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HANNU PIEKKOLA
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Tiivistelmä

Vuosina 2008–2011 käynnissä ollut INNODRIVE-projekti päättyi helmikuussa 2011. Tämä julkaisu kuvaa aineettoman pääoman aineistoa ja keskeisiä tuloksia. INNODRIVE-projektiin liittyvä tietokanta mittaa aineetonta pääomaa EU27 maissa ja Norjassa. Yrityssektorilla yritysten aineeton pääoma on kartoitettu kuudessa maassa: Suomi, Norja, Iso-Britannia, Saksa, Tšekki ja Slovenia.

Intellektuaalinen pääoma luo innovaatiota ja edistää kasvua, työllisyyttä ja Euroopan Unionin maiden kilpailukykyä. T&K toiminnan ja innovaatioiden merkitys on tunnustettu Lissabonin strategiassa ja uudessa EU2020 ohjelmassa. Kuitenkin aineettoman pääoman merkitys kasvulle on vähän tunnettu. Yritykset ovat epäilemättä innovaatioiden ja tuottavuuden kasvun ytimessä ja INNODRIVE-projekti on tarkastellut yritysten toimintaa empiiristen aineistojen avulla. Kansalliset tilastoaineistot sisältävät pääasiassa tietoa kiinteistä investoinneista ja tilastoitu aineeton pääoma kuten tietokannat, mineraalien etsintä ja taide, muodostavat vain noin seitsemännen osan kaikesta aineettomasta pääomasta.

Aineisto kattaa näin sekä yritys- että kansallisen tason. Mikrotasolla tutkitaan, miten aineeton pääoma edistää kasvua käyttäen hyväksi linkitettyjä yritys- ja työntekijäaineistoja (LEED) ja yritysten menestymiseen perustuvia mittareita. Tutkimuksessa tarkastellaan myös miten yritykset hyödyntävät aineetonta pääomaa ja miten osaava työvoima ja sen liikkuvuus vaikuttaa sen muodostumiseen. Kansallisella tasolla kasvulaskentaa on laajennettu kattamaan investoinnit aineettomaan pääomaan, joita aikaisemmin on laajalti pidetty kuluina.

Keskeiset tulokset osoittavat, että todellinen BKT EU27 alueella on 5,5 % suurempi kun aineettomat investoinnit otetaan huomioon. Aineeton pääoma on 6,7 % BKT:sta, tästä vain 1,1 % on sisällytetty kansantalouden tilinpitoon. Tästä lähes puolet on organisaatiopääomaa, jonka osuus on 3,1 % BKT:sta. Aineettoman pääoman osuus BKT:sta nousi aina 1990-luvun lopulle saakka, josta lähtien aineettomien investointien osuus BKT:sta on säilynyt kutakuinkin ennallaan.

Asiasanat
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Abstract

The 2008-2011 INNODRIVE project, which ended in February 2011, gathered and measured intangible capital data. This publication describes the data and the main results. INNODRIVE database is available with figures and tables at the national level for EU27 countries and Norway and for business sector own-account intangible investments from Finland, Norway, the UK, Germany, the Czech Republic and Slovenia, see www.innodrive.org.

Knowledge and intellectual capital are major determinants of innovation and thus of enhancing the growth, employment and competitiveness of the European Union. The importance of R&D and innovation is explicitly recognised in the 'Lisbon process' and in EU2020. However, our knowledge of the contributions of intangibles to economic performance remains incomplete. Undoubtedly, firms are at the centre of innovation and productivity growth, and INNODRIVE has analysed their activities empirically. Furthermore, at the macro level, the national accounts data on capital formation focus primarily on fixed investments, and attempts to measure investment in intangibles, such as software, mineral exploration and artistic creations, constitute only one seventh of all intangibles that we report here.

We examined the data at both the firm and national level. At the micro level, the goal of the research was to improve our insight into the contributions of intangibles to the growth of firms by exploiting the potential of recently established linked employer–employee datasets (LEEDs) and by also implementing a performance-based methodology to analyse how firms use knowledge and human capital to increase their productivity and how mobile workers react to these processes. At the national-economy level, we have expanded the traditional growth accounting framework by including in capital formation estimates of the investment in intangibles, which has hitherto been counted as current expenditures in the conventional national accounts.

Our main findings are as follows. The GDP in the EU27 area is 5.5% higher after including all intangible investments; see third article in this volume. In the national approach, the intangible capital investment share of GDP was 6.7% in the EU27 and Norway, whereas only 1.1% is recorded in the System of National Accounts. Organisational competence accounts for nearly half of this, at 3.1% of GDP. The intangible share of GDP increased during the latter half of the 1990s, whereas the GDP shares have stayed mostly constant in the 2000s.

Keywords

Intangible capital, innovations, economic growth, competitiveness

FOREWORD

The INNODRIVE project 2008-2011 focuses on intangible capital formation in Europe. This is against a backdrop of modest growth, despite an ambitious Lisbon target for Europe to become "the most competitive and dynamic knowledge-driven economy by 2010". We hope our work will promote further research in this and related areas, building on the intangible capital data we have collected for all EU27 countries and Europe. Our construction of firm-level own account intangible capital in six countries complements the overall picture.

We are grateful for the financial support received under the EU 7th framework and especially to Marianne Paasi, our scientific officer from DG Research, for all her encouragement and for facilitating links with other researchers in the area. In particular, the INNODRIVE project has benefitted from collaboration with Jonathan Haskel, coordinator of the EU 7th framework project COINVEST. We are also grateful to Bart van Ark from the Conference Board and Mariagrazia Squicciarini and Fernando Galindo-Rueda from the OECD, among others, for their contributions as discussants at our final conference in February 2011. Presentations from this conference are available at www.innodrive.org. The database is made public at www.innodrive.org and includes figures and graphs for the EU27 area and Norway. In particular, I am indebted to my partners in INNODRIVE: Cecilia, Massimiliano, Jorgen, Felix, Rebecca, Kate, Bernd, Kurt, Anne, Stepan, Juraj, Morten, Terje, Miroslav, Rita and Sami for enduring much trial and error, but delivering nonetheless. We all thank Mikko Lintamo for project management and for maintaining and building up our website.

Hannu Piekkola, *University of Vaasa*
INNODRIVE Coordinator

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INTANGIBLE CAPITAL – INNODRIVE PERSPECTIVE

Hannu Piekkola, University of Vaasa (UNIVAASA)

The 2008-2011 INNODRIVE project, which ended in February 2011, gathered and measured intangible capital data. This publication describes the data and the main results. INNODRIVE database is available with figures and tables at the national level for EU27 countries and Norway and for business sector own-account intangible investments from Finland, Norway, the UK, Germany, the Czech Republic and Slovenia, see www.innodrive.org.

Knowledge and intellectual capital are major determinants of innovation and thus of enhancing the growth, employment and competitiveness of the European Union. The importance of R&D and innovation is explicitly recognised in the 'Lisbon process' and in EU2020. However, our knowledge of the contributions of intangibles to economic performance remains incomplete. Undoubtedly, firms are at the centre of innovation and productivity growth, and INNODRIVE has analysed their activities empirically. Furthermore, at the macro level, the national accounts data on capital formation focus primarily on fixed investments, and attempts to measure investment in intangibles, such as software, mineral exploration and artistic creations, constitute only one seventh of all intangibles that we report here. The research project has improved our understanding by providing new data on intangibles and new estimates of the capacity of intangible capital to generate growth. This research has thus explored uncharted territories in EU socio-economic research.

We examined the data at both the firm and national level. At the micro level, the goal of the research was to improve our insight into the contributions of intangibles to the growth of firms by exploiting the potential of recently established linked employer–employee datasets (LEEDs) and by also implementing a performance-based methodology to analyse how firms use knowledge and human capital to increase their productivity and how mobile workers react to these processes. At the national-economy level, we have expanded the traditional growth accounting framework by including in capital formation estimates of the investment in intangibles, which has hitherto been counted as current expenditures in the conventional national accounts. This line of research has resulted in over 20 working papers and proceedings from final conference that are published on our website, www.innodrive.org.

Our main findings are as follows. The GDP in the EU27 area is 5.5% higher after including all intangible investments; see third article in this volume. In the national approach, the intangible capital investment share of GDP was 6.7% in the EU27 and Norway, whereas only 1.1% is recorded in the System of National Accounts. Organisational competence accounts for nearly half of this, at 3.1% of GDP. The intangible share of GDP increased during the latter half of the 1990s, whereas the GDP shares have stayed mostly constant in the 2000s.

Own-account intangible investment is a firm-level approach estimated in European firms to account for between 7% (Finland, Czech Republic) and 11% (the UK, Norway) of business sector new value added; see fourth article in this volume. Ignoring intangibles in national accounts implies an underestimation of GDP by 5.5% in the EU27 area and labour productivity growth of 10 to 20 percent.[1] The own-account intangible investment share of 7% to 11% of new value added is half of national measures in the national approach, which defines intangibles more broadly but defines companies' own-account intangibles more narrowly (Jona-Lasinio and Iommi 2011 and third article of this volume). Intangible investment is likely to become more important as greater emphasis is placed on 'smart' growth (Europe 2020). Investment in intangible assets has been shown to be an important factor in the performance of European and US companies that increases Tobin's q (e.g., Piekkola 2010, Lev and Radhakrishnan 2005), and intangible capital-type work is tied up with the total factor productivity of Finnish firms (Ilmakunnas and Piekkola, 2010). Macro-level studies have the same outcomes (Corrado, Hulten, Sichel 2006; Marrano, Haskel 2006; Roth and Thum 2010; Belhocine 2009).

Firm-level analysis also shows that own-account organisational capital can be an even greater share of intangible capital when a performance-based methodology is applied. Here, a productivity measure is used to replace the expenditure costs of input. The results highlight, in particular, the importance of organisational capital (management and marketing) as an important form of intangible capital exceeding even R&D investment in importance in many European countries. In fact, in nearly all EU27 countries except Finland and Sweden, the share of economic competence (including training and purchased components) in new value added exceeded the R&D share. Countries are also specialised in different types of intangible

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[1] See www.innodrive.org. Intangible investments included in the official systems of national accounts, software, licences and property rights and mineral exploration represent only a small fraction of all intangible assets accumulated in a firm or a whole economy (Corrado, Hulten, Sichel 2006, 40).

capital, with the share of R&D investment being highest in Nordic countries. In six countries with firm-level data on intangibles, the share of workers engaged in intangible capital-type work was around 18%, and the type of work differs from one country to another. We have also analysed innovation work and gender wage gaps; see fifth article of this volume. The average gender wage gap is usually larger among innovation workers than among non-innovation workers (Finland and Czech Republic), but there are exceptions (Norway).

Our working paper and proceedings from the final conference in Brussels are available on the project website, www.innodrive.org. Intangible capital is concentrated in metropolises, although the regional concentration is lower in Germany, with the 10 top regions accounting for half of all intangibles (Piekkola 2011, Riley and Robinson, Geppert and Neumann 2011). Organisational capital, in particular, creates important regional spillovers.

We have also published on our website intangible capital data for EU27 countries and Norway for 1995-2005, and variables are explained in full detail in the third article of this volume. National data cover intangibles reported in national accounts (entertainment, literary and artistic originals, databases and software) and eight types of new intangible capital: architectural design, new financial products, own-account and purchased economic competence, firm-specific human capital (training), branding (advertising), market research and scientific R&D. Firm-level data in six countries for the period of 1995-2008 (years vary by country) cover three types of own-account intangible capital: organisational capital, R&D capital and information and communication technologies ICT capital.

Potential impact of the results:

Intangible capital, from a broader perspective, describes the main innovation activities of private companies and is the source of future growth. Management activity encouraging longer-term productivity growth has been difficult to define. However, our performance-based estimates clearly show that the traditional expenditure-level estimates of organisational activity (mainly management and marketing) are lower bounds for the true value of organisational investments. The productivity of these types of activities usually exceeds the corresponding wage expenditures. The combination of labour, intermediates and capital in production of intangible capital increases value added by more than related expenditures cost. An important consequence of this relation is that intangible capital investment also improves markedly the profitability of the firm given the productivity-wage gap. It should be noted, though, that intangible capital also has a positive impact on hourly wage growth, but the improvement in efficiency allows a decrease in overall wage expenditures over the time. We have not analysed labour utilisation rates, but it may well be that good performance induced by intangible investment also increases overall demand for employment.

The share of intangible investment is increasing, although the growth has somewhat diminished in the 2000s. An exception is the new member states that are catching up to the rest of Europe both in GDP levels and in the intangible capital shares of GDP. Overall, the level of intangible investment in Europe appears insufficient when compared with the US, which is more likely to engage in all types of innovation activity more intensively.

We have also shown clearly that intangible investment in general, and not only R&D investment, drives productivity growth. Organisational and ICT work are close complements, but they may also work as substitutes in resource allocation for R&D work activity. Policies for promoting R&D activity alone may hence not be appropriate because such policies may crowd out other intangible investments. The EU 2020 program aims at smart, sustainable and inclusive growth, with the clear objective of investing 3% of the EU's GDP in R&D. Because Europe has an average R&D investment level below those of other developed countries, including the US, this target is well founded, but in the future, it should also cover a wider set of intangible capital assets. Our findings support the importance of organisational capital. Firm-level analysis is also able to show some numerical estimates of the growth effect of organisational capital. In Finland and Germany, the doubling of organisational investment, corresponding to less than 2% of business value added, increases productivity growth by 0.2% in a three-year period. Growth is stagnant or even negative for R&D investment. Nordic countries and Germany, which engage in intensive R&D activity, should focus on organisational investment. Many non-R&D-intensive countries (the UK, Belgium, the Czech Republic, the Netherlands, and Hungary) also have innovation models that emphasise organisational competence.

The clear differences found in the level of R&D investments in national and firm-level calculations are important. Our project has shown that R&D investments constitute only part of total intangible activity. It is likely that overall intangible capital can be calculated more precisely, representing the innovation potential of a country better than any individual type of intangible investment, such as R&D capital. It is also true that most R&D activity takes place in separate departments in the manufacturing sector, whereas R&D in the services sector is closely related to marketing and organisational activities. Proper measurement of R&D activity should include a broader scope of activities that may better capture R&D in the service sector compared to current measures. INNODRIVE applied a broad definition of R&D occupations in the firm-level approach, leading to a higher share of R&D workers in the UK in particular.

Our results emphasise intangible investment as tacit knowledge that is less bound to regional borders. Stable economic conditions without extensive market reallocation are typical for high-performing regions. Regional policies can also be targeted in subsidising innovative activity outside of the metropolitan area. Regional policies should also be targeted for providing *sufficient* educational skills because intangible and human capital are clear complements at the firm level. Most of the intangible capital spillovers, indeed all of them in the UK and Finland, also accrue for organisational capital. Businesses, in their location decisions, are interested in profitability rather than in productivity, where the tacit knowledge within the firm plays the most significant role.

The PIGS countries have recently suffered from the burden of financing sovereign debt. The investment policies in these countries rely more on tangible than on intangible investment, and therefore, they have suffered relatively more from the shifting of production outside of Europe, especially to Asia. Intangible capital investment in the future is likely to yield more solid growth. Intangible GDP shares in 2005 were 4.5% in Italy, 4.1% in Spain and Portugal and 2.0% in Greece, all below the average EU27 value and Norway's share of 6.7%. At the same time, the diversity of intangible capital should be emphasised so that policies do not promote R&D investment alone. Our research does not examine public intangible investment, which should also have far-reaching implications.

Contents

The first article in the manual, by Jorgen Mortensen from CEPS and Hannu Piekkola from UNIVAASA, gives an overview of growth accounting approaches and some main results of the INNODRIVE project. The main estimation strategy and results are reported separately in national (macro) and firm-level (micro) approaches. The next article, by Jona-Lasinio and Iommi Massimiliano from LUISS and Felix Roth from CEPS, describes in detail the variable definitions and the methodology and reports some of the main results. The following article, by Hannu Piekkola and Mikko Lintamo from UNIVAASA, Kurt Geppert, Bernd Görzig and Anne Neumann from DIW, Rebecca Riley and Kate Robinson from NIESR, Terje Skjerpen and Morten Henningsen from STATNO, Stepan Jurajda and Jura Stancik from CERGE-EI and Miroslav Verbic from IER, analyses firm-level own-account intangible investment in six countries: Finland, Norway, the UK, Germany, the Czech Republic and Slovenia. The methodology relies on Görzig et al. (2010). In the final article, by Sami Napari and Rita Asplund from ETLA, innovation work and income distribution are analysed with respect to gender wage gaps. All data are available at www.innodrive.org. The Microsoft Excel worksheets include graphs, and national estimates also report all intangibles at the level of the EU27 and Norway.

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INTANGIBLE CAPITAL AS A SOURCE OF GROWTH: AN INTRODUCTION

Jorgen Mortensen, Centre for European Policy Studies (CEPS)
Hannu Piekkola, University of Vaasa (UNIVAASA)

1 Introduction

Growth accounting, which aims at explaining the growth of productivity, was initiated essentially by Denison (1963, 1967, and 1979) in 1962. When investigating the sources of growth in the United States from 1909 to 1958, he concluded that the knowledge, skill and energy of labour were important determinants of economic growth. Subsequent analysis by, notably, Kendrick (1961), Jorgenson (1963) and Griliches (1984) has aimed by and large at identifying the contributions of various factors to the overall growth in productivity, in this context defined as the combined productivity of capital and labour, now more generally termed 'multi-factor productivity'. As Denison himself recognised, growth accounting by definition cannot appropriately account for the interactions among determinants and does not involve a 'controlled experiment'. The underlying causal relationships, consequently, can only be approximated by detailed, careful classification of the contributors to the production function.

The measurement of input of labour (in reality, labour services) in terms of hours or man-years has long been intuitively accepted as the relevant statistic. However, the pooling together of man years of an unskilled youngster and an engineer with a diploma from a leading institute of technology and several decades of professional experience, from the point of view of economic analysis, does not make sense. In fact, by failing to distinguish between different categories of labour input, the early production function simply assumed away an aggregation problem of the same fundamental nature as for the stock of fixed capital or output. The effect of changes in the quality of labour is therefore an important feature of growth accounting exercises.

The mere process of constructing and estimating a production function in which output and capital stock were calculated as weighted indices of the constituent elements and the input of labour was considered to be homogeneous and onedimensional resulted in a residual between the growth of output and the growth of input. In other words, the rise in the quality of labour input came back into the analysis as a rise in productivity. However, as has been stressed repeatedly, notably by Dale Jorgenson,[2] a part of the unexplained residual in estimated production functions would disappear if the input of labour were appropriately defined, with due consideration of the levels of education, skill and knowledge.

Nevertheless, a residual remains and, in the relatively few estimates based on very long time series for the US, shows a marked tendency to rise through time. According to estimates prepared by David and Abramovitz,[3] the part of the rise in output per unit of labour input that could be explained by an increase in the input of capital per unit of labour (capital intensity) during most of the 20th century was only between one half and one third of the level estimated for the 19th century.

Over the past several decades, a considerable amount of research has attempted to explain this growth accounting residual (technological progress or productivity) by introducing various additional assumptions concerning the nature of innovation (e.g., embodied or disembodied technical change). This research has, on the whole, concluded that the residual could, as Jorgenson argued, be attributed to improvements in intellectual capital, that is, a number of factors that constitute the main characteristics of the knowledge society. This led leading researchers in this field to conclude that the residual was not an unexplained aspect of economic growth but essentially the result of a *gap in the understanding of the growth process* and in the availability of data. The measurement problem therefore arises from the failure of most economists to make a clear distinction between productivity growth and technological change. The solution to this measurement problem lies in the introduction of a much broader concept of investment, including investment in R&D, in the creation of ideas and in training and education.

That the rise in factor productivity could be attributable to a considerable investment in human capital and thus to a deepening of intangible capital was pointed out by a few researchers back in the late 1960s. In a paper from 1967,[4] Zwi Griliche concluded (pp. 316–317) that accounting for improved labour quality reduces

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[2] See, for example, Jorgenson's speech to the Conference on Service Sector Productivity and the Productivity Paradox, Centre for the Study of Living Standards, Ottawa, 11-12 April 1997.

[3] M. Abramovitz and Paul A. David: *Economic Growth in the US*, in Employment and Growth in the Knowledge-based Economy, OECD 1996.

[4] Griliches, Z. (1967). Production functions in manufacturing: Some preliminary results. In: Brown, M. (Ed.), The Theory and Empirical Analysis of Production, NBER, Studies in Income and Wealth, Vol. 31. Columbia University Press, New York, pp. 275–340. [PE].

the size of the residual from about 60% of the rate of growth to about 20% of the rate of growth. This work, and especially his concurrent work with Jorgenson, was an important step in the development of Griliche's thinking on the role of technology in explaining productivity growth. The 1967 paper concludes that when inputs are measured properly and the estimation is done properly, all of productivity growth is accounted for, leaving no room for the residual that many had associated with technological progress.

