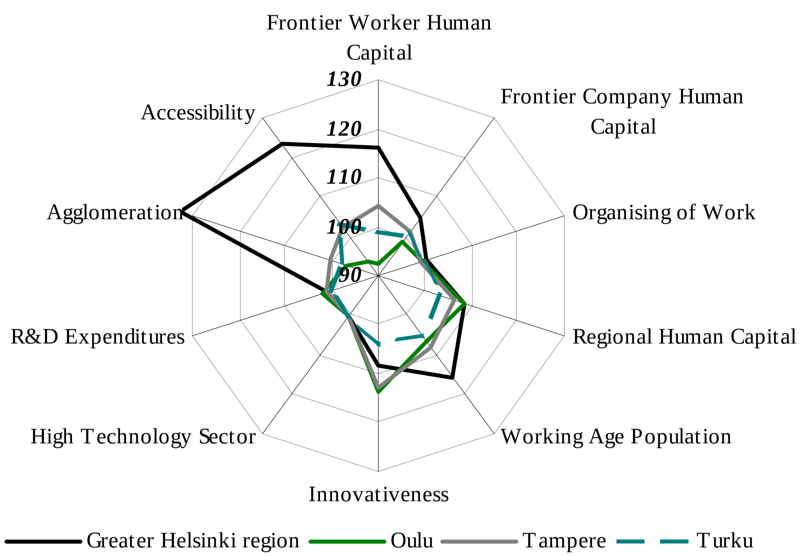


Figure 5.11 Greater Helsinki region, Lohja, Tammisaari



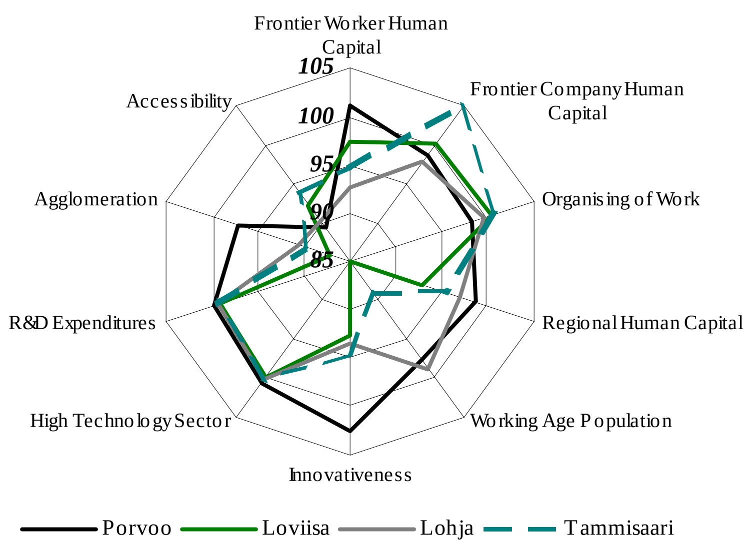
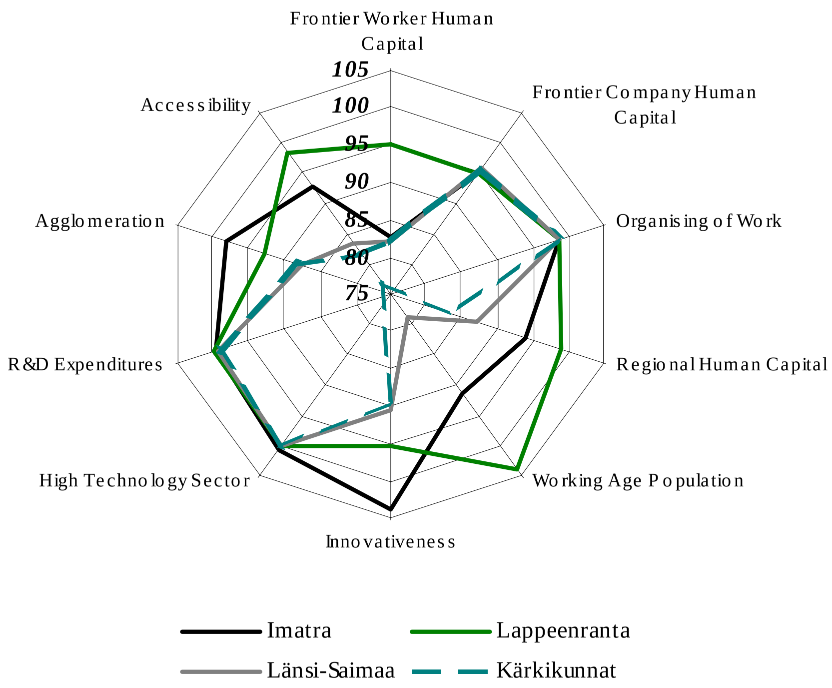
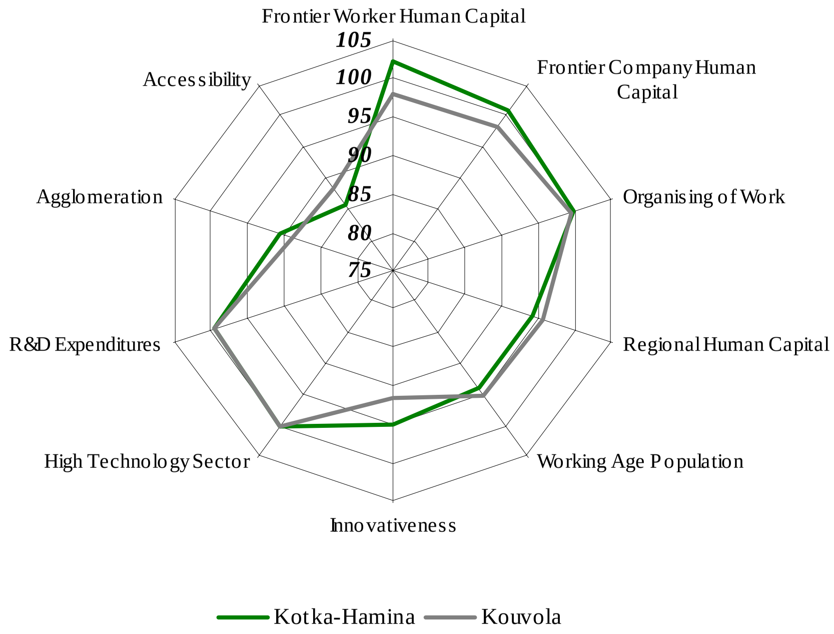