Nevertheless, as underlined by Abramovitz and David in 1973,[5] the impact of this increase in human capital continued to be largely ignored in the calculation of productivity indicators. In fact, in accordance with Griliches, Abramovitz and David argued that a reformulation of the conventional production function to include "unconventional capital" (which, in their definition, is essentially the huge and rising stock of immaterial assets) would result in a much lower estimate of multi-factor productivity than is obtained in the estimates based only on the more traditional inputs of labour and fixed capital services.[6] Despite their conclusion that it was fundamentally misleading to persist in seeking to apportion the growth rate of per capita product between only two factors, namely, Invention and Accumulation, the actual measurement of the full contribution of the stock of education (human capital) took a long time to emerge in business and national accounting.

The solution to this apparent paradox from a conceptual point of view would appear to be found in a considerable broadening of the ancient concept of capital formation to include in investment spending on education, training, R&D, software design, marketing, and even certain kinds of expenditures on reorganisation of production and marketing aimed at making more efficient use of technology. Indeed, in this perspective, it could be argued that every kind of spending that is not directly related to current operations but constitutes a commitment of resources to ensure the survival of the firm beyond the current period be considered as investment.

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5 Abramovitz, Moses and Paul A. David: *Reinterpreting economic growth: parables and realities*, The American Economic Review, Vol. 63, No. 2 (Papers and Proceedings of the Eighty-fifth Annual Meeting of the American Economic Association, May 1973).

6 Technically, they argue that the stock of human capital (unconventional capital) during the period from 1927 to 1967 rose much faster than even the "refined" measure of labour input proposed by Christensen and Jorgenson in a 1971 paper. Introducing a much higher growth of labour input in the production function thus results in a remarkable lowering of the residual factor productivity growth.

The first estimates, notably by J.W. Kendrick,[7] of the total amount of intangible investment in the United States during the 20th century indeed show a pronounced increase in the proportion of intangible to tangible investment, reflecting the important rise in resources devoted to education, training and R&D, in particular. The rise in intangible investment has translated into a substantial rise in the stock of intangible capital. Furthermore, during the first half of the 20th century, the relative prices of conventional tangible capital goods – at least those that have been used as deflators to create constant-price estimates of the capital stock – rose more rapidly than the prices of consumer goods and real wages. This, and the shorter and shortening service lives of tangible reproducible assets, especially in comparison with the assumed longevity of educational and training investment embodied in the labour force, have also contributed to the differentially rapid growth of the intangible component of the total capital stock.[8]

These findings thus shed new light on a policy issue that was a concern for policy-makers on both sides of the Atlantic during the 1970s and 1980s: the decline in fixed capital formation in proportion to GDP. In fact, in the context of the emerging knowledge economy and changes in the nature of competition, enterprises have not reduced the overall capital formation but rather shifted more and more resources into investment in intangibles. Because investment in intangibles, from the point of view of accounting, was not normally considered as capital formation, this change in the behaviour of firms and managers went unnoticed by academics and policy-makers for a long time, possibly resulting in failures and mistakes in the design of economic policy in certain countries and periods.

A further large step in the analysis of the effect of intangibles on economic growth was made in 2002 by Corrado, Hulten and Sichel (2006) in a paper presented at an NBER conference. In what could perhaps be considered a return to Böhm-Bawerk's interpretation of capital as an "advance of money", the 2002 paper argues that the conventional production function treats capital as "predetermined" (p. 16) and therefore cannot fully describe the growth process; saving and investment are considered "choice variables" in a complete model of growth. According to the authors, this choice dimension is important because it determines the quantity of capital available at each point in time, but it also determines what should be counted as capital. They therefore argue (p. 19) that *any* use of resources that reduces current consumption in order to increase it in the future

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[7] Kendrick, J.: *Total Capital and Economic Growth*, Atlantic Economic Journal, Vol 22, 1994.

[8] See Abramovitz and David, op.cit. p. 41.

qualifies as an investment. This approach requires a *symmetrical treatment of all types of capital*. Consequently, in national accounting systems, investment in knowledge capital should be placed on the same footing as investment in plant and equipment. This expanded definition of capital thus includes *all* investments in human capital (not just outlays by government and not-for-profit institutions on education), R&D expenditure, and indeed any expenditure in which a business devoted resources to projects designed to increase future rather than current output, whether it is intangible or tangible.

They recognise, of course, that many practical difficulties arise in implementing the symmetry principle and that these difficulties are one reason why financial accountants prefer to classify large parts of investment in intangibles as current costs that are entered into the accounts as current expenditures. They stress that, in particular, much intangible investment occurs within the company, household, or government unit that has the intellectual property right to the capital and that no arm's-length valuation of the investment exists. They also underline that the appropriability and identification of property rights and the spillover of externalities present problems.

In an application of this theoretical framework, they identify a number of innovative property categories that are not normally included in the list of intangibles established, for example, by Kendrick and others and recalculate the amount of business spending on intangibles in selected periods for the United States.The 2002 paper is followed up and expanded with a growth accounting analysis in a Federal Reserve working paper in 2006, which fully confirms and reinforces the earlier analysis by Kendrick.

Stressing that published macroeconomic data traditionally exclude most intangible investment from measured GDP (they suggest that as much as $800 billion is still excluded from US published data as of 2003), Corrado, Hulten and Sichel find that this conventional approach leads to the exclusion of more than $3 trillion of business intangible capital stock. To assess the importance of this omission, they produce a new estimate of intangible capital. They add this to the standard sources-of-growth framework used by the Bureau of Labor Statistics and find that the inclusion of intangible assets thus defined makes a significant difference in the observed patterns of US economic growth. The rate of change of output per worker increases more rapidly when intangibles are counted as capital, and capital deepening becomes the unambiguously dominant source of growth in labour productivity. The role of multifactor productivity is correspondingly diminished, and labour's income share is found to have decreased significantly over the last 50 years.

The work by Corrado, Hulten and Sichel (CHS) was followed up by Marrano and Haskel (2006) for the UK and presented in a working paper in 2006. They find that the UK private sector in 2004 spent about 10% of GDP on investment in intangibles, an amount equal to the investment in tangible assets. They thus confirm the huge importance for growth in the UK of intangible investment, although its role is marginally smaller than what CHS found for the US.

From a methodological point of view, the key question as laid out by CHS is whether a certain amount of expenditure at the level of the firm or nation is to be classified as an intermediate expenditure (input) in the production process or as an investment designed to produce services in a future production process. This distinction does not present problems when a machine or a computer is bought and installed because this is clearly done with the aim of ensuring the provision of future services from this machine, but it presents considerable difficulties for a host of other categories of spending.

To ensure a smooth and efficient insertion of a purchased machine or robot into the production process, the workers or clerks who will work with this new equipment may need to attend training courses extending over days or weeks, and during this period they are not involved in the ordinary production process. The firm thus spends money to enhance these workers' knowledge and productive capacity, and there is every reason to consider this spending as an investment in the *human capital* of the employees.

However, the human capital thus generated, even if it is absolutely necessary to ensure an efficient production process, is not controlled by the firm and would disappear if the employees went to another firm. Consequently, there would be good reason not to consider this spending on training an investment, although it is a part of the process of renewal of the fixed equipment. Thus, it could well be argued that it should not be counted either as an ordinary current production cost or as an investment equivalent to the purchase of the machine.

Another, more evident example is the case where the firm is actually spending directly on research aimed at creating new products or inventing new ways of producing existing goods or services. To the extent that this R&D actually results in the acquisition of patents or the marketing of a new product, the spending should clearly be identified as being an investment and not as expenditure related to the current production process.

But what if, in addition to undertaking R&D and directly training employees to ensure that they make appropriate use of the new equipment, the firm encounters a reorganisation of the system of production with the help of external consultants? This may involve an important investment of employees' working time to attend meetings and training sessions with the aim of introducing new methods of work, new internal security systems and a more horizontal organisation of communication lines with more autonomy for the production teams.

In this case, intellectual capital is also generated, and the human capital of the employees concerned is enhanced to a certain degree. However, by and large, the intellectual capital thus generated will constitute an integrated (incarnated) part of the intellectual capital of the firm and thus of the individual persons concerned. It could be classified as an expenditure on an invisible (intangible) new part of the production system of the firm, a *structural intangible capital.*

However, while the structural capital thus generated is anticipated to contribute to strengthening the competitiveness of the firm and to the profitability of the firm's own capital, it basically exists in the firm only as a going concern and would disintegrate instantly if the firm went bankrupt.

Nevertheless, it constitutes a kind of invisible intangible asset that would not fade away, or at least would be maintained to some extent, if the firm, instead of going bankrupt, were sold to or merged with another firm. In this case, the value of the firm would clearly not include just the value of the machines and equipment installed but also the total structural intangible capital that is an integral part of the identity of this particular firm.

But, of course, the value of the firm involved in this process of merging or acquisition is most unlikely to be determined only by the cost of the machinery and equipment, possibly adjusted to take account of past spending on training, research and development, generation of structural capital and other categories of spending on intellectual capital or intangibles. The acquisition value of the firm will, of course, also take into account the existence of patents and the firm's general image in the market in relation to clients and suppliers.

From the very beginning of the growth accounting exercises in the 1960s, it has indeed been recognised that conventional business accounts and statistical data could provide only scant and incomplete evidence of the presence of the intangibles described above. First, there was a perceived need to distinguish clearly between investment in (expenditure on) intangibles and the resulting improvement in the *stock of intellectual capital*. Second, the classifications utilised in national and business accounts in general did not allow a separate identification of investment in intangibles. Third, the general failure to distinguish between services and intangibles creates fundamental problems of perception and taxonomy in the analysis of economic performance. Although there is broad recognition that intellectual capital formation has become a decisive factor of economic growth and welfare, our knowledge of the process has remained elusive, subjective and dispersed.

2 INNODRIVE findings

Innovative growth requires investment in intangibles, most of which are imprecisely valued in any balance of accounts. There is a clear need for a broad view of intangible capital type work that includes managerial and marketing work. More and more of the expenditures on marketing and organizational investment need to be recognized as intangible investments that increase productivity over a longer period. Organizational capital is also more clearly firm-specific and owned by the firm than are other types of intangibles. Businesses, in their investment and location decisions, are interested in profitability rather than in productivity, where the tacit knowledge within the firm plays the most significant role.

The INNODRIVE project has applied a general approach in measuring intangibles. In data covering EU27 area an expenditure-based approach was necessary as the performance of any single nation is difficult to measure in any comparable way. In firm-level approach own account intangible is also measured in view of the performance. Simply put, wage costs are replaced by productivity as these two can differ in intangible-capital type work.

Expenditure-based approach in national measurement is described in greater detail in the second article of this volume: "*National Measures of Intangible Capital in the EU27 and Norway*". Figure 1 shows the evolution of new intangibles not currently recorded in national accounts as shares of GDP in a national approach in the EU27 and Norway.

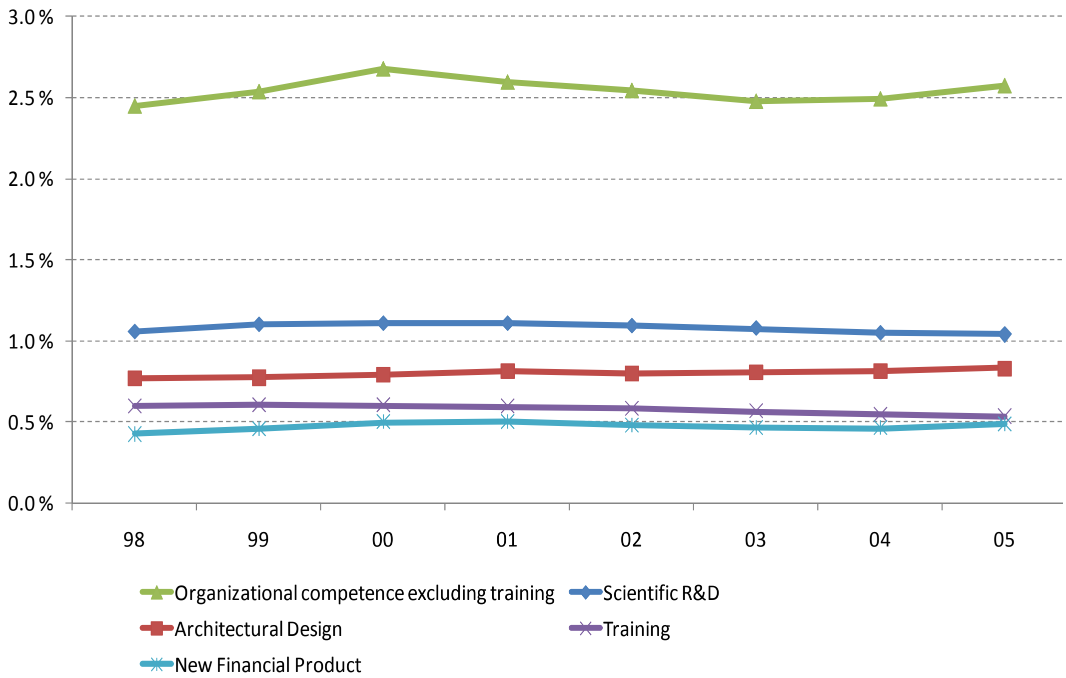

Figure 1. Investment in New Intangibles as share of GDP (%) 1995-2005: EU-27 countries (and Norway)

Organisational competence, including organisational capital and market research, accounts for over half of all new intangibles at around 2.5% of GDP. Training is 0.6% of GDP. As discussed in the introduction, both kinds of activity may involve an important investment of employees' working time to attend meetings and training sessions with the aim of introducing new methods of work, new internal security systems and a more horizontal organisation of communication lines with more autonomy for the production teams. Own account organisational competence is the most important part of it.

The total intangible share of GDP has not been increasing in any of the countries, remaining at EU27 level approximately at 5.5% of GDP. The INNODRIVE findings confirm that, as could be expected, the inclusion of intangible capital significantly reduces the unexplained component of productivity growth: Total Factor Productivity (TFP). While TFP becomes less important, physical capital turns out to be strongly complementary to intangible capital:

- The relative contributions of capital deepening and TFP to labour productivity growth changed considerably after the inclusion of all intangibles; the rate of capital deepening increased and the growth of TFP decreased. Capital deepening becomes the dominant source of labour productivity growth.

In an analysis of regional effects in Germany, Finland and the UK, company-level productivity is also shown to be strongly related to firms' own intangible capital and to regional intangible capital, suggesting positive localised spillovers. Productivity is highest in firms that also have considerable human capital. There is a need to be clear about the distinction between human capital and intangibles; intangibles enhance the profitability of economic activity, whereas human capital is owned by the employee and capitalised in wages. Organisational capital, i.e., the competence of management and marketing workers, appears to be the form of intangible capital that is most clearly related to productivity growth.

The significance of a skilled workforce for economic growth lies in its ability to create value added in the form of intangibles. The INNODRIVE project has documented the important role that intangibles play as a new source of growth; it is therefore crucial not only to measure them, but also to improve their management and exploitation. This is why policy measures should aim to stimulate a better understanding of intangibles by including them in the GDP measure and encouraging their use by means of appropriate incentives.

Key messages

1. The GDP in the EU27 area is 5.5% higher due to the classification of certain categories of expenditures, hitherto considered as current costs, as investments in intangibles.
2. Intangibles are an important source of capital deepening in European countries, albeit with important cross-country differences.
3. Intangibles explain a substantial part of the market value of companies. This is only partially captured in standard economic analysis.
4. High-income countries with a comparatively low level of investment in tangible capital tend to invest more in intangible capital, confirming a transition towards the knowledge economy.
5. The observed decrease in tangible capital investment over time is to a large extent, albeit not fully, offset by a rise in intangible capital investment.
6. Nordic countries are R&D intensive and have relatively less organisational capital than the UK, Belgium and the Netherlands and, in company-level analysis, in Germany.

7. Organisational capital investment is one of the key drivers of capital formation, accounting for close to three times more investment than in R&D at the national level, but also due to the narrow definition of R&D activity.
8. Intangible capital is agglomerated in metropolitan areas in the private sector: the greater Helsinki area accounts for 48% of all intangibles in Finland and the London city-region 41% of UK intangibles. In Germany, intangible capital is more dispersed, with the top ten regions accounting for 48.3% of the German total (Munich 7.5%, Stuttgart 7.2%, Frankfurt 6.4%, Düsseldorf 5.6%, Hamburg 5.2%, Berlin 4.7%, Cologne 3.9%, Duisburg/Essen 2.8%, Nürnberg 2.7% and Karlsruhe 2.3%).
9. Foreign direct investment is an important aspect of intangible growth in the EU8. Greenfield FDI brings with it more R&D, and the companies in the Czech Republic are seen to have a higher share of organisational workers.
10. Future research should focus on refining the range of production inputs and the extent to which they should be classified as intermediate consumption or intangible investment. For example, one could incorporate the training provided by firms and address the issues of double-counting of R&D and ICT investments (database and software investments), which are often estimated in national accounting systems using employment compensation in relevant occupations.

Intangible capital, from a broader perspective, describes the main innovation activities of private companies that are, almost by definition, the sources of future growth. Management activity aimed at productivity growth in the longer term is, however, hard to estimate. However, our performance-based estimates clearly show that the traditional expenditure-level estimates of organisational activity (mainly management and marketing) are lower bounds for the true value of organisational investments. The productivity of these types of activities usually exceeds their respective wage expenditures.

An important consequence of this is that intangible capital investment also increases markedly the measured profitability of the firms given the productivity-wage gap. It should be noted that intangible capital also has a positive impact on hourly wage growth, but the improvement in efficiency allows a decrease in overall wage expenditures over time. We have not analysed labour utilisation rates, but it may well be that good performance induced by intangible investment also increases overall demand for employment.

The share in GDP of intangible investment is increasing in Europe over the longer term, although the growth of the shares has diminished somewhat in the 2000s. An exception is the new member states that are catching up to the rest of Europe both in GDP levels and in the intangible capital shares of GDP. Overall, the level of intangible investment in Europe appears insufficient when compared with that of the US, where companies are more prone to engage in all types of innovation activity more intensively.

3 Conclusions

In section 1, we introduced three important avenues to improve our understanding of intangible capital. First, there is a perceived need to distinguish clearly between investment in (expenditure on) intangibles and the resulting improvement in the *stock of intellectual capital*. Second, the classifications utilised in national and business accounts in general should allow a separate identification of investment in intangibles. Third, the general failure to distinguish between services and intangibles creates fundamental problems of perception and taxonomy in the analysis of economic performance.

Our measures of some forms of intangible such as economic competence were based on the assumption of a fixed share of services considered as intangible investment. However, the same methodology applied across the countries make the intangible investment figures comparable across countries and over time. As such this is important as in general discussion it has been widely accepted that GDP is insufficient measure of general well-being and growth. Incorporating intangible capital investment would be the first-step to measure the GDP that better also evaluates the intellectual capacity of the nations. Finally, our depreciation rates are also not econometrically estimated but show that service life of intangible assets are in general lower than the service life of tangible assets.

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NATIONAL MEASURES OF INTANGIBLE CAPITAL IN THE EU27 AND NORWAY

Cecilia Jona-Lasinio, LUISS Lab of European Economics (LUISS)
Massimiliano Iommi, LUISS Lab of European Economics (LUISS)
Felix Roth, Centre for European Policy Studies (CEPS)

Abstract. This article provides an overview of the methodology adopted in the INNODRIVE project to measure gross fixed capital formation (GFCF) at the macroeconomic level and illustrates the main data sources used to estimate intangible GFCF for the EU27 countries. The LUISS team has coordinated efforts to define the general estimation strategy for intangible variables at the macroeconomic level. LUISS and CEPS shared the responsibility for the estimates of the intangible variables, as indicated in appendix 1. The estimation strategy is based on the following criteria:

- *An expenditure-based approach*. We use expenditure data to develop direct measures of intangible GFCF and capital.
- *Exhaustiveness*. We estimate total expenditures for each type of intangible and how much each type of expenditure might be considered GFCF. Our estimates include both purchased and own-account components of expenditures on intangible assets.
- *Consistency with national accounts*. The purchased component of expenditure on an intangible is already included in the production boundary of national accounts, whereas the own-account component is excluded. We want to guarantee that our estimates of the purchased component are consistent with national accounts production data. To this end, our estimation method is based as much as possible on variables expressed in per capita terms (per worker or per employee) or as a percentage of a national accounts variable (e.g., as a share of output or of labour costs).
- *Reproducibility and international comparability*. To guarantee reproducibility and international comparability, our estimates are, wherever possible, based on official data sources that are homogeneous across countries (mainly Eurostat surveys, national accounts data, and supply and use tables).
- *Sectoral coverage*. Our estimates include only the non-agricultural business sector, defined as a grouping of all industries except agriculture (NACE Rev 1.1, category A), fishing (category B), public administration, defence and compulsory social security (category L), education (category M), health (category N), other community, social and personal service activities (category O) and private households (category P). The exclusion of categories M, N, O and P in the definition of the business sector constitutes a pragmatic solution; the ideal approach would be to distinguish between establishments that are market producers and those that are not and then to define the business sector to include only market producers, but we do not have access to the data needed to implement such an approach. For some variables, the estimates that we have already produced do not refer exactly to the business sector as defined above; we plan to produce fully consistent estimates at a later stage.

1 Measuring intangible capital: The state of the art[9]

There is extensive literature on intangible investment, but most of it focuses solely on some assets (R&D capital, for example), leaving out other elements, such as organisational capital or brand equity. Some of the most recent and general approaches to measuring intangibles in the economic literature can be identified (following Sichel 2008) as financial market valuation, other performance measures and direct expenditure data. The financial market valuation approach assumes that the value of intangible capital corresponds to the difference between the market value of firms and the value of tangible assets.

Brynjolfsson, Hitt and Yang followed this approach in some papers to analyse the link between intangible investments and investment in computers in the US (Brynjolfsson and Yang 1999; Brynjolfsson, Hitt and Yang 2000 and 2002). They used firm-level data, and their main finding was that each dollar of installed computer capital in a firm was associated with between five and ten dollars of market value. According to them, this difference reveals the existence of a large stock of intangible assets that are complementary with computer investment.

Webster (2000) adopted a comparable approach with Australian data, assuming that any residual market value of the firm (stock market value plus liabilities) not explained by the balance sheet value of tangible assets must be due to intangible assets. He found that the ratio of intangible capital to all enterprise capital rose by 1.25% per year over the 50 years ending in 1998. The work done by the World Bank (2006) to measure intangible capital at the country rather than the firm level was similar. The value of intangible capital was obtained as the residual after deducting natural capital and produced capital from total wealth (measured as the net present value of future sustainable consumption).

Another widely used method to estimate the value of intangible capital is the ‘other performance’ approach, concentrating mostly on measures such as productivity or earnings. Cummins (2005), for example, defined intangible capital in terms of adjustment costs and estimated these costs econometrically from US firm-level panel data. His idea was to create a proxy for the intrinsic value of the firm from the discounted value of expected profits based on analysts’ forecasts (which he suggested reflect the analysts’ valuation of intangibles) and to estimate

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[9] This brief literature review on the state of the art in the research is enlarged for the micro and macro approaches in the INNODRIVE report, *State of art in research on the economics of intangibles* (Deliverable No. 12, WP2), by C. Jona-Lasinio et al. (2009).

the return on each type of capital (tangible and intangible). He found no appreciable intangibles associated with R&D or advertising but sizable intangibles (organisational capital) created by IT. McGrattan and Prescott (2005) inferred the value of intangible capital from corporate profits, the returns to tangible assets and the assumption of equal after-tax returns to tangible and intangible assets. They calculated a range for the value of intangible capital from 31 to 76% of US GDP.

From a similar perspective, Lev and Radhakrishnan (2005) developed a firm-specific measure of organisational capital, modelling the effect on sales of organisational capital (proxied by reported sales, general and administrative expenses, which includes expenditures that generate organisational capital). They found that the marginal productivity of organisational capital ranged between 0.4 and 0.6, and the mean organisational capital was 4% of average sales of their sample of US firms.

As stated in Cummins (2005), the first two approaches may be subject to considerable measurement error – for example, stock market values may reflect a mismeasurement to the extent that asset prices depart from their intrinsic values, and analysts' measures of earnings can be subject to mistakes and biases.

Yet, the direct expenditure-based approach can also be subject to measurement error and data limitations, including whether the list of measures of intangibles is comprehensive and able to capture changes in the nature of intangibles over time.

This approach was first adopted by Nakamura (1999 and 2001), who measured gross investment in intangible assets by means of a range of measures, including R&D expenditure, software, advertising and marketing expenditure, and the wages and salaries of managers and creative professionals. He found that in 2000, US investment in intangibles was $1 trillion (roughly equal to that in non-residential tangible assets), with an intangible capital stock of at least $5 trillion.

Starting from Nakamura's work, Corrado, Hulten and Sichel (2005) developed expenditure-based measures of a larger range of intangibles for the US. They estimated that investment in intangibles averaged $1.1 trillion between 1998 and 2000 (1.2 times the tangible capital investment), or 12% of GDP. They then developed a methodology for explicitly identifying the contribution of intangibles in the national accounts and growth accounting in Corrado, Hulten and Sichel (2006). They calculated that previously unmeasured intangible capital contributed 0.24 of a percentage point (18%) to conventionally measured multifactor productivity (MFP) growth in the US between the mid-1990s and early 2000s. The Corrado, Hulten and Sichel methodology has been applied in a number of studies of other countries, with estimates of the contribution of previously unmeasured intangible capital to MFP growth ranging from 0% in the Netherlands (van Rooijen-Horsten et al. 2008) and 3% in Finland (Jalava, Aulin-Ahmavaara and Alanen 2007) to 14% in the UK (Marrano, Haskel and Wallis 2007) over similar periods. Other studies have simply estimated the contribution of *all* intangibles to national MFP growth, yielding results of -19% in Japan (Fukao et al. 2008), 0% in Italy, 9% in Spain, 18% in Germany, and 19% in France (Hao, Manole and van Ark 2008).[10]

2 Main Results, Including Growth Accounting

Cecilia Jona-Lasinio, LUISS Lab of European Economics (LUISS)
Massimiliano Iommi, LUISS Lab of European Economics (LUISS)

Figure 1 shows the estimates of GFCF in intangibles and in R&D as shares of GDP for the EU-27 (excluding Cyprus and Luxembourg) for the year 2005.

The GDP intensities are rather heterogeneous across countries. Sweden and the UK have the highest shares (9.1 per cent and 8.9.1 per cent, respectively) The GDP shares are also greater than or equal to 7 per cent in Denmark (7.1% per cent), Slovenia (7.2% per cent), Finland (7.3% per cent), Hungary (7.5% per cent), France (7.6% per cent), the Netherlands (7.7% per cent), the Czech Republic (8.0% per cent) and Belgium (8.2% per cent); Germany and Austria are in the middle, both with a GDP intensity for intangibles of 6.4 per cent. Investment in intangible assets accounts for less than 5 per cent of GDP in Italy (4.7 per cent), Poland (4.7 per cent) and Spain (4.4 per cent). Greece and Romania are at the bottom end at 2.1 per cent and 2.2 per cent, respectively.

Among the high R&D countries, Sweden and Finland also tend to rank above average in terms of their investments in total intangibles, while Germany and Austria are in the middle. On the other hand, some countries that are not typically regarded as particularly R&D intensive rank very high on this broader measure of innovation intensity: the UK, Belgium, the Czech Republic, the Netherlands, France, Hungary and Slovenia.

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[10] See Barnes and McClure (2009) for a comprehensive review of the empirical literature.

Figure 2 shows business sector GFCF in tangible and intangible assets (excluding residential capital) as shares of GDP in the year 2005 for EU25 countries (excluding Cyprus and Luxembourg). The EU15 countries have shares of total GCFC between 15 per cent and 20 per cent (with the exception of Greece, with a share of 10 per cent). Eastern economies are more GCFC intensive, with shares between 19 per cent and 27 per cent (with the exception of Poland, with a share of 15 per cent).

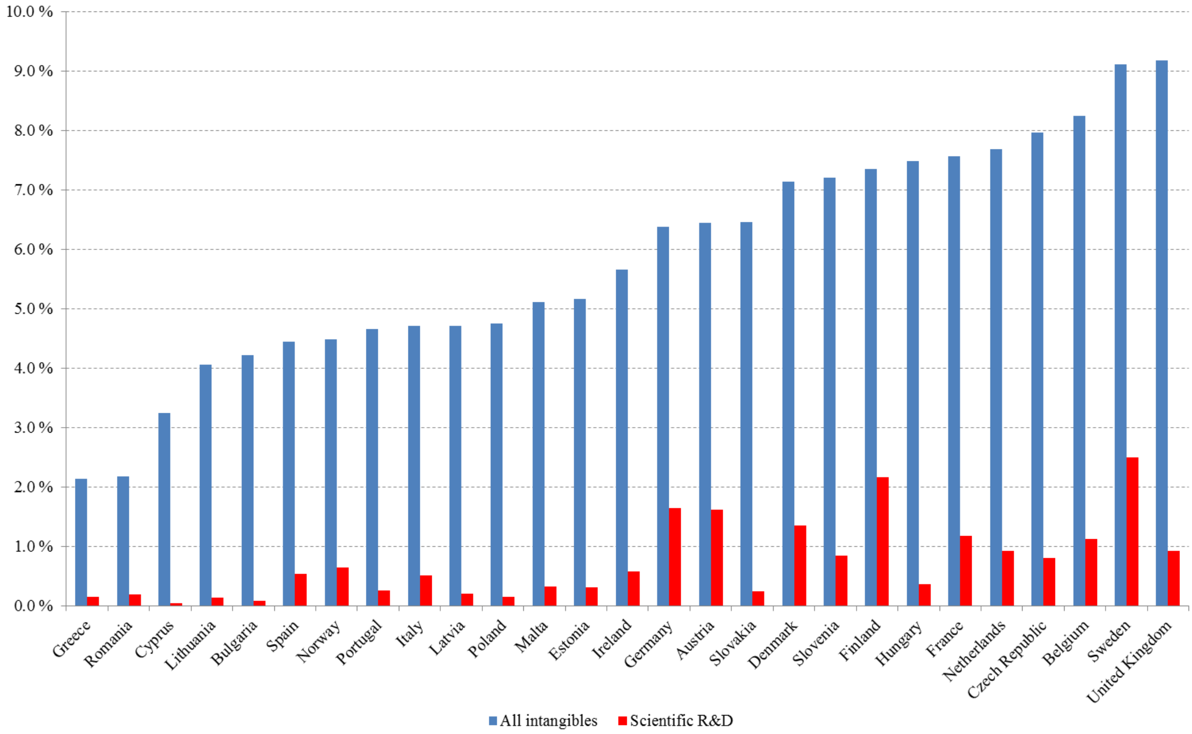

Figure 1. Tangible and intangible business sector GFCF excluding residential capital as shares of GDP (2005)

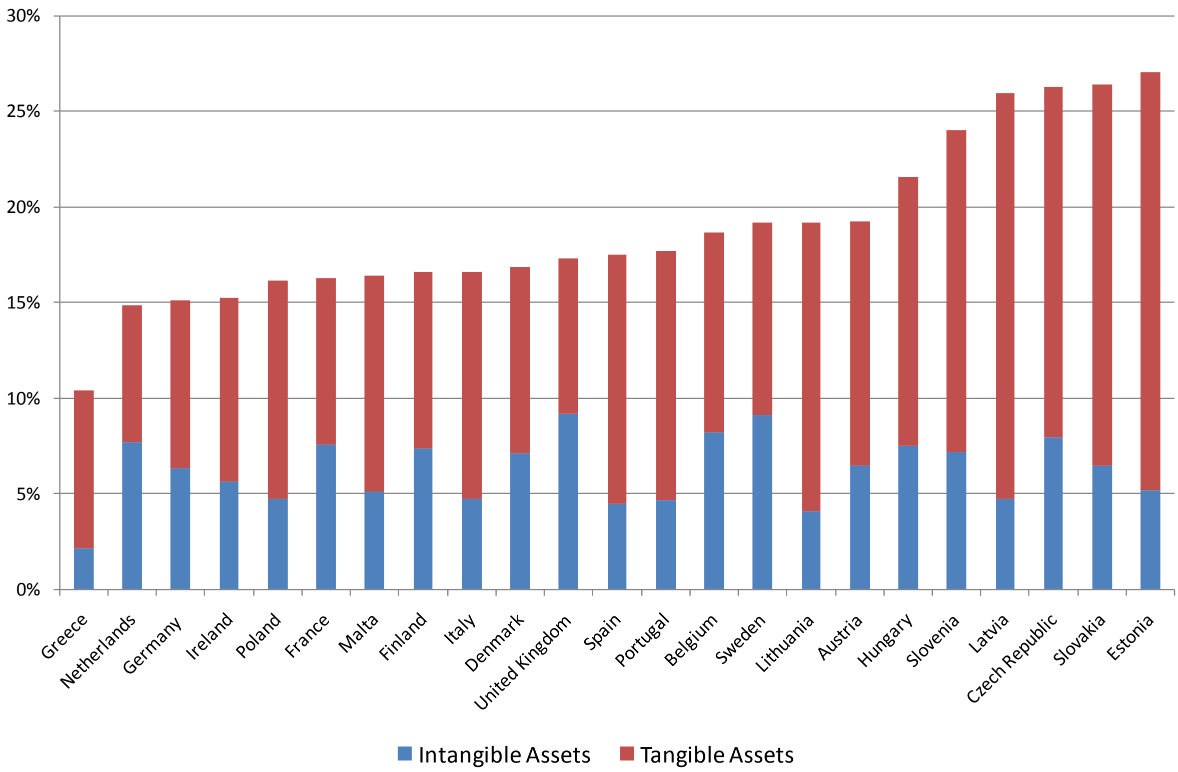

Figure 2. Total intangible and R&D GFCF as shares of GDP (2005)

The growth accounting framework allows decomposing GDP growth into its labour, capital and total factor productivity (TFP) components. The reference model to evaluate the contribution of intangibles to economic growth is the CHS model (2005). In their model, intangibles are treated symmetrically as tangibles in the standard growth accounting framework. The explicit inclusion of intangible capital within a growth accounting framework can affect both the input and output sides of the model, thus also influencing the residual TFP growth[11].
The extended growth accounting equation is

(1) $$gQ(t) = vL(t)gL(t) + vT(t)gT(t) + vI(t)gI(t) + gA(t)$$

where gX(T) denotes the logarithmic rate of growth of variable X, and vY(t) denotes the share of input Y in total output (more precisely, the average of the shares between time t and time t-1). L, T and I are, respectively, the labour input, tangible capital and intangible capital, and gA(t) denotes the rate of growth of

[11] See Barnes and McClure (2009) for a detailed description of the effects of capitalising intangibles.

multifactor productivity. Q is national accounts' value added, revised to be consistent with the newly measured intangible GFCF.

This section presents the results obtained by performing a growth accounting exercise using a slightly different classification of capital:

$$gQ(t) = vL(t)gL(t) + vNA(t)gNA(t) + vNI(t)gNI(t) + gA(t) \quad \textbf{(2)}$$

where NA and NI are, respectively, national account assets (which include software, mineral exploration and artistic, literary and entertainment originals) and intangible assets not currently included in national accounts.

An analysis of the results obtained for the above definitions provides a picture of the impact of intangibles on measured productivity growth and the extent to which national accounts are affected by omitting some intangible assets.

Table 1. Growth accounting results (1995-2005)

	Current Asset Boundary			Extended Asset Boundary						
	Contributions to Labour Productivity Growth			Contributions to Labour Productivity Growth				Estimated Impact		
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(d-a)	((e+f)-b)	(g-c)
	LPG	CD	TFPG	LPG	NA CD	NI CD	TFPG	LPG	CD	TFPG
Austria	1.87	0.78	1.08	2.05	0.72	0.34	0.97	0.18	0.29	-0.11
Denmark	1.55	0.55	1.00	1.61	0.50	0.27	0.83	0.06	0.22	-0.16
Finland	2.98	0.28	2.69	3.07	0.25	0.37	2.43	0.09	0.34	-0.26
France	2.01	0.39	1.61	2.07	0.36	0.23	1.47	0.06	0.20	-0.14
Germany	1.59	0.80	0.78	1.69	0.74	0.27	0.68	0.11	0.21	-0.11
Italy	0.17	0.55	-0.37	0.26	0.51	0.09	-0.35	0.09	0.06	0.02
Netherlands	2.20	0.69	1.50	2.25	0.62	0.31	1.31	0.05	0.24	-0.20
Portugal	1.81	1.82	-0.01	1.94	1.72	0.24	-0.03	0.13	0.14	-0.02
Spain	0.21	0.53	-0.32	0.24	0.50	0.03	-0.29	0.04	0.01	0.03
Sweden	3.73	1.14	2.56	3.69	1.01	0.44	2.20	-0.04	0.32	-0.37
United Kingdom	2.62	1.06	1.55	2.71	0.95	0.34	1.39	0.09	0.24	-0.15

Notes: LPG stands for labour productivity growth; CD is capital deepening, distinguishing between national account (NA) and new intangible (NI) CD; TFP is total factor productivity.

Table 1 shows the relative contributions of capital deepening and TFP to labour productivity growth in the current asset boundary compared to the extended asset boundary when intangible assets are capitalised for the period 1995-2005.

Labour productivity growth is generally higher when intangibles are included in capital stock in all of the sample countries with the exception of Sweden, where it decreases a bit. The greatest impact is seen in Austria, where labour productivity increases by 0.18 percentage points; Portugal, with an increase of 0.13 percentage points; and Germany, with 0.11 percentage points. Among these countries, only Austria is an intangible-intensive country, although all of them were fast-growing economies in the second half of the 1990s.

The relative contributions of capital deepening and TFP to labour productivity growth changed considerably after the inclusion of all intangibles, with the role of capital deepening increasing and that of the growth of TFP decreasing. The contribution of capital deepening increased from 0.28 to 0.62 percentage points per year in Finland (an increase of 0.34 percentage points), from 1.14 to 1.457 percentage points per year in Sweden (an increase of 0.33 percentage points) and from 0.78 to 1.06 percentage points in Austria (an increase of 0.3 percentage points).

Denmark, Germany, the Netherlands and the UK registered quite similar effects of capitalising new intangibles, with an average increase in the contribution of capital deepening of 0.22 percentage points. Italy and Spain stand out as exceptions, with negligible increases in the contributions of capital deepening equal to 0.06 and 0.01 percentage points, respectively. For all of the remaining countries but Italy, the contribution of capital deepening increased on average by 0.12 percentage points after the inclusion of all intangibles.

The lower TFP growth shows that when intangibles are not capitalised, their contribution to labour productivity growth is captured by TFP, in line with its residual nature (Jorgenson and Griliches (1967)). In all countries apart from Italy and Spain, the inclusion of intangibles in the asset boundary involves a larger role of capital deepening that in most cases becomes the main source of growth. However, the effect on TFP growth is quite heterogeneous across countries and mirrors only partially the effect on capital deepening. For instance, in Sweden, the strong increase in the contribution of capital deepening is associated with a negligible effect on labour productivity growth: as a consequence, the capitalisation of intangibles causes a large decrease in TFP growth (0.37 percentage points). On the other hand, in Austria, the large increase of the contribution of capital deepening is associated with a large increase in labour productivity growth, making the reduction in TFP growth relatively smaller (0.11 percentage points).

3 Growth Econometric Results

Felix Roth, Centre for European Policy Studies (CEPS)

In this section, we give an overview of the results of the econometric analysis that was performed in WP9 within the INNODRIVE project (Roth and Thum 2010). In the study, an econometric model was estimated to assess the impact of business intangible capital on labour productivity growth using a panel dataset for the EU-15 countries over a ten-year period from 1995-2005. The model follows an approach taken by Benhabib and Spiegel (1994) and Temple (1999) that the latter calls "cross-country growth accounting". It combines the growth accounting approach with the growth regression approach and has the advantage of taking into account cross-country variation and of enabling the consideration of non-monetary as well as monetary indicators.

The econometric model upon which the results in this section are based can be written as

(3) $$\Delta \ln Y^*_{it} = \alpha_{0i} + \eta \ln Y_{it-1} + \alpha \Delta \ln K_{it} + \beta \Delta \ln H_{it} + \gamma \Delta \ln I_{it} + \delta \Delta \ln N_{it} + \mu B_{it} + \lambda X_{it} + w_{it}$$

where Y^*_{it} denotes labour productivity, including intangible capital investment in the asset boundary[12], K_{it} denotes physical capital, H_{it} human capital, I_{it} intangible capital and N_{it} hours worked. B_{it} is a control variable for the business cycle, which is necessary when using annual growth data, and X_{it} are additional controls, such as government expenditure, openness to trade and inflation[13]. α_{0i} denotes country-specific effects, and w_{it} is an error term. As noted above, the specification is adopted from Benhabib and Spiegel (1994) and Temple (1999).