Figure 5.12 Imatra, Lappeenranta, Länsi-Saimaa, Kärkikunnat, Kotka-Hamina, Kouvola





5.8 Uusimaa, Itä-Uusimaa, Kymenlaakso

The Greater Helsinki region (1,216,300 inhabitants) is the most competitive region being 13% more competitive than other regions on average. The next most competitive region is Tampere, which is 5% more competitive than other areas on average (see Figure 4.2 in Chapter 4). Lappeenranta with 69,700 inhabitants ranks 16th and Imatra with 46,700 inhabitants 18th in competitiveness. In Kymenlaakso, Kouvola with 97,818 inhabitants and Kotka-Hamina with 87,800 inhabitants rank as the 35th and 23rd most competitive regions. In Figure 5.11 the Greater Helsinki region is also compared with three other most competitive big cities: Tampere, Oulu and Turku.

Human Capital

In the Greater Helsinki region the share of the working age population is highest 70%, which is 15% above the Finnish average. The share of the working age population usually varies between 61% and 68% with 65% as the average. The other regions have below average working age population shares with Lappeenranta as the clear exception. Cities in the Greater Helsinki region are top in the highly educated worker share, which is 41.2% in Espoo, 33.9% in Helsinki and 27.4% in Vantaa. The shares of highly educated workers are, respectively, in Kouvola 25.5% and Kotka-Hamina 20.4% and 18.75%. In Kouvola and Kotka-Hamina higher education institutes include a polytechnic in Kotka and Kouvola linguistic centre, a unit of the University of Helsinki. The shares of highly educated workers are, respectively, in Lappeenranta and Imatra 23.9% and 18.75%. Lappeenranta's relatively good ranking is explained by human capital intensive companies, a high share of the working age population and average accessibility. It is seen that despite the high share of educated workers, frontier company human capital intensity is only 5% above average.