Figure 3 depicts the results of regressing the effect of growth of both physical and intangible capital deepening, called 'total capital deepening', on labour productivity growth given important controls. As a first analysis, the graph shows that the association is strongly positive and appears to be robust because excluding single countries will not affect the significance of the relation. The regression results in Table 2 affirm these results.

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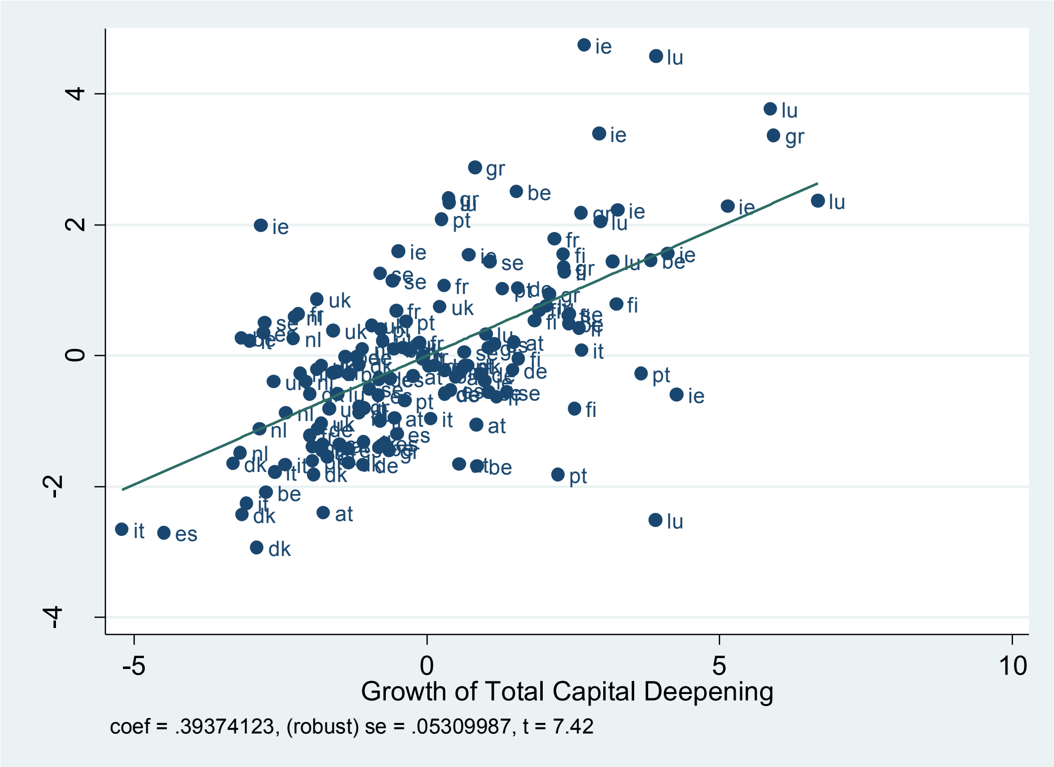
[12] Intangible capital investment is included in the asset boundary and therefore also in the GDP variable because we are following and trying to incorporate the growth accounting approach of Corrado, Hulten and Sichel (2006).

[13] For a more detailed analysis, see table 8 in Innodrive: Roth and Thum (2010) "Does Intangible Capital affect Economic Growth?" Innodrive Working Paper No. 3.



Source: Innodrive: Roth and Thum (2010) "Does Intangible Capital affect Economic Growth?" Innodrive Working Paper No. 3

Figure 3. Partial regression plot between total capital deepening and labour productivity growth – pooled cross-section estimation for the EU-15 countries

Table 2 shows the econometric regression results using different estimation techniques – ordinary least squares, random effects and a classical general method of moments (GMM) estimator developed by Arellano and Bover (1995) for the special case of growth regressions using panel data[14]. All regression techniques provide effects expressing a weighted average between the within-country and the across-country variation, which are both available in panel data. Columns (1), (3) and (5) show results for a traditional growth model, not accounting for intangible capital measures, and columns (2), (4) and (6) show the results when including intangible capital within the asset boundary. The table shows that, across all estimation techniques used, the effects of the capital deepening and education inputs

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[14] This methodology addresses all major problems occurring in panel growth models, such as endogeneity of the lagged dependent variable, endogeneity of the regressors and persistence of the growth time series.

become weaker when intangible capital is included. Additionally, the variance explained by the model increases when adding intangible capital. These results indicate that intangible capital matters significantly for labour productivity growth. Roth and Thum (2010) show that this result does not hold within countries; rather, it can only be shown across countries[15].

Table 2. Intangible capital and labour productivity growth – alternative estimation techniques

Estimation Method	OLS (1)	OLS (2)	RE (3)	RE (4)	GMM sys (5)	GMM sys (6)
Lagged Labour Productivity[a]	-2.040***	-1.192**	-3.227**	-1.545	-1.774*	-0.654
	(0.511)	(0.543)	(1.319)	(1.091)	(1.037)	(0.472)
Education	1.936***	1.477***	2.379***	1.658***	1.764**	1.189***
	(0.332)	(0.326)	(0.735)	(0.580)	(0.697)	(0.449)
Growth of Capital Deepening	0.662***	0.438***	0.679***	0.488***	0.686***	0.459***
	(0.0918)	(0.0949)	(0.0921)	(0.116)	(0.138)	(0.117)
Growth of Intangible Capital Deepening		0.312***		0.235***		0.330***
		(0.0545)		(0.0703)		(0.0731)
Proxy Business Cycle	-4.166	-9.440***	-16.21***	-13.00***	-6.769	-15.08*
	(3.162)	(3.010)	(6.190)	(4.792)	(5.727)	(8.224)
Constant	4.338	7.190***	17.74**	10.40**	5.485	11.44
	(3.016)	(2.726)	(7.144)	(5.033)	(5.702)	(7.849)
Observations	150	150	150	150	150	150
R-squared[b]	0.472	0.587	0.4027	0.5607	-	-
Time effects	yes	yes	yes	yes	yes	yes
Number of countries	15	15	15	15	15	15

[a] Labour productivity augmented by investment in intangible capital if intangible capital stock is included in the regression.

[b] The reported values for R squared are the overall values for the OLS and RE estimators and the within value for the FE estimator.

Note: Robust standard errors are given in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

[15] The table above does not show the results for the within-country estimator because no significant results were found.

The sensitivity analysis that Roth and Thum (2010) conduct shows that the relationship between intangible capital and labour productivity growth is slightly stronger in 1995-2000 than between 2000 and 2005 and in coordinated countries. It further shows that additional control variables do not alter these results, indicating that the results are robust.

Overall, the results of the analysis can be grouped according to the following five points: First, this relationship is cross-sectional and proves to be robust to a range of alterations. The relationship is stronger in the time period of 1995-2000 and in coordinated countries. This result indicates that a high intangible capital deepening growth rate in a country is associated with a higher labour productivity growth rate. Second, the relationship does not hold when controlling for country-specific effects, so an increase of intangible capital deepening in a country is not associated with an increase of labour productivity growth in that country in the time frame from 1995 to 2005. Third, the empirical analysis confirms that the inclusion of intangible capital investment within the asset boundary of the national accounting framework implies that the rate of change of output per worker increases more rapidly. Fourth, the empirical analysis confirms that intangible capital investment is able to explain a significant portion of the unexplained international variance in labour productivity growth and thus diminishes the unexplained part of labour productivity growth and, hence, the extent of our ignorance about its sources. Fifth, the empirical analysis confirms that capital deepening becomes more important when incorporating intangibles into the national accounting framework.

In terms of policy conclusions, the results imply three main issues[16]. First, other elements of intangible capital in addition to R&D matter for economic growth. This is an important fact in light of the Europe 2020 Strategy, which so far emphasises solely the importance of R&D. Second, the national accounting frameworks should take measures of intangible capital into account because these measures reflect the ongoing and continuous transition towards a knowledge society. Policy conclusions based solely on 'brick-and-mortar' measures of capital are no longer valid, especially in the growing service sectors. Third, a wider concept of innovation seems to be the first step towards revising the national accounts framework. In the future, an even broader understanding of intangible capital than

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[16] See here also Roth (2010).

business intangible capital should be developed – it should include measures of human, environmental, health and social capital[17].

4 Methodology: The macro approach[18]

The objectives of the work on the macro approach were the following:

- to identify some detailed criteria on which to screen the intangible variables (appendix 1) originally proposed by Corrado, Hulten and Sichel (2005) in order to select those to be capitalised;
- to outline a general estimation strategy for INNODRIVE;
- to screen the data sources available for each variable not currently included in GFCF and to define an estimation method; and
- to provide an estimate of intangible assets for the EU-27.

Given the complex nature of intangible assets, there is no definition of or single method to measure intangibles that is accepted worldwide (Corrado, Hulten and Sichel, 2005). Most of the literature simply identifies three critical attributes of intangibles: i) they are viewed as sources of probable future economic profits, ii) they lack physical substance, and iii) to some extent, they can be retained and traded by a firm (OECD, 2008). Yet, characteristics (i) and (iii) are also largely reflected in the more general definition of *economic assets* provided by the 1993 System of National Accounts (SNA) that classifies them (Harrison, 2006) as those entities:

- over which ownership rights are enforced by institutional units, individually or collectively; and
- from which economic benefits may be derived by their owners by holding them or using them over a period of time.

On the other hand, Corrado, Hulten and Sichel (2005) proposed the widest definition of intangibles, referring to a standard intertemporal framework that leads to the conclusion that "any use of resources that reduces current consumption in order to increase it in the future…qualifies as an investment". This definition implies that all types of capital should be treated symmetrically, thus leading to a

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17 See here, e.g., the report by Sen, Fitoussi and Stiglitz (2009).

18 The methodology is also described in the INNODRIVE report by C. Jona-Lasinio et al. (2009).

very broad definition of capital, including, for example, intellectual and human capital as well as organisational assets (Schreyer, 2007).

Taking into consideration the above definitions, we have classified the expenditures as GFCF according to the following principles:

1. if the asset is identifiable; in other words, if it is separable (capable of being separated and sold, transferred, licensed, rented or exchanged, either individually or as part of a package);
2. if it is possible to identify the owner of the asset or the intellectual property;
3. if the asset produces economic benefits for its owner; and
4. if the asset is used in the production process over several time periods. In particular, it is expected that the asset will provide capital services for over a year in the production of different products.

Our estimation strategy is based on the five criteria outlined in the Abstract. Besides the general estimation strategy illustrated above, we also have to focus on three important implementation issues:

- *The estimate of intangible GFCF*. Our estimates of GFCF are based on the assumptions of Corrado, Hulten and Sichel (2005) about how much of each expenditure is assumed to be GFCF. This choice is dictated mainly by international comparability requirements because most of the estimates of intangible GFCF available for European countries are based on the assumptions of Corrado, Hulten and Sichel.
- *The calculation of national accounts' value added in a way that is consistent with the newly measured intangible GFCF*. For the business sector, the calculation of the revised value added is quite straightforward: for market producers, value added simply increases with the newly measured intangible GFCF (both purchased and produced on own-account).
- *The exclusion any double counting of costs in the estimates of own-account components of capital formation*. Double counting can arise if costs are summed to obtain estimates of the own-account capital formation of one asset; at the same time, some or all of the same expenditures are summed to obtain the own-account capital formation of some other asset.

  If the costs of production are used more than once to derive estimates of own-account capital formation in the same period, then the value asset production for that period will be over-estimated.

This kind of double counting is likely to take place for R&D and software because of

a) R&D undertaken in the course of producing software or
b) Software produced in the course of R&D.

Indeed, own-account software from the national accounts should include R&D connected to software development (the purchased R&D is included in the production costs as an intermediate input, and the time spent by software personnel undertaking software R&D in-house is included in labour costs).

On the other hand, an R&D survey adhering to the Frascati Manual (the reference manual for R&D surveys) would record either some or all of the expenditures in case (a) and all of the expenditures in case (b) as expenditures on R&D.

The capitalisation of R&D based on data from R&D surveys may then lead to double counting unless R&D connected to software development is subtracted from R&D data.

The double counting of costs may be present in all estimates based on the sum of costs (not only for R&D and software), so we need to be aware of the problem and scrutinise our estimates to make sure that no double counting takes place.

5 Variable screening

The screening of the selected variables follows the classification scheme proposed by Corrado, Hulten and Sichel (2005), who grouped intangible assets into three main categories:

- computerised information,
- innovative property, and
- economic competencies.

In this section, we describe both the data sources and the measurement issues for each of the selected variables.

5.1 Computerised information

This category includes knowledge embedded in computer programmes and computerised databases. The main component of computerised information is **computer software**, which is already included as a GFCF in the national accounts (although not every country provides estimates of software GFCF; several countries include software in more aggregated variables). **Computerised databases** are not identified as economic assets by themselves in the national accounting system, but they are supposed to be captured by national account software measures (both purchased and own-account).

Data sources

Our estimates of software are based on three different data sources: the EU KLEMS database, official national accounts data and the use table from the supply and use framework.

The preferred source is the EU KLEMS database. In the capital input module, it provides time series of software investments disaggregated by purchasing industry. Unfortunately, the capital input module is available for only thirteen countries. For countries not covered by the EU KLEMS database, we have used estimates of software GFCF for the total economy from official national accounts or, when they are not available, estimates from the use tables. In these cases, we have produced our own estimates of business software GFCF (according to the definition of business sector provided in paragraph three). Table 5 reports the data sources we used for each of the EU27 countries and for Norway.

Estimation method for countries included in the EU KLEMS capital input module:

> *Business Sector software GFCF = Total economy software GFCF – software GFCF of industries A, B, L, M, N, P and Q*

Estimation method for countries not included in the EU KLEMS capital input module:

> *Business Sector Employment Share = Employment in industries C_to_K+O / Employment in industries C_to_O (from NA)*
> *Business Share EU KLEMS = Business Sector software GFCF (EU KLEMS) / Total Economy software GFCF (EU KLEMS)*

Correction Factor = Business Share EU KLEMS / Business Sector Employment Share
*Business Sector software GFCF =Business Sector Employment Share * Correction Factor * total software GFCF (from NA) * Correction Factor*

The only country for which no estimate is available is Cyprus. The Statistical Service of Cyprus informed us that no official estimate is available.

Table 3. Data sources for software GFCF

Country	*Data source*
Austria	EUKLEMS
Belgium	NA
Bulgaria	SUT
Cyprus	-
Czech Republic	EUKLEMS
Denmark	EUKLEMS
Estonia	SUT
Finland	EUKLEMS
France	EUKLEMS
Germany	EUKLEMS
Greece	SUT
Hungary	NA
Ireland	NA
Italy	EUKLEMS
Latvia	SUT
Lithuania	SUT
Luxembourg	SUT
Malta	SUT
Netherlands	EUKLEMS
Poland	SUT
Portugal	EUKLEMS
Romania	SUT
Slovakia	NA
Slovenia	EUKLEMS
Spain	EUKLEMS
Sweden	EUKLEMS
United Kingdom	EUKLEMS
Norway	SUT

NA=national accounts, SUT=Supply and Use Tables

5.2 Innovative property

This category refers to the scientific knowledge embedded in patents, licenses and general know-how and the innovative and artistic content of commercial copyrights, licenses and designs (Corrado, Hulten and Sichel, 2005; van Rooijen-Horsten et al., 2008).

Scientific R&D

As one part of innovative property, Corrado, Hulten and Sichel (2005, 2006) include "firms' scientific and non-scientific R&D spending", with scientific R&D here including the scientific knowledge embedded in patents, licenses and general know-how.

According to the 1993 SNA, expenditures on R&D are not treated as capital formation, even though it is acknowledged that they are of an inherently investment nature. Paragraph 6.163 states that although R&D is aimed at future benefits, there are no clear criteria on how to distinguish R&D expenditures from those on other activities to enable the identification and classification of the assets produced and therefore to know the rate at which these depreciate over time. As it is difficult to meet all of these requirements, R&D outputs are treated as intermediate inputs, even though some of them may bring future benefits (Advisory Expert Group, 2005). Nevertheless, the revision of SNA 1993 (which was released in 2008) recommends that R&D expenditures be recorded as GFCF if they meet the general characteristics of a fixed asset. At the same time, the revised SNA 1993 also clarifies that there are substantial difficulties in implementing this recommendation and that the integration of technological assets will start by means of satellite accounts prior to a full consolidation in the SNA.

Foreseeing the revision of the 1993 SNA, Corrado, Hulten and Sichel (2005) consider scientific R&D as well as non-scientific R&D as investments in intangible capital. Referring to the vast amount of literature[19] on the capitalisation of R&D and taking into account criteria 1-4 (outlined above), we can summarise the main reasons why R&D should be recorded as GFCF as follows:

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[19] Anticipating the revision of the SNA, several national statistical institutes have already developed experimental satellite accounts for research and development. The accounts show how GDP and other measures would be affected if R&D spending were treated as GFCF rather than as a current expense. Among them are the US (BEA, 2007), the Netherlands (Statistics Netherlands, 2008) and Norway (Statistics Norway, 2008).

- Expenditure on R&D is identifiable, e.g., is capable of being separated and sold, transferred, licensed, rented or exchanged, either individually or as part of a package, because spending money on R&D activity usually leads to a patent or a license.
- It is possible to identify who owns the asset because normally it is the cooperation or institution that performs the research and spends the money that is the owner of the asset. This could be a company, a government, a higher education institute or a private non-profit company.
- The asset produces economic benefits for its owner because the money that is spent on R&D has the clear purpose of creating new products, patents or licenses and optimising the existing production processes to exploit them in the future by selling those licenses and increasing the production capacity by means of the innovative production processes.
- It is expected that the asset will provide capital services for over a year in the production of different products because most often the profits from licenses and patents yield benefits that last far longer than one year. This is also true for innovative production processes.

Construction of the intangible capital variable 'scientific R&D'

Because the INNODRIVE project aims to construct an intangible capital dataset that focuses on business expenditures, data on scientific R&D were collected; more concretely, data on Business Expenditure on Research and Development (BERD) were retrieved. Although the Analytical Business Enterprise Research and Development database ANBERD from the OECD provides data of higher quality, the data were drawn from Eurostat because it also provides information for the 12 new member states. Eurostat provides such data under the category "Science and Technology" and the subheading "Research and Development".

For the relevant period, from 1980 to 2005, the Eurostat BERD dataset had only a few missing observations; missing data were inter- and extrapolated.

To avoid the double counting of software investment (software investment is an own intangible capital variable), as pointed out by Marrano et al. (2006), data for "K72 – Computer and related activities" were collected. Because the data were not balanced, imputation was applied.

To retrieve the investment in intangible capital, the R&D in K72 was subtracted from the total scientific R&D (here again, see Marrano et al. 2006). Because the investment in scientific R&D should be considered a 100% investment in intangible capital, these subtracted figures provide us with the final intangible capital investment.

Non-scientific R&D (R&D in social sciences and humanities)
Non-scientific R&D reflects the innovative and artistic content of commercial copyrights, licenses and designs. The R&D expenditure on social sciences and humanities is one aspect of non-scientific R&D. As there are only very scarce data available for R&D in social sciences and humanities (NACE K73.2) and as the amounts of the expenditures are non-significant, the variable was not considered.

Mineral exploration and new motion picture films and other forms of entertainment
Expenditures on mineral exploration and new motion picture films and other forms of entertainment are already recorded as GFCF in national accounts. The rationale is that mineral exploration creates a stock of knowledge about the reserves that will be used as inputs in future production activities. A fundamental question has been raised, however, as to whether such knowledge should be seen as independent of the stock of economically exploitable reserves or whether this approach leads to double counting when both discovered stocks of resources and stocks of exploration are capitalised.

The revised SNA indicates that a distinction will be maintained between the act of exploring for mineral deposits (treated as a produced asset) and the mineral deposits themselves (treated as non-produced assets).

Data sources

Our estimates of GFCF for mineral exploration and entertainment, literary and artistic originals are based on two different data sources: official national accounts data, when available, and the use table from the supply and use frameworks for the remaining countries. Table 6 reports the data sources we used for each of EU27 countries and for Norway.

Estimation method

We assume that all GFCF in mineral exploration and new motion picture films and other forms of entertainment is performed by firms included in our business sector.