Industry Structure

In the Greater Helsinki region agriculture, forestry and mining are marginal industries. The employment share of manufacturing is below 10% of the total employment, which is less than 50% of the Finnish average, see Figure 5A.6. It should be noted that most of the headquarters of big manufacturing companies are located in the Greater Helsinki region so the very top employees are located there. It is interesting to see that of the four biggest regions manufacturing employment plays an important role only in Oulu. Manufacturing is a 80% of the average level in regions surrounding the Greater Helsinki region. In Lohja, satellite regions around the Greater Helsinki region (PK-seudun kehyskunnat) and Tammisaari construction, IT and metal industries are relatively important. Employment is expected to decrease especially in large companies, but not in construction. Manufacturing plays an important role in Kouvola (123%), Kotka-Hamina (106%), Lappeenranta (111%) and Imatra (154%).

Kymenlaakso profiles in the pulp and paper cluster, as well as in the metal industry and logistics connections to Russia. Kotka-Hamina profiles in transport (shipping) and has human capital intensive manufacturing. Lappeenranta has important mining and energy industries. Kymenlaakso, Lappeenranta and Imatra have many subcontracting small and medium-sized enterprises that benefit from the presence of a large paper and pulp industry. These firms also practice R&D work.

Innovativeness

In the Greater Helsinki region the share of innovative companies is fairly large. The Greater Helsinki region does not differ substantially from the average in R&D expenditures and the share of high technology. Imatra is dominated by innovative manufacturing companies and the share of manufacturing employment is 160% of the average. The reasonably good ranking in competitiveness is explained by R&D, high technology and innovativeness in Imatra.

Other Factors

The greatest advantage of the Greater Helsinki region is its size. Agglomeration of highly educated workers is high and air connections domestically and abroad are superior relative to other regions.

5.9 Conclusions

Siuruainen discusses the second wave of public investment in R&D to support the growth of selected clusters that are especially found in the areas of pulp and paper, metal and IT. He gives a prominent position to the universities when it comes to maintaining international competitiveness. Siuruainen also notes that 70% of young people begin higher level education (lower level and high level university degrees, that is, polytechnics and universities) and only 5% of those who graduate become entrepreneurs. Thus entrepreneurial activity should be supported. The governmental programme also announced the aim of having 95,000 new entrepreneurs in 2003-2007. Siuruainen also discusses the third wave of public investment in R&D to support growth outside regional centres. One reason is that large areas are uncovered by these programmes including Lapland and large parts of Northern Pohjanmaa and part of Western Uusimaa.

We can see that the line of innovative and R&D intensive research areas runs from Helsinki via the Lahti motorway in the direction of Jyväskylä (with the exception of Lahti and Joutsa) and the human capital intensive area from Helsinki in the direction of Tampere. We can roughly divide Finland into southern, western and eastern parts. Pohjanmaa and the Oulu region in the west rely on a high degree of innovativeness. The regions are not necessarily human capital intensive (except for Vaasa and Oulu) but do have skill intensive companies of varying sizes. The young workforce is absorbed into regional centres and ageing of the workforce is very clearly marked in the surrounding regions. The emphasis has been on innovative ability that should be further supported. The supply of educated labour can be sufficient in the regional centres but not necessarily in the surrounding areas.

Eastern Finland should rely on R&D investment and possibly also on subcontracting opportunities. A clear example of an exceptional and well-performing region is Pohjois-Savo and cities like Varkaus and Kuopio. In the future subcontracting also in the engineering industry is likely to increase and this offers small cities like Varkaus new opportunities for the establishment of small units, although growth in recent years has not yet been very strong. Eastern Finland also has many areas where manufacturing is underrepresented. Technology centres are big opportunities like in Kuopio where 190 companies and organisations (2,000 employees) work under the umbrella of the Technology Centre. The problem with Eastern Finland is the low growth in trade and services also feeded up by the fastest rate of ageing in Finland. Heavy industry, in particular, paper and pulp industry, is not likely to offer new job opportunities. The construction sector has also been one cornerstore, where growth has lagged behind the average.

Southern Finland and particularly the Greater Helsinki region are the agglomerated areas in human capital. Availability of skilled labour and good accessibility offer good growth prospects. Growth is based on innovativeness, but not solely on R&D investment. The service sector is overrepresented, while in the Greater Helsinki region manufacturing employment is only 50% of the Finnish average. The growth in these high productivity areas is maintained by human capital. The size of the region alone leads to the absorption of resources from other regions and further concentration of economic activity. The industrial structure is also changing away from manufacturing to services, which further benefits the biggest cities in the south. The high share of the working age population and easy accessibility also give a strategic advantage. Southern Finland is essential to solving the unemployment problem in Finland. Employment growth is promoted by a high rate of participation and by the establishment of innovative companies. Employment and productivity growth are also rapid in human capital intensive companies and regions. Public funding of companies with the most advanced and highly paid workers in R&D also provides employment opportunities for the whole region.

It is evident that supply of highly-educated workers is very important for the location decision of companies. Agglomeration of human capital creates many positive spillovers for the companies. R&D investments have many global spillovers and the gain to neighbour firms in the region can be limited. The ageing of workforce will also be problematic for new entrepreneurship. Large firms are not likely to locate easily in an environment with only limited availability of workforce in the future. It is clear that availability of skilled workforce is very important for balanced regional growth.

Appendix 5A. Industrial Structure

Figure 5A.1 Kemi-Tornio, Rovaniemi, Torniolaakso, Pohjois-Lappi (North Lapland), Tunturi-Lappi, Itä-Lappi, Pohjois-Pohjanmaa (Northern Ostrobothnia)

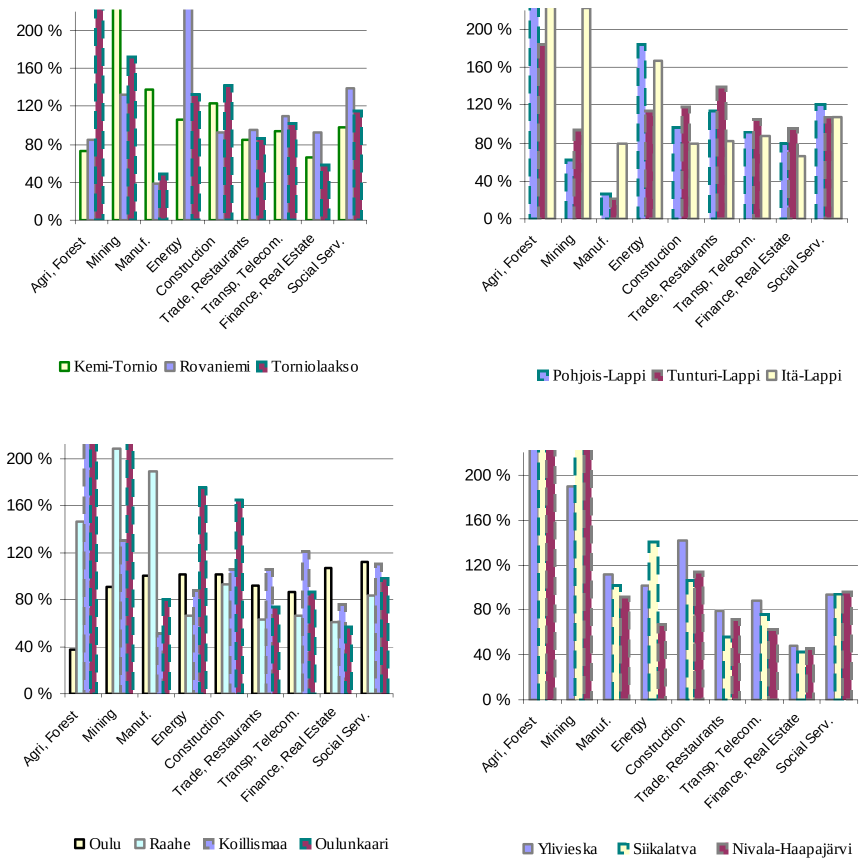


Figure 5A.2 Keski-Pohjanmaa (Central Ostrobothnia), Etelä-Pohjanmaa (South Ostrobothnia)