Table 4. Data sources for GFCF in mineral exploration and entertainment, literary and artistic originals

Country	*Data source*
Austria	NA
Belgium	SUT
Bulgaria	SUT
Cyprus	-
Czech Republic	NA
Denmark	NA
Estonia	SUT
Finland	NA
France	NA
Germany	SUT
Greece	SUT
Hungary	NA
Ireland	NA
Italy	NA
Latvia	SUT
Lithuania	SUT
Luxembourg	SUT
Malta	SUT
Netherlands	NA
Poland	NA
Portugal	NA
Romania	SUT
Slovakia	NA
Slovenia	NA
Spain	SUT
Sweden	NA
United Kingdom	NA
Norway	SUT

Note: NA=National Accounts, SUT=Supply and Use Tables

New architectural and engineering designs

At present, most of these expenditures are recorded as GFCF in the national accounts. They are included in the estimates of dwellings and of non-residential buildings[20] and are estimated as a percentage of the expenditures on the accompanying tangible capital.

Nonetheless, we should consider that most of the expenditures related to the development of an architectural (engineering) project might also be included among the R&D expenditures sustained by the architect or firm that effectively produces the design. Furthermore, a portion of the expenditures related to the development of the project is spending by the firm (architect) on behalf of its clients. In this case, the spending is an intermediate input of the firm, and it is included in its output. But at the same time, it is also considered capital spending by the buyer. Thus, recording the expenditures sustained by the firm as capital spending would lead to double counting of these costs.

Another important point to consider is that generally an architectural (engineering) design is used to produce a single good that is not repeatedly used in the production process (see Aspden 2007). Therefore, in this respect, it does not satisfy the fourth fundamental criterion necessary to be classified as an economic asset.

New product development costs in the financial services industry

Corrado, Hulten and Sichel (2005) include new product development costs in the financial services industry as a component of innovative property. In our opinion, the development of new financial products produces know-how that meets the criteria we have proposed to define an asset: the knowledge is identifiable, there is no doubt that it produces economic benefits for more than one year and the financial institution that has developed a new product is clearly the owner of the asset.

Although the inclusion of new product development costs in financial services in the extended asset boundary is quite uncontroversial, the estimation is problematic. According to Corrado, Hulten and Sichel, in the US, the R&D survey is designed to capture only innovative activity built on a scientific base of knowledge, and it is likely that it does not fully capture R&D expenditures (broadly defined) in the financial services industry. On the other hand, the Frascati Manual gives explicit examples of R&D in banking and insurance: "[m]athematical research relating to financial risk analysis and R&D related to new or significantly improved financial services (new concepts for accounts, loans, insurance and saving

[20] The NACE Rev. 2 code of the corresponding economic activity is 74.20.

instruments)". In principle, therefore, the R&D survey data should capture not only scientific R&D but also R&D in financial services (van Rooijen-Horsten et al., 2008). We think that more research is needed to clarify whether the R&D in banking and insurance, as defined in the Frascati Manual (and measured in the R&D surveys), captures all expenditures to produce innovative property.

Estimation method

Following Corrado, Hulten and Sichel (2005), we have estimated new product development in financial services as 20% of total intermediate spending for intermediate inputs by the financial intermediation industry, which is defined as excluding insurance and pension funding (NACE J65).

Further improvements and refinements

- Estimate the variable as 20% of intermediate inputs by the financial services industry, which is defined as including insurance and pension funding (NACE J66).
- Compare with data on R&D.

5.3 Economic competencies

Corrado, Hulten and Sichel (2005) define the economic competencies category of intangibles as "the value of brand names and other knowledge embedded in firm-specific human and structural resources". It comprises expenditures on advertising, market research, firm-specific human capital and organisational change.

Advertising expenditure
Expenditure on advertising is intended to create a perceived image of the firm in the minds of potential consumers. Because the consumer's choice among the products of competing firms is often driven by a perception of reliability and trustworthiness, the development of this image or brand has to be considered key in obtaining future benefits.

Thus, in light of this simple consideration, advertising expenditure (or at least part of it) should be viewed as an investment in intangible capital rather than as simple short- or medium-term costs.

If we consider the criteria 1-4, we can argue as follows:

- advertising expenditure is identifiable, e.g., is capable of being separated and sold, transferred, licensed, rented or exchanged, either individually or as part of a package, as advertising activity is quite often outsourced to specialised firms;
- it is possible to identify who owns the asset because the product of the firm or the firm's brand name, in general, is the object of the advertising, and hence, the firm is clearly the owner of the asset;
- the asset produces economic benefits for its owner because the advertising expenditure contributes to the value of the brand and, in this sense, produces benefits for the owner; and
- it is expected that the asset will provide capital services for over a year in the production of different products, as advertising expenditure is the fundament on which the image or the brand name of the firm is built, and thus its effects cannot be restricted to one year.

Construction of the intangible capital variable, 'investment in advertising'

To construct the investment in advertising variable, data on the turnover (v12110) for "K74 – Other business activities" from Eurostat's Structural Business Survey were collected; the same source was used for the subcategory "k744 – Advertising". Only data for the time period 1995–2005 were used.

After thorough analysis, however, it was concluded that the data were plagued with measurement errors. The time trends of Zenith Optimedia (ZO)[21] (a private data source) were therefore compared with the data from the Structural Business Surveys, and the latter were altered accordingly.

In a next step, the spending of the public sector was subtracted from the data by considering public-sector consumption as a percentage.
Subsequently, the shares between K74 and k744 were calculated and applied to the national accounts data on the output (P1) of K74, expressed in millions of national currency (including the 'euro fixed' series for the euro area countries).

Although it seems plausible to regard advertising expenditure as an investment, it is not feasible to consider its total amount (100%) of GFCF because a share of the expenditure in advertising is spent for short- or medium-term purposes, thus not

[21] The authors would like to thank Zenith Optimedia for making the data available to us.

providing economic benefits for more than one year. Landes and Rosenfield (1994) found that, in the US, around 60% of advertising expenditure could be capitalised; therefore, Corrado, Hulten and Sichel (2005) recorded 60% of advertising expenditure as investment. This method of evaluating only 60% of spending was replicated in the UK study by Giorgio Marrano and Haskel (2006), in the study of Japan by Fukao et al. (2007) and in the study of the Netherlands by van Rooijen-Horsten et al. (2008). Consequently, investment in intangible capital was estimated by applying a share of 60%.

Construction of the intangible capital variable, 'investment in advertising', from Zenith Optimedia data

In view of the deficiencies that emerged from the Structural Business Survey dataset and the fact that the data from these surveys are not able to capture own-account spending (see Haskel et al. 2006), ZO data for the 1996–2005 period were also retrieved.

Because the actual expenditure is lower, owing to methodological issues within the Zenith Optimedia report compared with the benchmark figures of Haskel et al. (2006) and Edquist (2009), a ratio was calculated and applied to the ZO data, taking the UK and Sweden as references.

As mentioned above, only 60% of the actual expenditure was considered to represent investment.

As a final step, the 2005 Structural Business Survey data were compared with the ZO data. It emerged that the ZO data report values twice as high; this is not unusual because only the ZO data are able to capture the own-account spending. We therefore decided to use the ZO data for the final estimation of the intangible capital stock. Data for the three missing countries Malta, Cyprus and Luxembourg were received by applying average ratios from the new and old member states to the SBS dataset.

Expenditure on market research

The intangible dimension of expenditure on market research constitutes, in addition to expenditure on advertising, an important part of the investment in brand equity. Until now, national accounting frameworks have not recorded this kind of expenditure as business investment but rather deemed it an intermediate cost that does not provide future benefits. Corrado, Hulten and Sichel (2005) instead proposed including this expenditure in the asset boundary; this argument is based on the view that although the properties of markets tend to change consistently over time, it is reasonable to assume that the knowledge of certain market segments and consumer attitudes holds benefits for more than one year because the information gathered tends to be valid for several years.

If we consider criteria 1-4, we can argue that:

- expenditure on market research is identifiable, i.e., is capable of being separated and sold, transferred, licensed, rented or exchanged, either individually or as part of a package, because the results, especially market data research, can easily be sold to other agents;
- it is possible to identify who owns the asset because firms that spend money on market research own the data and the results, and they have more knowledge of the specific market structures;
- the asset produces economic benefits for its owner because the expenditure on market research contributes to the value of the brand and in this sense produces benefits for the owner; and
- it is expected that the asset will provide capital services for over a year in the production of different products. Because some market segments only evolve slowly, knowledge of the specific market segment will hold benefits beyond one year.

Construction of the intangible capital variable, 'investment in market research'

Corrado, Hulten and Sichel (2005) took the data from the Census Bureau's Services Annual Survey and used the "turnover of market research firms" as a proxy for the expenditure. This approach may draw some criticism: when measuring aggregated firm investment in intangible capital, it is crucial to analyse the *demand side* (aggregated expenditure) of market research activities and not the *supply side* (turnover of the market research industry). To give an example, if Nestlé, a Swiss corporation, invests in market research activities in one of the new EU member states, for instance, Poland, the investment should be included in the accounting framework of Switzerland because Nestlé has invested in its brand development. However, when taking the turnover of market research firms in a country as a proxy for the expenditure, Nestlé's expenditure would be included as an investment in intangible capital in Poland instead of Switzerland.

Although analytically weak, there is one clear pragmatic reason to use the turnover data: information on firms' expenditure on market research is not available.

Representatives of Eurostat and ESOMAR (European Society for Opinion and Marketing Research) have underlined that firms' expenditure data on market research are deemed sensitive and thus are not collected and made public.

Moreover, when comparing the data consistency of Eurostat and ESOMAR,[22] it can be observed that Eurostat turnover is systematically higher for all countries, with the exceptions of Germany, France, Finland and Sweden. This could be because of different definitions of turnover or because of a unique item included in the variable (such as data on public opinion). Consequently, to construct the variable on investment in market research, the data on the turnover (v12110) for "k7413 – Market research" from the Structural Business Survey dataset was taken for the period 1995–2005.

Nevertheless, the Structural Business Survey dataset was affected by several measurement errors; the problem was successfully tackled by comparing the data on the turnover for k7413 with ESOMAR time trends and modifying the Structural Business Survey dataset accordingly.

In a next step, the spending of the public sector was subtracted from the data by considering public-sector consumption as a percentage. Afterwards, the shares of K74 and k7413 were calculated and applied to the national accounts data on the output (P1) of K74, expressed in millions of national currency (including the euro fixed series for the euro area countries).

Finally, following the approach of Corrado, Hulten and Sichel, the prevalence of own-account market and consumer research was estimated by doubling the estimate of the data on market research.

Firm-specific human capital

Corrado, Hulten and Sichel (2005) include firm-specific human capital (FSHC) as a component of the broader category 'economic competencies', but they do not provide any rationale for including FSHC as a component of intangible capital.

It is virtually unquestionable that expenditure on training brings future benefits (as is also recognised by the 1993 SNA), and hence training expenditures should be recorded as GFCF.

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[22] The authors would like to thank ESOMAR for making their data available to us.

On the other hand, it is not so clear who owns the asset that is generated by training expenditures. Concerning the idea of capitalising FSHC, we can follow three different approaches:

- We can agree with the SNA and exclude training expenditures from our extended asset boundary because they "do not lead to the acquisition of assets that can be easily identified, quantified and valued for balance sheet purposes" (1993 SNA, paragraph 1.51);
- We can follow Corrado, Hulten and Sichel (as have all papers that have replicated their analysis for other countries) and treat training expenditures as GFCF. For example, van Rooijen et al. (2008) provide a rationale for including FSHC as a component of intangible capital. Here, the main point is that it can reasonably be argued that a company would not pay for training unless it expected a return on its investment. They note that the extent to which a firm really exercises ownership rights over the new knowledge embodied in its personnel is questionable (e.g., a trained employee may choose at any point in time to leave the company for another job). However, they conclude that the benefits of job training are expected to be captured largely by the employer (e.g., because firms may demand compensation from recently trained employees who leave shortly after being trained).
- We can assume that the asset belongs to the employee and not the employer. In other words, we can treat expenditure on employer-provided training as the production of human capital. This is what is proposed, for example, by the PRISM initiative:[23]

  > Businesses can try to tie in skilled employees by offering long term contracts or inducements to prevent them leaving, in which case there may be scope for treating some knowledge assets as effectively 'belonging' to the business, at least for a time. In general, however, knowledge assets belong to individuals or households. They continue to exist and be valuable even if the businesses that make use of them cease to exist. Even if knowledge assets are recognised as intangible assets within the system, it is difficult to see how they can be attributed to the business sector.

  In their opinion, the benefits for the employer derive from the expectation of being able to retain the services of the employees and to continue to rent

[23] See the website http://www.euintangibles.net.

their special skills for a considerable length of time – not from becoming the owner of the asset (Hill and Youngman, 2002; Hill, 2003).

Our first estimates will be consistent with the approach by Corrado, Hulten and Sichel (2005). In a second stage, we will reconsider the three alternatives stated above and evaluate which one should be adopted.

Data sources

The main data source from which we estimate employer-provided training is the Eurostat Continuing Vocational Training Survey (CVTS). In our opinion, this source is preferable to national sources because it provides comparable statistical data on enterprise training across countries.

Survey description

- Years available from Eurostat's website: 1999 (CVTS2) and 2005 (CVTS3, which is still preliminary and incomplete). The survey for 1993 (CVTS1) was of a pioneering nature and is no longer disseminated.
- Country coverage: The CVTS3 and CVTS2 cover the EU-27 member states and Norway (except Cyprus, Malta and Slovakia in CVTS2; in the case of Poland, only the Pomorskie region is in CVTS2). For the UK, however, the results from the two surveys are not comparable.
- Industry coverage: Agriculture, fishery, education and health are not covered by the surveys.
- Industry detail: Data are available for 6 macro industries and 21 branches (CVTS3 is not yet available for 21 branches).
- Variable of interest for our estimates:. *Cost of CVT courses as a % of total labour cost (all enterprises)*.

Estimation method

*Training expenditure = Cost of CVT courses as a % of total labour cost * Compensation of employees (from NA)*
We assume that 100% of spending is GFCF.

The estimation method for the years not covered by the survey

- We have held the share constant for the years before 1999, and we have (linearly) interpolated values for the years between 1999 and 2005.

- We have applied our estimation method at the industry level and then aggregated it to obtain national-level estimates in order to reflect changes in industry composition.

Further improvements and refinements

Use more disaggregated results for CVTS3 when these are available.

Organisational structure

The literature dealing with the issue of the measurement and evaluation of intangibles' considers organisational capital to be one of the most important contributors to corporate performance and growth. The concept of organisational capital refers to "an agglomeration of technologies – business practices, processes and designs, and incentive and compensation systems – that together enable some firms to consistently and efficiently extract from a given level of physical and human resources a higher value of product than other firms find possible to attain" (Lev and Radhakrishnan 2005). According to the short literature review in Lev and Radhakrishnan (2005), some studies on organisational capital view this resource as embodied in employees (e.g., Jovanovic, 1979; Becker, 1993), whereas others view organisational capital as being beyond that embedded in people and define it as "a firm-specific capital good" (Arrow 1962; Rosen 1972; Tomer 1987; Ericson and Pakes 1995; and also Lev and Radhakrishnan 2005).

Corrado, Hulten and Sichel (2005) include investment in organisational change and development in their definition of economic competencies. They follow the firm-embodied concept of organisational capital, but with a very important peculiarity. Most of the literature assumes that organisational capital is acquired by endogenous learning-by-doing (i.e., it is jointly produced with measured output) or through other externalities deriving from IT or R&D management, for example. Externalities are excluded by the Corrado, Hulten and Sichel expenditure-based approach (so that their approach is consistent with the SNA).

Corrado, Hulten and Sichel define investments in organisational change and development as the sum of two components: the purchased component (represented by management consultant fees) and the own-account component (represented by the value of executive time spent on improving the effectiveness of business organisations, i.e., the time spent on developing business models and corporate cultures). Therefore, the Corrado, Hulten and Sichel investment in organisational structure can be thought of as a subset of organisational capital, as it is usually referred to in the literature.

In our opinion, the Corrado, Hulten and Sichel definition of organisational structure meets the definition of an asset. It is rather obvious that it produces economic benefits for more than one year. Moreover, it also meets the ownership criterion as it can be retained by the firm. In other words, following the categorisation proposed by the European Commission through the MERITUM project, it is a form of structural capital because it stays with the firm after the staff leaves at night (and it is not a form of knowledge that employees take with them when they leave at night).

Data sources and estimation method for the own-account component

Data sources

To preserve cross-country comparability and consistency with national account data, we base our estimates on the Structure of Earnings Survey (SES) and the Labour Force Survey (LFS).

1) Structure of Earnings Survey

SES represents EU-wide, harmonised structural data on gross earnings, hours paid and annual days of paid holiday leave that are collected every four years. It gives detailed and comparable information on the relationships between the level of remuneration, individual characteristics of employees (e.g., gender, age, occupation, length of service, highest educational level attained) and their employers (economic activity, size and location of the enterprise).

Survey description

- Years available from Eurostat's website: The Eurostat website provides data only for the 2002 survey. In the near future, the results for the year 2006 will also be available.
- Country coverage: The 2002 SES covers all EU member states as well as the candidate countries, Bulgaria and Romania, and the European Economic Area countries, Iceland and Norway.
- Industry coverage: The statistics of the 2002 SES include enterprises with at least 10 employees in the areas of economic activity defined by sections C-K of NACE Rev. 1.1. The inclusion of sections L-O is optional for 2002, as is the inclusion of enterprises with fewer than 10 employees; all enterprises are, however, included for several countries (Cyprus, Germany, Estonia, Finland,

Hungary, Ireland, Lithuania, Latvia, the Netherlands, Norway, Poland, Slovenia, the Slovak Republic and the UK).

- Variable of interest for our estimates: *Mean annual earnings by profession*.

Industry detail: The NACE one-digit level was used, but the variable of interest for our estimates (*mean annual earnings by profession*) from the Eurostat website is only available at the aggregate level.

2) Labour Force Survey (LFS)

The EU LFS is a quarterly household sample survey administered in the EU member states, candidate and European Free Trade Association (EFTA) countries (except for Liechtenstein). It is the main source of information about the situation and trends in the labour market in the EU. It provides data on employment, unemployment and inactivity together with breakdowns by age, gender, educational attainment, temporary employment, full-time/part-time status and many other dimensions. The survey's target population is all persons aged 15 years or older living in private households.

Survey description

- Years available and country coverage: Data for all member states are mostly available from 1999 or 2000 onwards. Data relating to the former EU-15 are available from 1995 onwards. Data relating to the former EU-12 are available from 1987 onwards. Results for the candidate countries date back to 2002 and for the EFTA countries to 1995.
- Variable of interest for our estimates: *Number of employees by occupation*.

Estimation method

- Estimate the *gross earnings of managers* and *gross earnings of all employees* by multiplying the mean annual earnings (from the SES) by the number of employees (from the LFS).
- Calculate the share of gross earnings of managers as:

manager_comp_share = Gross earnings of managers / Gross earnings of all employees.

- Estimate the total expenditure for management compensation consistent with national accounts data by applying the share of gross earnings of managers to the total compensation of employees:

*manager_comp = manager_comp_share * Compensation of employees (from NA).*

- Make an assumption about what proportion of spending is to be considered investment (*inv_share*). Following Corrado, Hulten and Sichel (2005), we have assumed *inv_share*=20%.
- Estimate the value of own-account investment in the organisational structure (*own_organiz_structure*) by applying the investment share to the total manager compensation:

*own_organiz_structure= manager_comp * inv_share.*

Estimation method for the years not covered by the survey
Because, for the time being, only the 2002 SES is available, we have held *manager_comp_share* constant to the value for the year 2002.

Further improvements and refinements

- When the SES for the year 2006 is available, we can interpolate to obtain a time-varying share.
- Apply the proposed method at the industry level and then aggregate to obtain national-level estimates to reflect changes in industry composition.

The Eurostat website does not cross-classify data by industry and category of occupation. Possible sources of more disaggregated data are listed below.

- We can ask national statistical institutes if they can disseminate the data cross-classified by industry and category of occupation.
- The Eurostat website notes that, at present, access to the SES micro data is only possible through the SAFE Centre at the premises of Eurostat in Luxembourg. The confidential micro data of (in principle) 15 countries are covered,[24] depending on the authorisation of use by these countries.
- LEED data constitute an additional source.

Possible bias in the results

The share of legislators, senior officials and managers (ISCO1) in the total number of employees in the LFS shows a high degree of variation across countries (e.g., about 14% in the UK and about 3% in Italy and Germany). It may be that

[24] These are Cyprus, the Czech Republic, France, Hungary, Ireland, Lithuania, Latvia, Luxembourg, Poland, Portugal, Romania, Sweden, Slovenia, Slovakia and Norway.

this variation stems from a lack of comparability of results across countries, but it requires further investigation.

Data sources and estimation method for the purchased component

The purchased component can be computed using the nominal gross output or turnover of the NACE 2002 version of industry "7414 – Business and management consultancy activities".