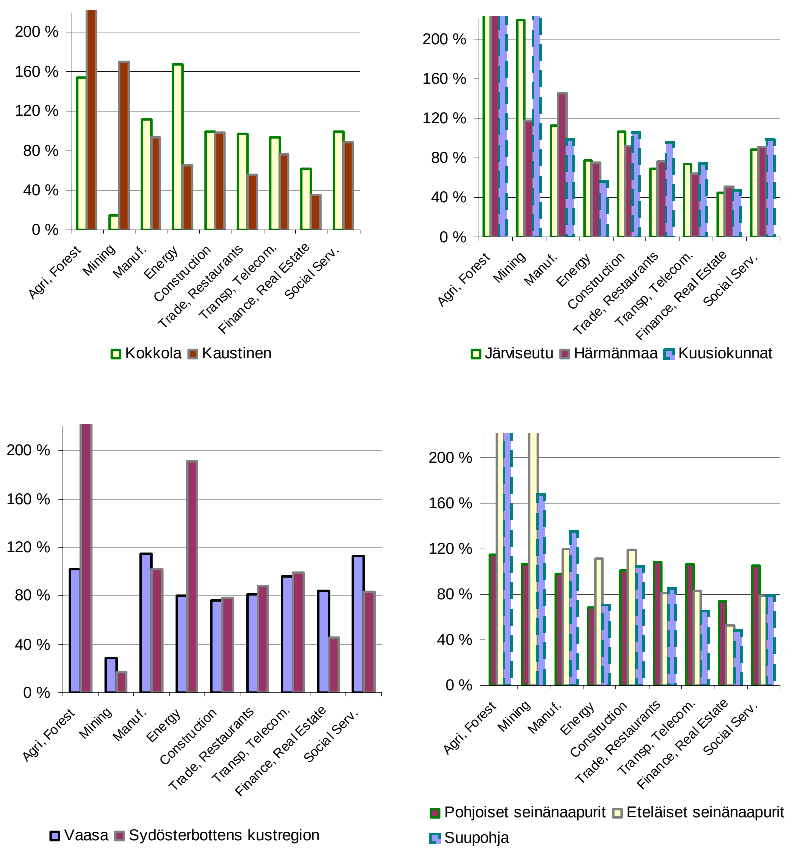


Figure 5A.3 Kainuu, Pohjois-Karjala (North Karelia), Pohjois-Savo, Etelä-Savo

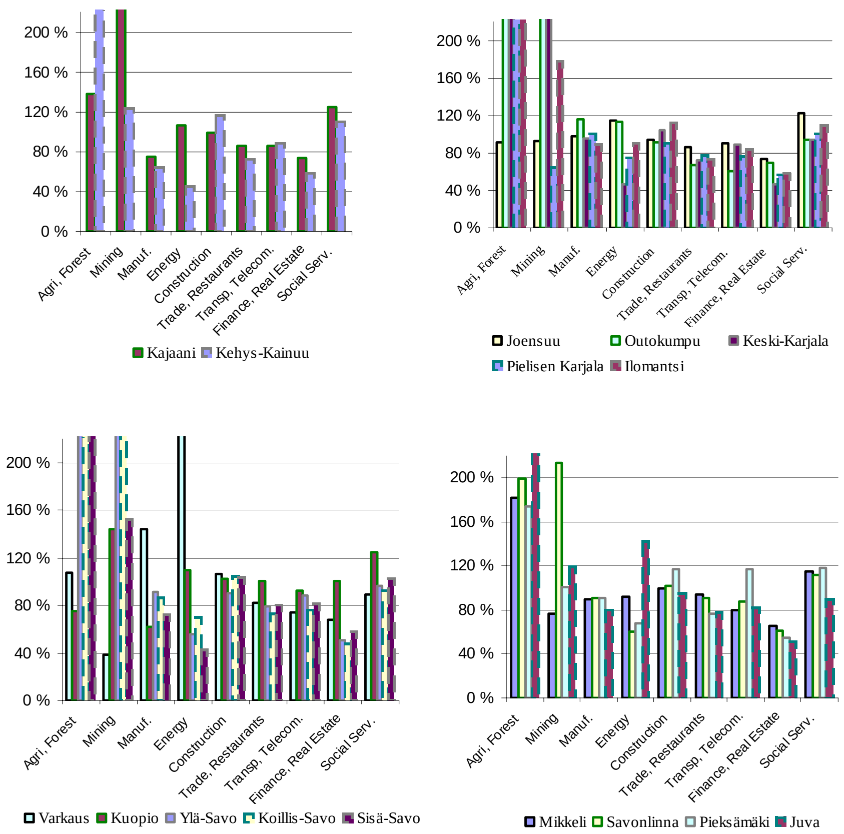


Figure 5A.4 Jyväskylä, Äänekoski, Jämsä, Keuruu, Saarijärvi-Viitasaari, Joutsa, Turku, Salo, Turunmaa, Vakka-Suomi, Loimaa, Pori, Rauma, Pohjois-Satakunta