Data sources

The data sources are annual, detailed enterprise statistics on services from the Structural Business Statistics (Annex 1), with the following caveats:

- Eurostat or OECD website data at the four-digit level of disaggregation for NACE 7414 are only available for Italy, Germany and Ireland; and
- for many countries, only a long time series is available.

Concerning the Structural Business Statistics on Business Services (available from the Eurostat website),

- the turnover of NACE 7414 is available, and
- data are available only for some selected countries and some selected years (see Table 5)

A further source is the FEACO Survey of the European Management Consultancy Market[25]. Table 5 reports the data source that is used for each country.

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[25] FEACO is the European Federation of Management Consultancies Associations, the European umbrella organisation for 20 national management consultancies associations, and it is the sole European federation representing and promoting the management consulting sector.

Table 5. Structural Business Statistics on Business Services (millions of euros)

Structural Business Statistics on Business Services nace 7410 - Turnover					
	2001	**2002**	**2003**	**2004**	**2005**
Austria	-	-	-	-	-
Belgium	-	-	-	-	-
Bulgaria	-	-	-	-	-
Cyprus	-	-	-	-	-
Czech Republic	-	-	-	-	-
Denmark	1,648	-	1,185	1,509	1,746
Estonia	-	-	-	-	-
Finland	1,102	-	-	1,172	-
France	15,031	-	-	-	-
Germany	-	-	-	16,327	-
Greece	-	-	764	762	-
Hungary	-	-	-	-	-
Ireland	-	-	-	-	-
Italy	-	-	-	-	-
Latvia	-	-	31	57	-
Lithuania	-	-	-	91	-
Luxembourg	-	-	178	-	-
Malta	-	-	-	52	-
Netherlands	-	-	-	-	-
Poland	-	-	1,871	-	-
Portugal	1,379	-	-	2,181	3,794
Romania	-	-	-	691	863
Slovakia	-	-	-	107	-
Slovenia	-	-	475	343	391
Spain	2,630	-	3,059	3,029	3,552
Sweden	5,262	-	4,399	4,511	4,940
United Kingdom	31,862	-	28,224	30,211	-
Norway	-	-	-	1,048	1,248

Table 6. Main Data Source for Purchased Organisational Structure

Country	**Source**
Austria	feaco
Belgium	feaco
Bulgaria	feaco
Cyprus	business surveys
Czech Republic	feaco
Denmark	business surveys
Estonia	business surveys
Finland	business surveys
France	business surveys
Germany	business surveys
Greece	business surveys
Hungary	feaco
Ireland	business surveys
Italy	business surveys
Latvia	business surveys
Lithuania	business surveys
Luxembourg	business surveys
Malta	feaco
Netherlands	feaco
Poland	business surveys
Portugal	business surveys
Romania	business surveys
Slovakia	business surveys
Slovenia	business surveys
Spain	business surveys
Sweden	business surveys
United Kingdom	business surveys
Norway	business surveys

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Appendix 1 List of variables in the macro approach

Variables already included in gross fixed capital formation from national accounts

1. Computer software (LUISS)	National accounts
2. Computerised databases (LUISS)	Special research
3. Mineral exploration (LUISS)	National accounts; expenditure on prospecting for new oil wells with the expectation of future returns
4. Copyright and licence costs (LUISS)	National accounts

Variables for which official, well-known sources are available

5. Scientific R&D (CEPS)	BERD (Business Expenditure on Research and Development)
	ANBERD, Community Innovation Survey, national accounts
6. Firm-specific human capital (LUISS)	OECD and Eurostat surveys on training

Variables for which ad hoc sources or estimation methods were used

7. New product development costs in the financial industry (LUISS)	National accounts
8. New architectural and engineering designs (LUISS)	National accounts
9. Market research (CEPS)	Special survey
10. Advertising expenditure (CEPS)	Special survey
11. Own account development of organisational structures (LUISS)	Ad hoc examination of national resources
12. Purchased organisational structures (LUISS)	Examination of revenues
13. R&D in social science and humanities (CEPS)	Ad hoc research
14. Intangible capital creation through market restructuring (LUISS)	LEED data

Appendix 2 Industry coverage macro approach

Industry coverage	
c_to_k_o	***All NACE branches covered by CVTS (Continuing Vocational Training)***
c_e_f_h_i	**Mining and quarrying; electricity, gas and water supply; construction; hotels and restaurants; transport, storage and communication**
c	Mining and quarrying
d	**Manufacturing**
da	Manufacture of food products; beverages and tobacco
db_dc	Manufacture of textiles and textile products; manufacture of leather and leather products
dd_dn	Manufacture of wood and wood products; manufacturing n.e.c.
de	Manufacture of pulp, paper and paper products; publishing and printing
df_to_di	Manufacture of coke, refined petroleum products and nuclear fuel; chemicals, chemical products and man-made fibres; rubber and plastic products; other non-
dj	Manufacture of basic metals and fabricated metal products
dk_dl	Manufacture of machinery and equipment n.e.c.; manufacture of electrical and optical equipment
dm	Manufacture of transport equipment
e	Electricity, gas and water supply
f	Construction
g	**Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods**
g50	Sale, maintenance and repair of motor vehicles
g51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
g52	Retail trade, except of motor vehicles, motorcycles; repair of personal and household goods
h	Hotels and restaurants
i60_to_i63	Land transport; transport via pipelines; water transport; air transport; supporting and auxiliary transport activities; activities of travel agencies
i64	Post and telecommunications
j	**Financial intermediation**
j65_j66	Financial intermediation, except insurance and pension funding; insurance and pension funding, except compulsory social security
j67	Activities auxiliary to financial intermediation
k_o	**Real estate, renting and business activities; other community, social, personal service activities**
k	Real estate, renting and business activities
o	Other community, social, personal service activities

Preferred estimation method (based on business survey data)

1. Calculate the share of turnover of industry 7414 in the turnover of industry 74 from survey data (Structural Business Statistics):

NACE7414_share = NACE7414_turnover / NACE74_turnover.

2. Estimate the gross output of NACE 7414 consistent with the national accounts by applying the share to the gross output of industry 74 from the national accounts:

*NACE7414_output = NACE7414_share * NACE74_output.*

3. Estimate the share of turnover of NACE 7414 purchased by the business sector (*NACE7110_enterprise_share*) from the data disaggregated by client type (information available from both the Structural Business Statistics on Business Services and the FEACO survey).
4. Estimate the business sector expenditure on organisational structure as:

organiz_structure_expenditure = NACE7110_enterprise_share NACE7414_output.*

5. Make an assumption about what proportion of spending is to be considered investment (*inv_share*). Following Corrado, Hulten and Sichel, we have assumed *inv_share=80%*.
6. Estimate the value of investment in organisational structure (*purch_organiz_structure*) by applying the investment share to the managers' total compensation:

*purch_organiz_structure= organiz_structure_expenditure * inv_share.*

Alternative estimation method (based on the FEACO survey)

- Assume that *NACE7414_output* = total turnover in management consulting from the FEACO survey.
- Replicate points 3-6 from the preferred estimation method above.

Estimation method for the years not covered by the survey

We have held *NACE7414_share* constant.

Further improvements and refinements

- Extend the country coverage and the time span of the data on turnover of NACE 7414 from the Structural Business Survey. Possible sources of more disaggregated data are national statistical institutes and Eurostat.
- Estimate investment in purchased organisational structure using a commodity flow approach, e.g., as output + imports – exports. Data on imports and exports of services are available from balance of payments statistics, but further investigation is needed to determine whether the data are available at the level of disaggregation required for our estimates.
- Revise the assumption about *inv_share* on the basis of information on the type of management consultancy service provided (this information is available from both the Structural Business Statistics on Business Services and FEACO).

FIRM-LEVEL INTANGIBLE CAPITAL IN SIX COUNTRIES: FINLAND, NORWAY, THE UK, GERMANY, THE CZECH REPUBLIC AND SLOVENIA

Hannu Piekkola, University of Vaasa (UNIVAASA)
Mikko Lintamo, University of Vaasa (UNIVAASA)
Rebecca Riley, National Institute of Economic and Social Research (NIESR) & LLAKES
Catherine Robinson, Swansea University & WISERD
Kurt Geppert, Germany Institute for Economic Research (DIW)
Bernd Görzig, Germany Institute for Economic Research (DIW)
Anne Neumann, Germany Institute for Economic Research (DIW)
Morten Henningsen, Statistics Norway, Research Department for Labour Market (STATNO)
Terje Skjerpen, Statistics Norway, Research Department for Labour Market (STATNO)
Stepan Jurajda, Center for Economic Research and Graduate Education of Charles University and the Economics Institute, Academy of Sciences of the Czech Republic (CERGE–EI)
Juraj Stancik, Center for Economic Research and Graduate Education of Charles University and the Economics Institute, Academy of Sciences of the Czech Republic (CERGE–EI)
Miroslav Verbic, Institute for Economic Research (IER)

1 Firm-Level Intangible Capital: State of Art

Investment in intangible assets has been shown to be an important factor in the performance of European and US companies that increases Tobin's q (e.g., Piekkola 2010, Lev and Radhakrishnan 2005). Intangible capital-type work is an element of the total factor productivity of Finnish firms (Ilmakunnas and Piekkola, 2010). It is often understood that intangible capital explains a substantial part of the difference between the market value (stock market value plus liabilities) and the balance sheet value of tangible assets (for recent studies, see Brynjolfsson and Hitt, 2000, and Brynjolfsson, Hitt, and Yang 2002). Using Australian data, Webster (2000) found that the ratio of intangible to all enterprise capital rose by 1.25% annually over 50 years up to 1998. The World Bank (2006) found an increasing gap between total wealth (measured as the net present value of future sustainable consumption) and natural and produced capital in the 120 countries studied. The gap, referred to as intangible capital and comprising human capital, trust, and the value of institutions, constitutes the largest share of wealth in virtually all countries, with Nordic countries at the top of the list of richest countries, followed by Switzerland, the US and Germany.

Company-level intangible capital focuses on organisational capital, R&D capital and databases and software that either are own-account investments or were purchased from other companies (Sichel, 2008). At the country level, as reported by Jona-Lasinio and Iommi (2011) and in the second article of this volume, organisational capital (economic competence, excluding training) accounts for 38% of all intangible capital in the EU27 area and 33% in Finland, making it very important.

The performance-based approach taken here values intangibles by their productivity or profitability. Cummins (2005) used the discounted value of profit forecasts as a key to evaluating the intangible capital inherent in the firm. He included the adjustment costs in the estimated return on each type of capital (tangible and intangible) from US firm-level panel data. He found R&D and advertising insignificant, whereas sizable intangibles were created by information, communications, and technology (ICT). McGrattan and Prescott (2008) used profits as the performance measure, with the assumption of equal after-tax returns to tangible and intangible assets. They calculated the range for the value of intangible capital to be from 31 to 76% of the US GDP.

Lev and Radhakrishnan (2005) measured the contribution of intangible capital as the difference in sales growth with versus without intangible capital to estimate a production function in US firms. Piekkola (2010) found Lev and Radhakrishnan's instrument for organisational capital, "selling, general and administrative expenses" to be rather sensitive to economic cycles using Finnish data. In any case, both Lev and Radhakrishnan (2005) and Piekkola (2010) found that not all intangible capital is appropriately valued in analysts' forecasts. Thus, intangibles have significant predictive power for the future performance and market value of corporations.

Innovative growth requires investment in intangibles, most of which are imprecisely valued in any balance of accounts. There is a clear need for a broad view of intangible capital-type work that includes managerial and marketing work. More and more of the expenditures on marketing and organisational investment need to be recognised as intangible investments that increase productivity over a longer period. Organisational capital is also more clearly firm specific and owned by the firm than are other types of intangibles (Youndt, Subramaniam and Snell 2004; Subramaniam and Youndt 2005; Lev and Radhakrishnan 2003 and 2005). Organisational capital is less tradable than other forms of intangible capital and cannot be invested with only long-term goals, similar to investment in R&D. In turn, R&D expenditures are the first and only recognised type of intangible capital to be included in the satellite accounting of GDP by the OECD.

Investments in information and communications technology (ICT) are the third intangible capital-type work and also complement organisational work, as found in Ito and Krueger (1996) and Bresnahan and Greenstein (1999). ICT work needs to be analysed in conjunction with organisational capital, even in industries such as business services and finance. Indeed, Hitt and Yang (2002) argue that the reportedly high returns on ICT investments can be largely explained by a relation between the utilisation of ICT and skilled workers on one hand and human resource management on the other. We analyse intangible capital-type work and measure investment in organisational capital (long-term investment in management and marketing activity), along with intangible investment from all other intangible capital-type work, by accounting for expenditures and for productivity differences compared with other work.

2 Firm-Level Intangible Capital: Methodology

In the micro approach of the INNODRIVE project and in building up the harmonised data and methodology, an integral part of the analysis is to divide the intangible capital of firms into amounts related to organisational work, ICT and R&D. The basic idea in this project is that each firm produces goods of the following types:

- Information and communications technology (ICT),
- Research and development (R&D), and
- Organisational capital (OC).

It is assumed that the firm exclusively directs production of these types of goods towards own uses. If they are not used in the current year, these types of goods can be classified as intangible capital goods, which are not counted as investments in conventional calculations of capital stocks and depreciation, such as the national accounts. To produce these types of capital goods, firms apply resources supplied by different factors of production: labour, intermediate, and capital services. To assess labour services, we distinguish three types of labour input: ICT-, R&D-, and OC-related personnel (see table).

- *ICT* personnel are information and communication experts.
- *R&D* personnel are technicians, engineers, and similar occupations.
- *OC* personnel are management (including owners) and marketing employees.

The valuation of organisation and R&D capital is performed econometrically by the methodology explained in Görzig, Piekkola and Riley (2010). We assume that only a certain fraction of these personnel are involved in the production of intangible goods. The remaining employees of the respective types of labour are engaged in current production, which means that the service life of the goods they produce is less than a year.

We assume that the weighted average relation between the production factors (labour, intermediates, and capital) in these industries can also be taken as an indicator of the cost structure in own-account production of these types of goods in the firms. Following Görzig et al. (2010), data for the assessment of these factors are taken as a weighted average using the EU KLEMS database for Germany (40% weight), the UK (30% weight), Finland (15% weight), the Czech Republic and Slovenia (both 7.5% weights). The combined multiplier M_{IC} is the product of the share of intangible-type work and the use of the other inputs.[26]

Table 1. OC, R&D and ICT multipliers and depreciation

	OC	R&D	ICT
Combined weighted multiplier M_{IC}	0.35	1.1	0.7
Depreciation rate δ_{IC}	0.25	0.2	0.33

Overall, organisational investment is 35% of wage costs when the use of intermediates and capital are added to the wage costs, which are 20% of all wage costs in organisational work. In R&D and ICT work, the total wage costs are closer approximations of the total investment. Conventional capital stock estimates use the perpetual inventory method to quantify the capital stock. Using the EU KLEMS methodology, the general definition of the closing stock K_t for an establishment is given by:

[26] Capital cost is the sum of the external rate of return of 4% (representing the market interest rate) and depreciation multiplied by net capital stock.

(1) $$K_t = K_{t-1}(1-\delta) + I_t ,$$

with I_t for the capital formation of the current year and a constant depreciation rate δ. Expenditure-based calculations have been made for every type of intangible expenditure $I_{ICit} \equiv M_{IC} w_{ICit} L_{ICit}$ with $IC = OC,\ R\&D, ICT$. Here, M_X is the weighted multiplier in Table 1 by which labour costs are multiplied to assess total investment expenditures on intangibles, w_{ICit} is the wage cost for every type of worker (deflated by earnings index) and L_{ICit} is the corresponding labour input.

The performance-based approach uses these estimates as a starting point but re-estimates the productivity of organisational workers and R&D workers. In Mankiw, Romer and Weil (MRW) (1992), each individual makes his or her own human capital investment decision as part of a long-term investment (the alternative investment is in physical capital through savings). It is convenient to model the production function following MRW, but with human capital replaced by organisational capital. The organisational capital inherent in each organisational worker is considered fixed and is determined by the combination of labour costs with intermediates and capital, as in the expenditure-based approach. The effective labour input, however, is quality adjusted for the productivity of organisational workers and may thus differ from the wage costs used in the expenditure-based calculations. Indeed, Hellerstein, Neumark, and Troske (HNT) (1999) find a clear productivity-wage gap among managers. They also remark that labour market theory offers no clear explanation for this gap. Ilmakunnas and Piekkola (2010) further provide evidence that in Finland, organisational workers in particular and, to some extent, R&D workers increase profitability so that productivity exceeds wage costs.

In the simplest framework, workers are divided into two categories: organisation workers, OC, and others, non-OC (or R&D and non-R&D workers). The performance-based measure of OC investment is given by:

(2) $$I_{OCit} \equiv M_{OC} \hat{w}_{OCit} L_{OCit} ,$$

where M_{OC} is the total multiplier, as given before in a separate production function (from Table 1), and $\hat{w}_{OCit}$ is the estimated true productivity of OC labour, which may deviate from the wage costs.

3 Intangible capital workers in the six countries

The figures obtained so far have been useful in showing the micro data and evaluating the validity of national measures. The total shares of intangible capital-type workers do not deviate much from one country to another and are typically around 15-18% of all workers. Intangible capital-type workers include organisational workers (the sum of management and marketing workers), R&D workers and ICT workers. Organisational workers are the largest group, with the largest share being found in the UK, at around 12%. The shares of managers are around 9% in the UK, 4% in Finland, 8% in the Czech Republic, 9% in Germany, 3.5% in Norway and 6.5% in Slovenia. We believe that micro data can be used to adjust the national figures. In Germany, the share of managers would be only 2-3% of all workers based on the Labour Force Survey by Eurostat.

R&D workers represent a rather notable share at around 6%. The share of R&D workers is surprisingly low in Germany, at around 5%, although the manufacturing sector is large. Finland, with a 9% share, and Slovenia, with 7%, stand out as the most R&D-intensive countries. In recent years, the share of ICT workers has been 3% on average, and in this category the share is highest (4%) in Norway.

We hold that the use of the share of organisational workers is more appropriate than the use of the share of management workers alone when evaluating organisational structures of the own-account type in the Corrado, Hulten, and Sichel (2006) approach. In fact, including all intangible-type workers in the analysis gives more harmonised figures compared to counting only the number of managers.

Overall, Nordic countries have large amounts of R&D capital and relatively little organisational capital (in management and marketing). Large countries such as the UK and Germany are rather intensive in organisational capital and have relatively less R&D capital.

In most of the countries, intangible capital is around 40% of new value added. Intangible capital intensity has been increasing in the Czech Republic and Slovenia. Overall, our analysis confirms the finding from national-level estimates that countries with less tangible capital invest more in intangible capital, indicating the degree of transition towards a knowledge economy. However, this transformation took place mostly in the 1990s, except in the Czech Republic and Slovenia.

The expenditure-based approach gives only part of the picture regarding the value of intangibles when they are owned by the firm and employees are not fully compensated for the value of intangible production. Indeed, the performance-based approach increases the relative importance of organisational investment, which is also supported by its impact on the market value of Finnish listed firms.

In an analysis of regional effects in Germany, Finland and the UK, company-level productivity is shown to be strongly related to firms' own intangible capital and to regional intangible capital, suggesting positive regional spillovers. Intangibles are agglomerated, with the greater Helsinki area accounting for 49% of all intangibles in Finland and the London city-region accounting for 41% of UK intangibles. In Germany, intangible capital is more dispersed, with the top ten regions accounting for 48.3% of the German total.

Micro-level firm data from the six countries under study vary by country (see the table in appendix 4). For the harmonised methodology, the project manager distributed the Stata econometric package scripts used in collecting LEED data in Finland. Finland and Slovenia have final micro-level data that cover all of the years from 1994-1995 to 2006-2007 and aim to evaluate intangible capital for the years 1998–2006. The most important differences between countries are that job switches from one firm to another cannot be tracked in the Czech data and some countries have data for only some years, as in the case of Germany, which has data only for 1999–2003. Data for the UK cover 1998-2006, but occupational information has to be evaluated using industry and firm size level information. Despite differences in the data, we have been able to construct a harmonised dataset for all of the countries – Finland, Norway, Slovenia, the Czech Republic, Germany and the UK. In constructing the tables, we have deflated earnings by the earnings index in each country based on the evolution of regular wages, with the base year being 2000.

Access to the micro data used in the project is restricted. In general, micro data are made available for researchers based on project descriptions and approval of projects. The rules are usually strict for foreign-based researchers. Data are obtained on a country-by-country basis and are available at a non-aggregated level for the individual researcher only. The LEED data, almost without exception in the research community, are received from data suppliers on the condition that they will not be disseminated.