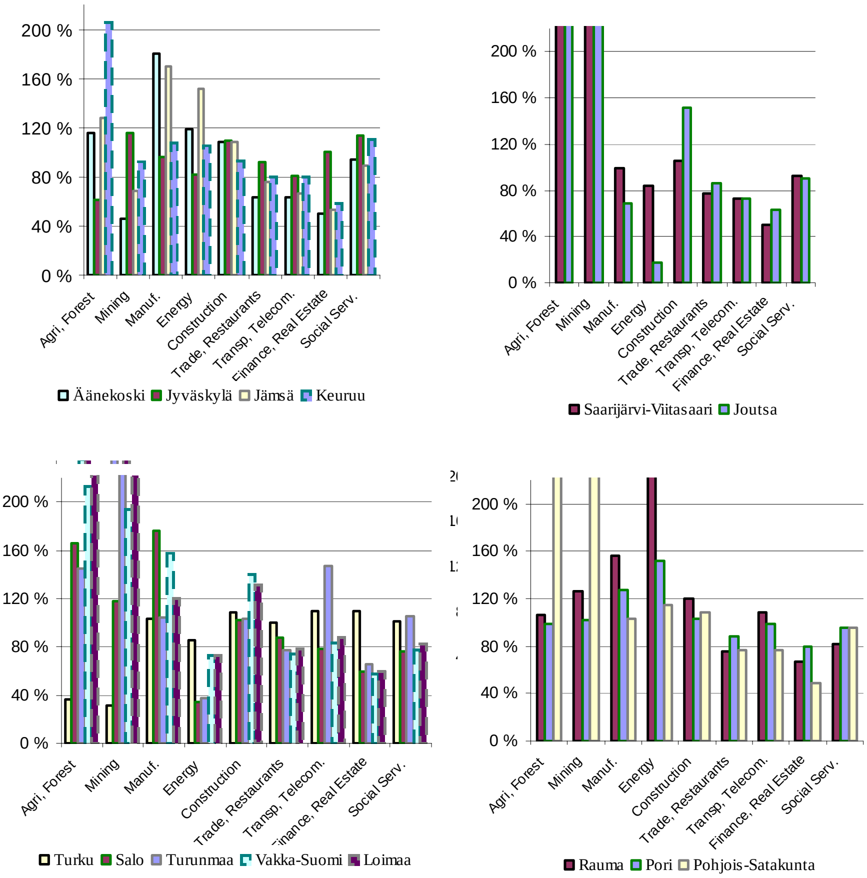


Figure 5A.5 Tampere, Ylä-Pirkanmaa, Lounais-Pirkanmaa, Etelä-Pirkanmaa, Luoteis-Pirkanmaa, Kaakkois-Pirkanmaa, Forssa, Hämeenlinna, Riihimäki, Lahti, Heinola