The UK statistical data come from the Office of National Statistics (ONS), which has Crown copyright and is reproduced with the permission of the controller of Her Majesty's Stationary Office and the Queen's Printer for Scotland. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. Data for Slovenia and Norway are also withheld in the statistical office. The firm-level data in the partner countries are aggregated at the national level using the industry and firm size distributions of firm sales or employees and represent national statistics only at a limited level. This proviso applies for all of the micro data.

3.1 Professions in intangible capital production: compensations and shares

We generated the overall tables on worker structures and employee compensation at the firm level to be used in the estimations. Summary tables are reported in Microsoft Excel format in the data available at www.innodrive.org. All figures reported here are also available on the website. Figure 1 reports the average occupational compensation across the countries by occupation for the year 2003, for which we have data from all six countries.

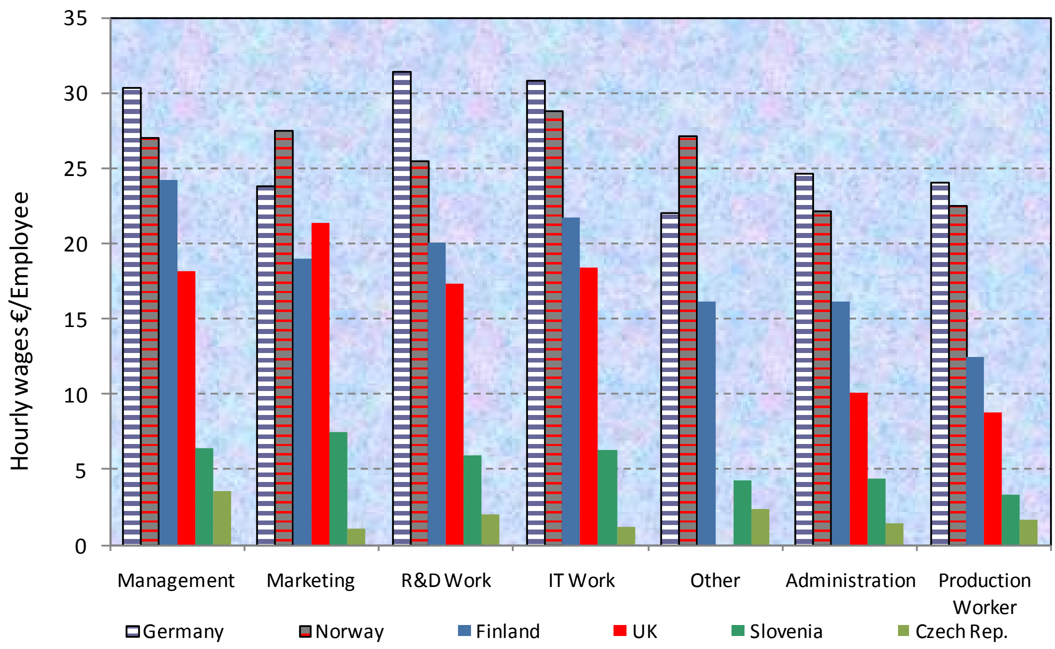

Figure 1. Occupational compensation: Hourly wages including social security tax

Figure 1 reveals that hourly wages are highest in Germany, followed by Norway, Finland and the UK (using exchange rates in conversion of all currencies into

Euros; in the UK, the 'administration' category includes other occupations). The relative wages by occupation in intangible capital-type work show some interesting results. Usually the hourly wages are highest for management work, except in the UK and Norway, where marketing is better paid. Wages in marketing are lowest in Germany, Finland and the Czech Republic and in R&D work in the UK, Norway and Slovenia. It is well known that wages are compressed in Nordic countries. Hourly wage variation is markedly higher in the UK and the Czech Republic than in other countries (see also evidence of wage distribution and gender wage gaps in Finland, Norway and the Czech Republic in the last article of this volume: "*Assessment of the Effects of Intangible Capital on Gender Wage Gaps in the Czech Republic, Finland and Norway*". It is of interest to next examine the distributions of workers across the occupational categories, as shown in Figures 2a and 2b below. Figure 2a shows occupational groups unadjusted for sample composition, while Figure 2b shows the groups' shares of all employees after data is aggregated to be representative of the respective country's economy. Business aggregates are obtained through weighting by the difference between the total sales/employees of firms in the sample and those in the whole business sector in five firm-size and one-digit industry categories.

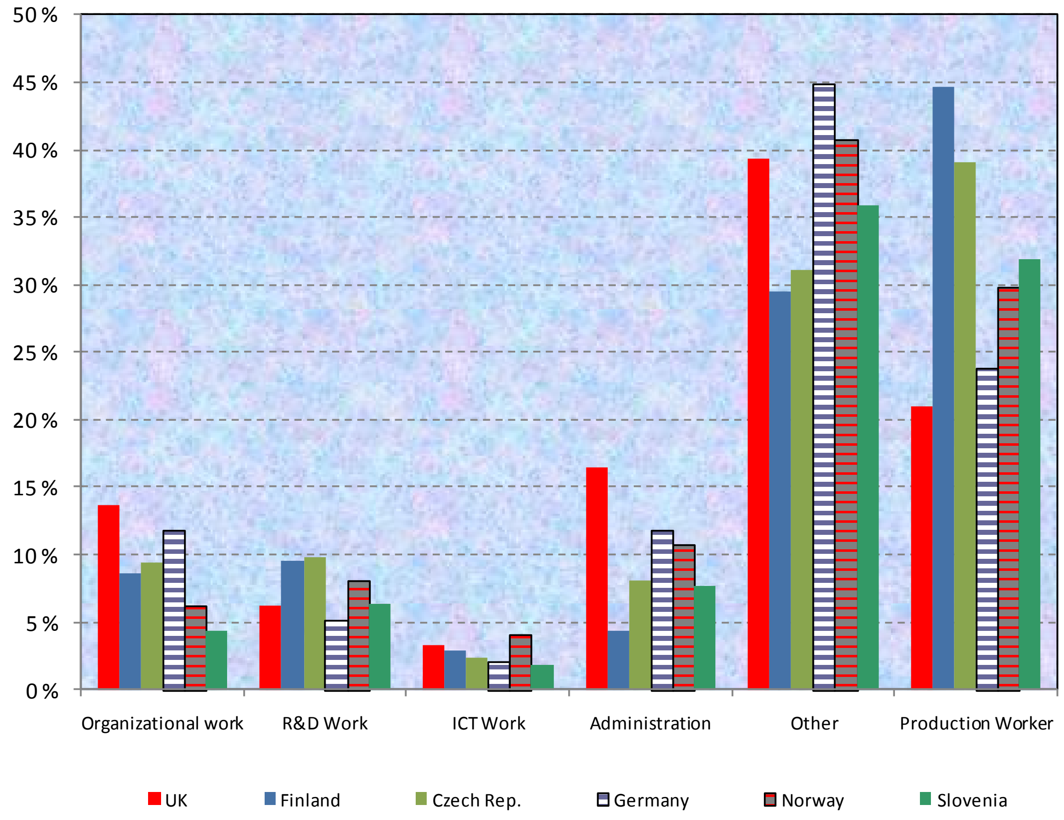

Figure 2a. Occupational shares sample data

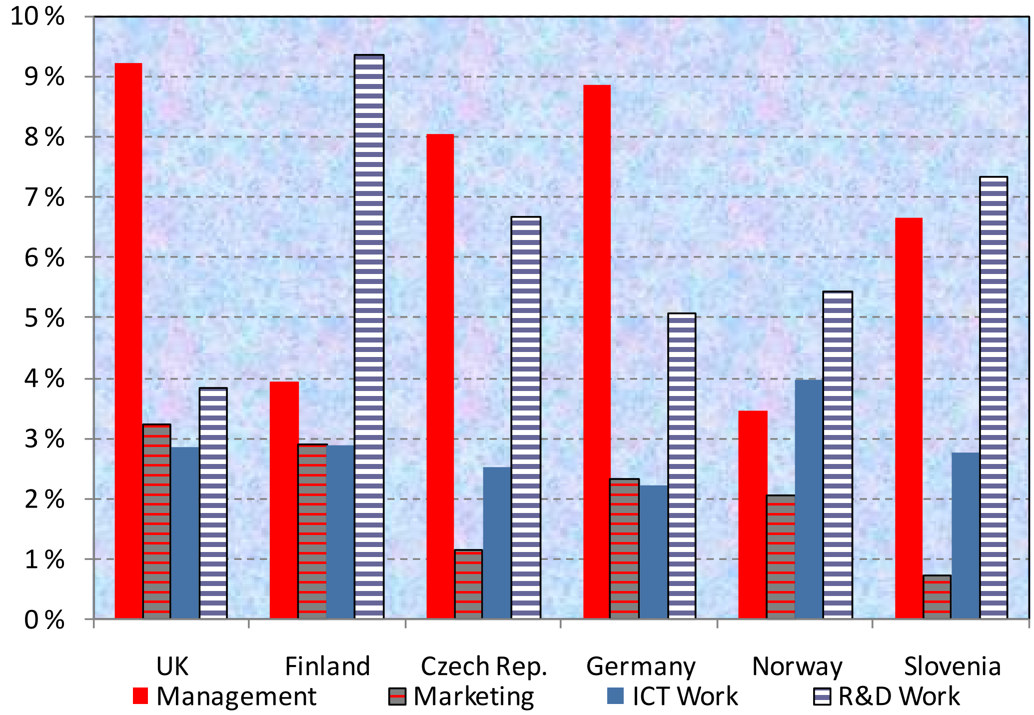

Figure 2b. Occupational shares in intangible capital-type work

It is clear that production workers comprise, on average, approximately 30% of all workers, although production workers are difficult to separate from other types of workers consistently across countries (Figure 2a) Countries are ordered in Figure 2b according to the share of workers engaged in intangible capital-type work. The total shares are all approximately 18%, except for Norway and Finland at 15%. Organisational workers (the sum of management and marketing workers) are the largest group, with the UK showing the largest share at approximately 12% (an unweighted sample would yield a larger figure of 14%, as seen in Figure 2a). The shares of managers are approximately 9% in the UK, 4% in Finland, 8% in the Czech Republic, 9% in Germany, 3.5% in Norway and 6.5% in Slovenia. The share obtained here is lower than that recorded in the Labour Force Surveys by Eurostat for the UK, whereas the share obtained here is higher for Finland and Norway and notably so for Germany. We believe that micro data provide more appropriate figures. The share of managers among all workers in Germany, according to the Labour Force Survey by Eurostat, would be only 2-3%. We also hold that the calculation of the share of organisational workers is more appropriate when evaluating organisational structures of the own-account type in the Corrado, Hulten, and Sichel (2006) approach.

R&D workers represent a rather notable share of all workers at around 6%. The share of R&D workers is surprisingly low in Germany, at around 5%, although the German manufacturing sector is large. Finland, with a 9% share, and Slovenia, with a 7% share, stand out as the most R&D-intensive countries. In recent years, the share of ICT workers has been 3% on average, and the highest share in this category is 4% in Norway.

Figure 3 shows the share of organisational workers over time and reveals the years covered by the data for each country. These figures were created after aggregating the samples to be representative of the corresponding private sector.

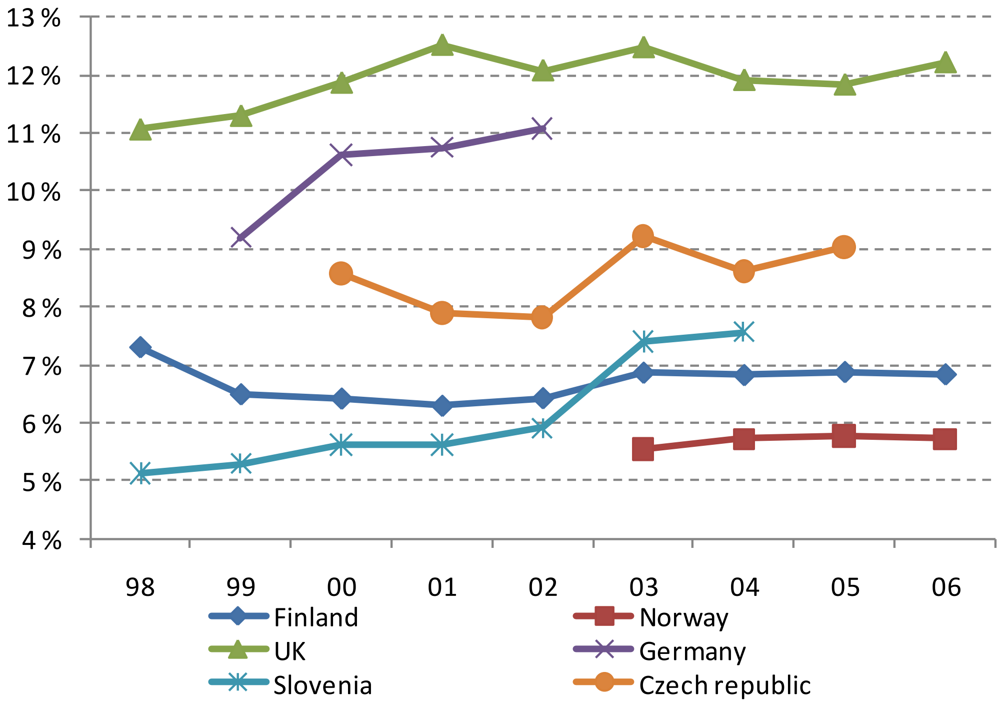

Figure 3. Shares of organisational workers by country

Figure 3 reveals that the share of organisational workers has been increasing in EU8 countries, with the Czech Republic and Slovenia serving as examples here. The UK and Germany have also experienced increasing shares, while the shares have been steady in the Nordic countries of Finland and Norway. In general, the type of organisational work differs by country, possibly because of different occupational classifications. Figure 4 shows the evolution in the share of managers (excluding marketing workers).

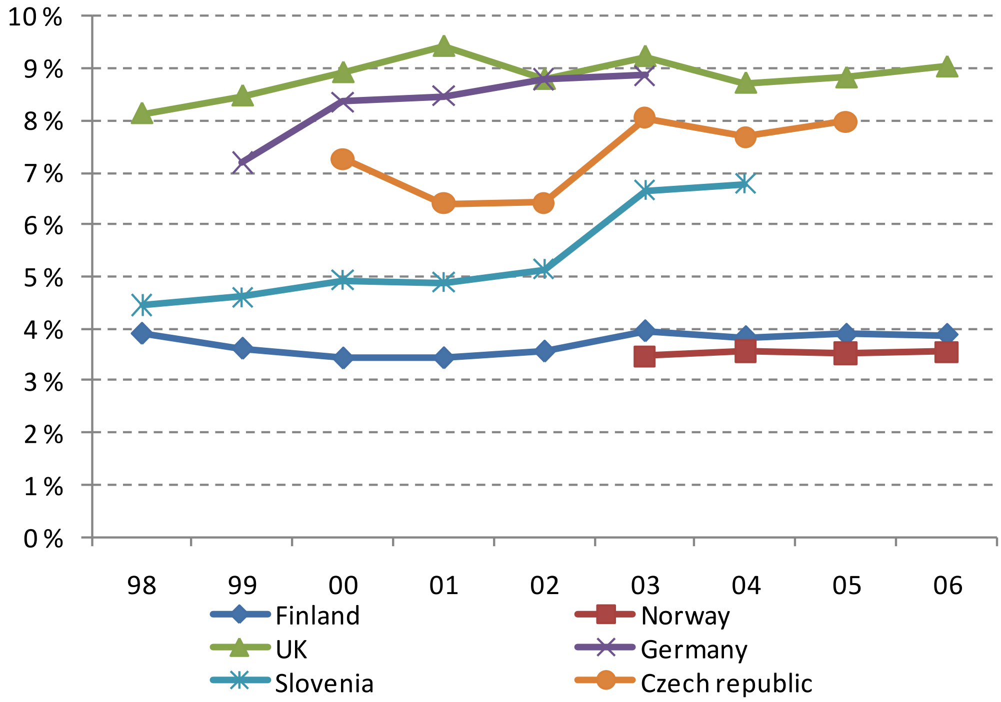

Figure 4. Shares of Managers

The trend in organisational worker shares in Figure 3 closely follows the evolution of the share of management workers in Figure 4 Here it can be seen that the shares of managers have increased in the Czech Republic, Slovenia and Germany. The share in the UK has stabilised to around 9%, and the shares in Finland and Norway are steady at around 4%.

Figure 5 shows the evolution of annual earnings for organisational work over the years.

The figure shows that the relative annual payments are as expected. Management represents a very large share of all workers in the UK, which may explain the lower annual earnings there than in Germany, Finland and Norway. Annual compensation has decreased somewhat in Norway, but this result relates primary to changes in exchange rates.

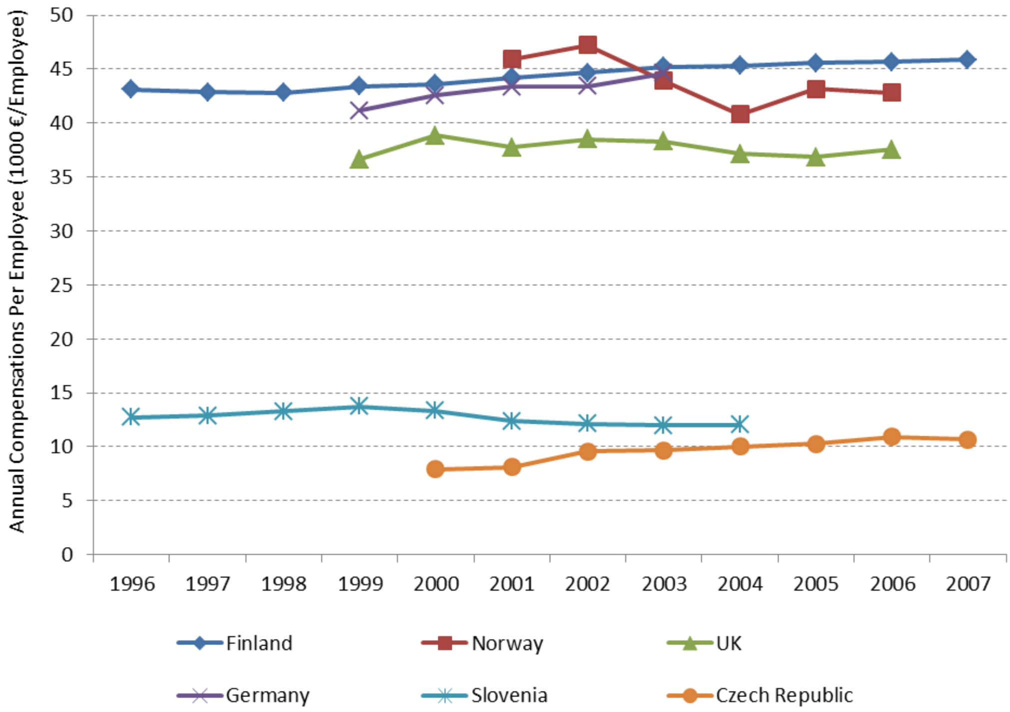

Figure 5. Organisational work: Annual compensation + social security tax

3.2 *Intangible investment at the firm level*

Organisational, R&D and ICT investment per new value added are useful metrics for comparing performance across countries. Stock values have been calculated by assuming a perpetual inventory method and starting values, as explained in Görzig, Piekkola and Riley (2010). The methodology for measuring the starting values differs from the country-level approach in Jona-Lasinio et al. (2010). The comparison with country-level measures is best performed in terms of investment per new value added in the businesses. Note also that the denominator, new value added, includes investment in intangibles. This follows the analogy that new intangibles are 5.5% of GDP and should be included in GDP for the same reasons as databases and software, mineral exploration and some other items that account for less than 2% of GDP in the EU27 area, see the second article of this volume: *"National Measures of Intangible Capital in the EU27 and Norway"*. Figures 6-10 show the evolution of intangible investment per new value added over the years in Finland, Norway, the UK, Germany, the Czech Republic, and Slovenia.