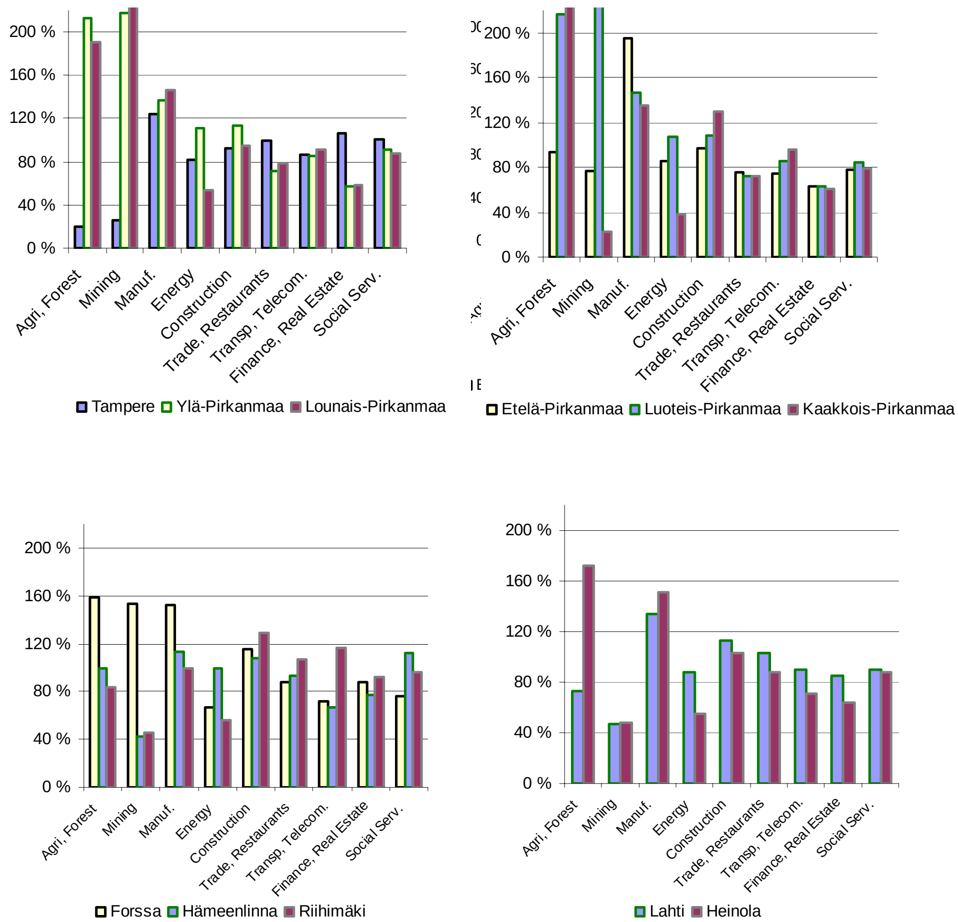
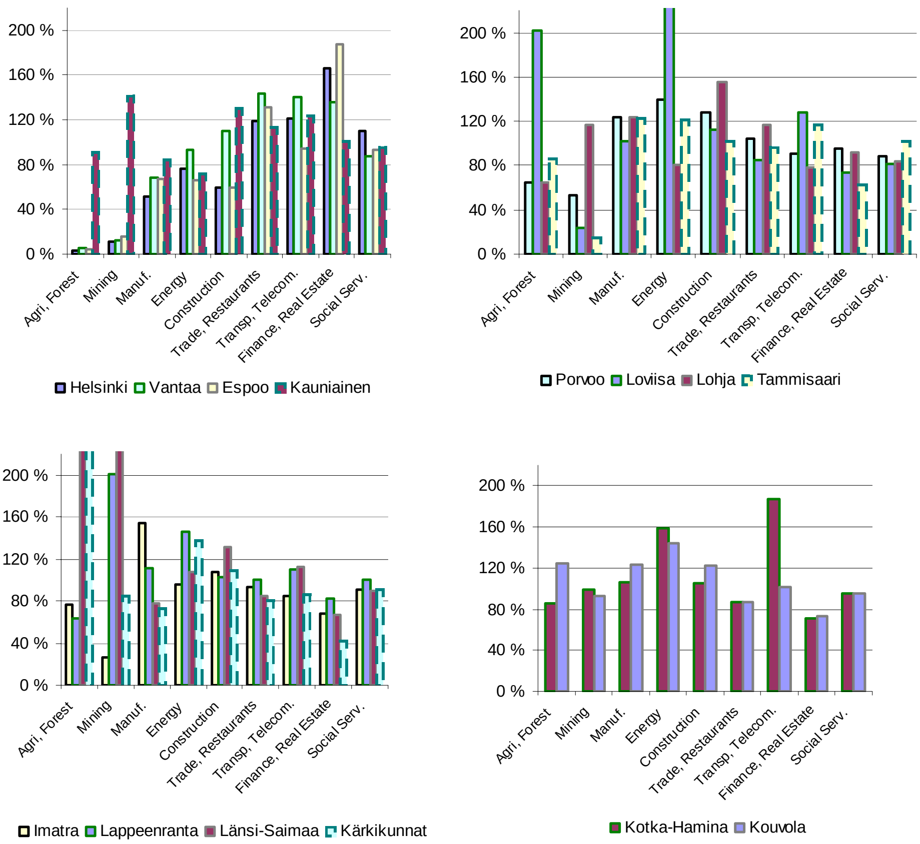


Figure 5A.6 Greater Helsinki area, Porvoo, Loviisa, Lohja, Tammisaari, Imatra
Lappeenranta, Länsi-Saimaa, Kärkikunnat, Kotka-Hamina, Kouvola



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