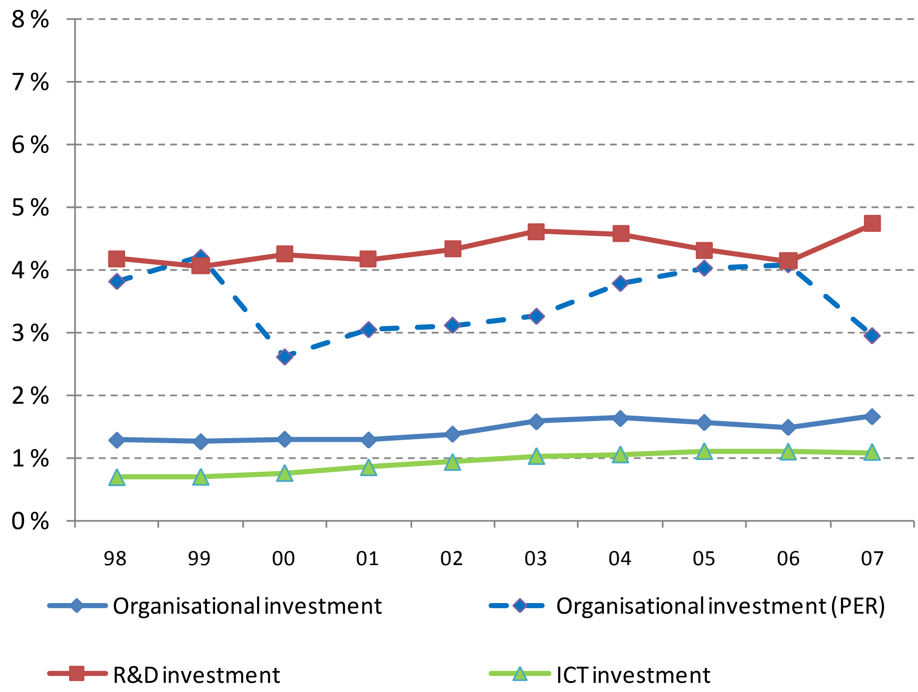

Figure 6. Organisational, R&D and ICT investment per new value added in Finland

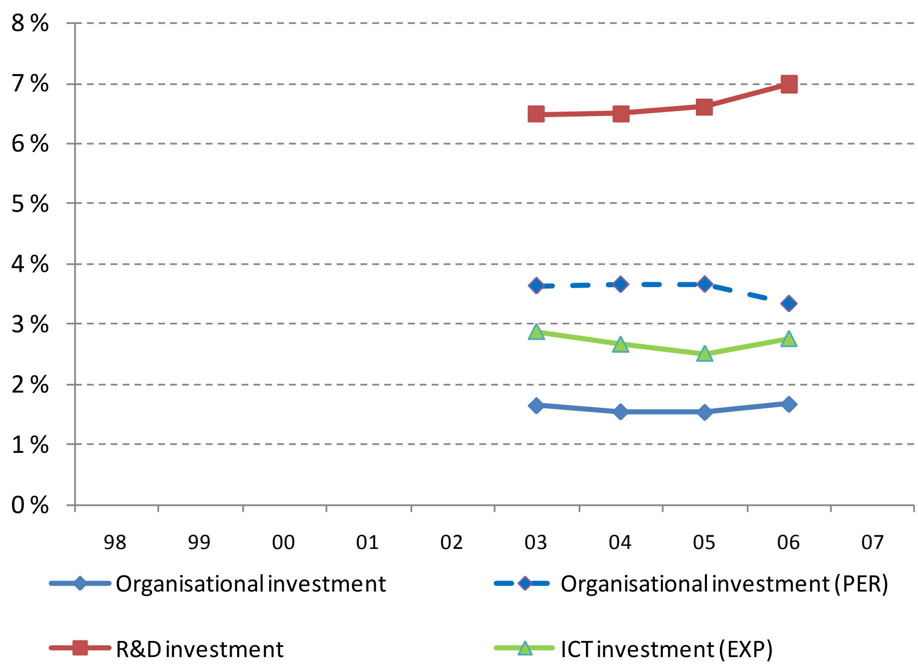

Figure 7. Organisational, R&D and ICT investment per new value added in Norway

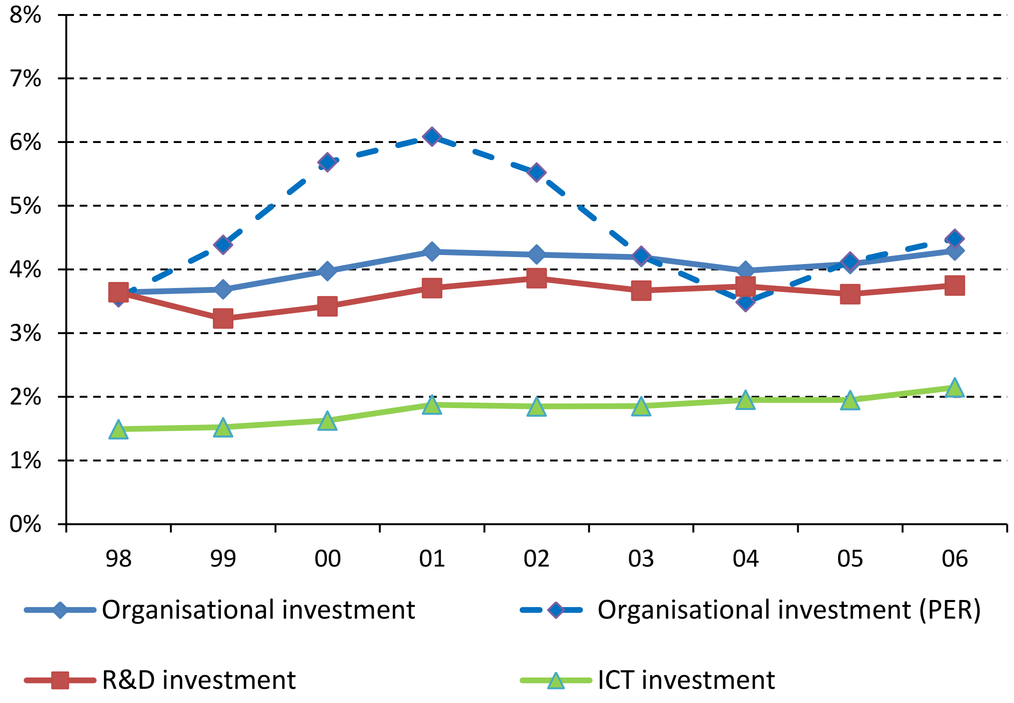

Figure 8. Organisational, R&D and ICT investment per new value added in the UK

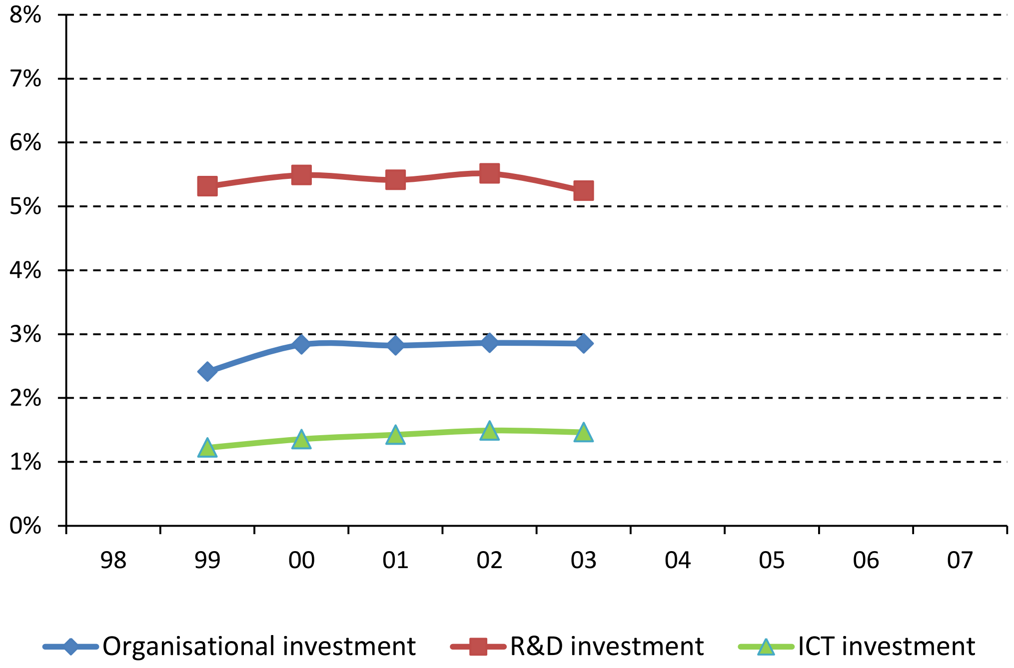

Figure 9. Organisational, R&D and ICT investment per new value added in Germany

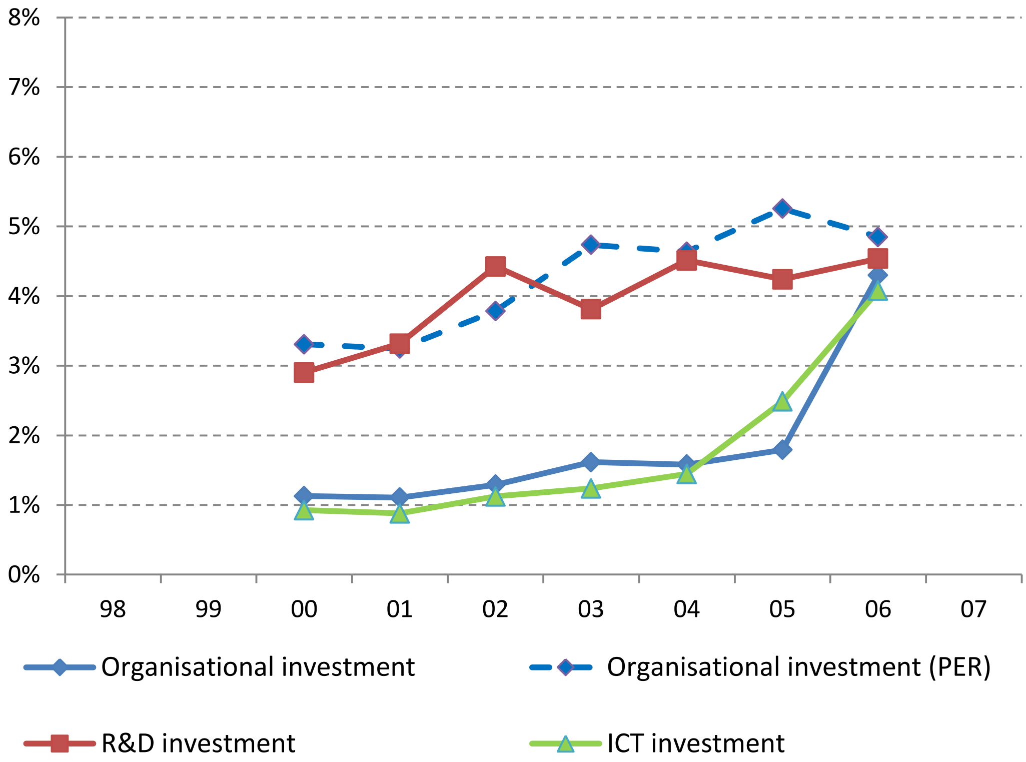

Figure 10. Organisational, R&D and ICT investment per new value added in the Czech Republic

The figures show that the shares of each type of intangible investment per new value added are fairly similar in Finland and Norway. R&D investment is 6-7% of new value added in Norway and 4-5% in Finland. Country-level estimates in Jona-Lasinio et al. (2010) instead suggest that R&D investment is lower in Norway than in Finland. In Norway, R&D activity is hence higher when using a broader definition of occupations with R&D intent than is assumed in national estimates relying on official statistics (GERD data). In company-level estimates, all engineering activity is included in R&D activity, and the worker share was between 5-10% of employees in Figure 2a

We have also reported organisational investment in the performance-based approach in Finland, Norway, the UK and the Czech Republic and described it in detail in Görzig, Piekkola and Riley (2011). The organisational investment is much higher using a performance-based approach in the Nordic countries and the Czech Republic, whereas the difference between expenditure- and performance-based approaches is smaller in the UK. Overall, the differences between investment levels across countries are narrowed. The second observation is that the productivity of organisational workers has decreased over time in Finland and the

UK, although general conclusions are hard to derive based on observations from only a few countries.

In Finland and Norway, as well as for all countries considered, organisational investment appears much higher with a performance-based approach where productivity rather than wage compensation is used to assess the investment rate. Organisational investment now comes close to 3-4% of new value added in Finland and Norway. The observed higher value for organisational investment based on productivity compared to wage compensations implies that organisational investment improves the profitability of the firms, as observed by Ilmakunnas and Piekkola (2010) in a production function estimation in Finland. Here, country differences may again be noticeable. The productivity-wage gap is narrower in the Czech Republic than in Finland according to Jurajda and Stancek (2011). It is noteworthy that the higher productivity can also be explained by productivity capturing the use of intermediates and purchased organisational assets, i.e., by the omitted variables explaining both higher productivity and value added created. These purchased elements of intangibles are not directly available in the company-level data (without any supplementing with internal reporting data). Görzig, Piekkola and Riley (2010) show that other performance-based measures give much the same result. Moreover, the assumed 20% share of organisational workers engaged in production of organisational capital-type goods is likely to be an underestimation of the true share. Thus, part of the higher productivity is explained by the low share of management and marketing employees that is assumed to be engaged in intangible capital productivity. This result implies that expenditure-based estimates are also biased downwards.

Germany has strong R&D activity, with a 5% share of new value added. The organisational investment share of 3% also exceeds that in Nordic countries, whereas it is 1% less than in the UK. The two new EU member countries, the Czech Republic and Slovenia, have been catching up to old EU member states in intangible capital activity. Much of this process involves foreign-owned companies in the Czech Republic. Jurajda and Stancık (2011) show that foreign-owned firms feature larger shares of intangible-type workers, who are more productive in these firms relative to other employees and to workers in domestically owned companies. In the Czech Republic, the share of R&D investment is now at the same level as in Germany, and the share of ICT workers has also increased up to 4%. German firms especially have increased their production in new member countries, and a large part of new R&D activity takes place in these countries as well.

The UK differs from Nordic countries in that organisational investment exceeds R&D activity. It should be observed that the differences between the UK and

Nordic countries would be smaller using the performance-based approach. Thus, we can see that high organisational activity in the UK is associated with lower returns to it. A performance-based approach would thus give more equal measure of the cross-country comparisons because organisational capital deepening is usually associated with lower returns. This is, of course, what we would expect under constant returns to scale. It is also seen that R&D activity is at the same level as in Finland using the broader concept of R&D activity presented here. In Norway and the UK, ICT investment is 2% of new value added, and this figure is lower in Finland. The lower figure in Finland may follow from database and software investments' being classified as R&D activity. Cross-country comparisons of any single item should thus be made with caution. It is indeed useful to have figures for all of the intangible-capital type occupations, where the share of workers is close to 18% of all workers. The cross-country variation is stronger within each occupation group.

The high investment rate in R&D is consistent with the observed R&D intensity of Nordic countries. We also see that Slovenia is R&D intensive, with its level of investment increasing over 8% in recent years. However, the Slovenian data may include the most innovative subset of Slovenian firms, so the country is unlikely to be more R&D intensive than Nordic countries, as the country-level data imply (investment figures are not reported). In country-level data, the GDP share of scientific R&D is 2.2% in Finland and 0.8% in Slovenia. In Germany, R&D investment is around 5% of new value added, and the Czech Republic has been approaching this share in recent years. Again, the sample in the Czech Republic may capture the most innovative subset of businesses, so the increasing share may not apply to all companies. The UK has the lowest share of R&D investment in the sample at around 4%. The variation in R&D investment is large but appears to be lower than in national-level estimates, where Nordic countries stand out as very R&D intensive (except Norway, probably due to some anomaly in the data).

Organisational investment is the second largest category. The UK, with a 5% share, and Germany, with 3%, invest the most in organisational capital. Finland and Norway have the lowest levels of organisational investment of around 1.5% of new value added. Organisational investment has also increased in recent years in the Czech Republic and Slovenia and now well exceeds the level in Nordic countries. ICT investment is between 1-2% of new value added, with the exception of Norway, which has the highest share of 3%.

We next determine the intangible capital per new value added.

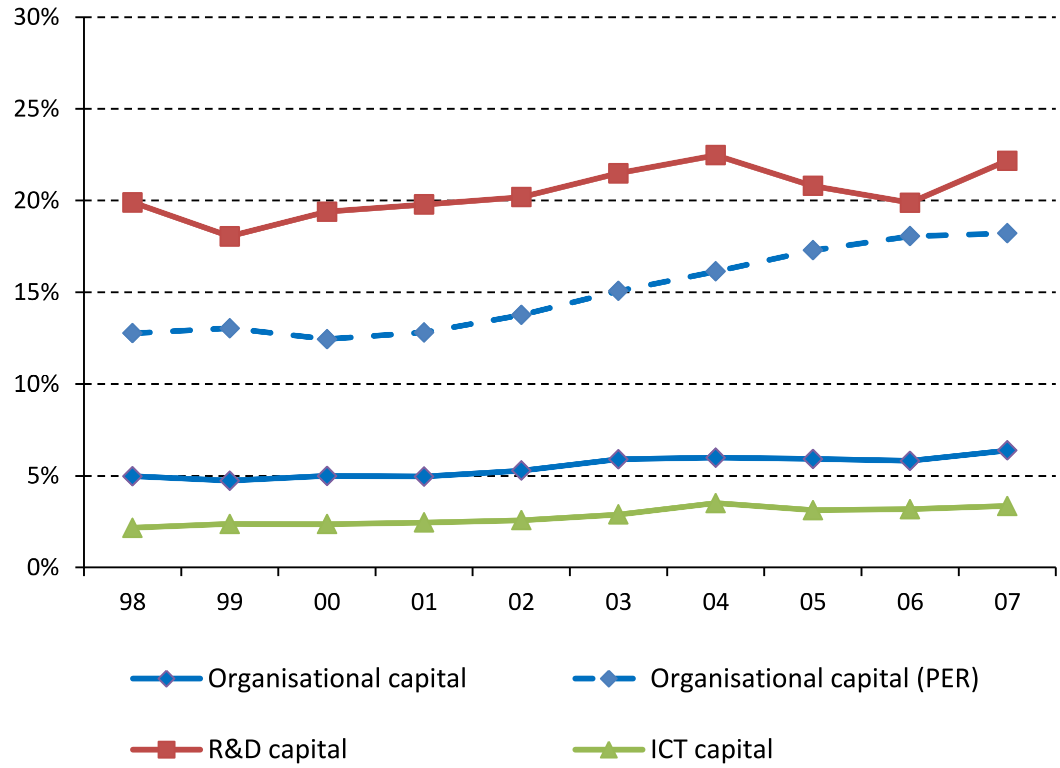

Figure 11. Organisational, R&D and ICT capital per value added in Finland

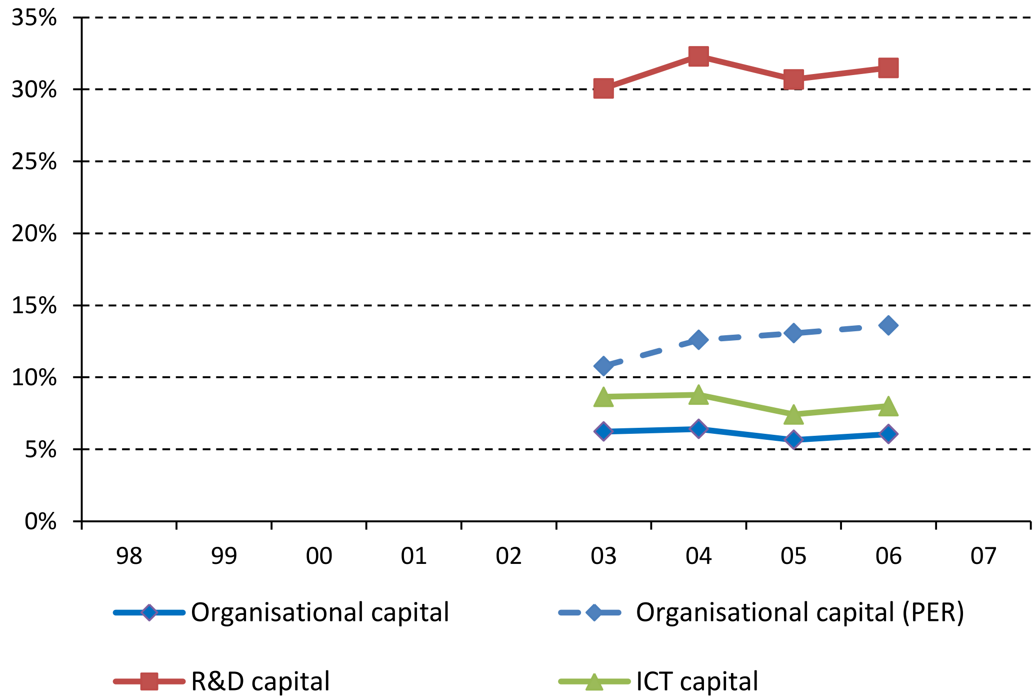

Figure 12. Organisational, R&D and ICT capital per value added in Norway

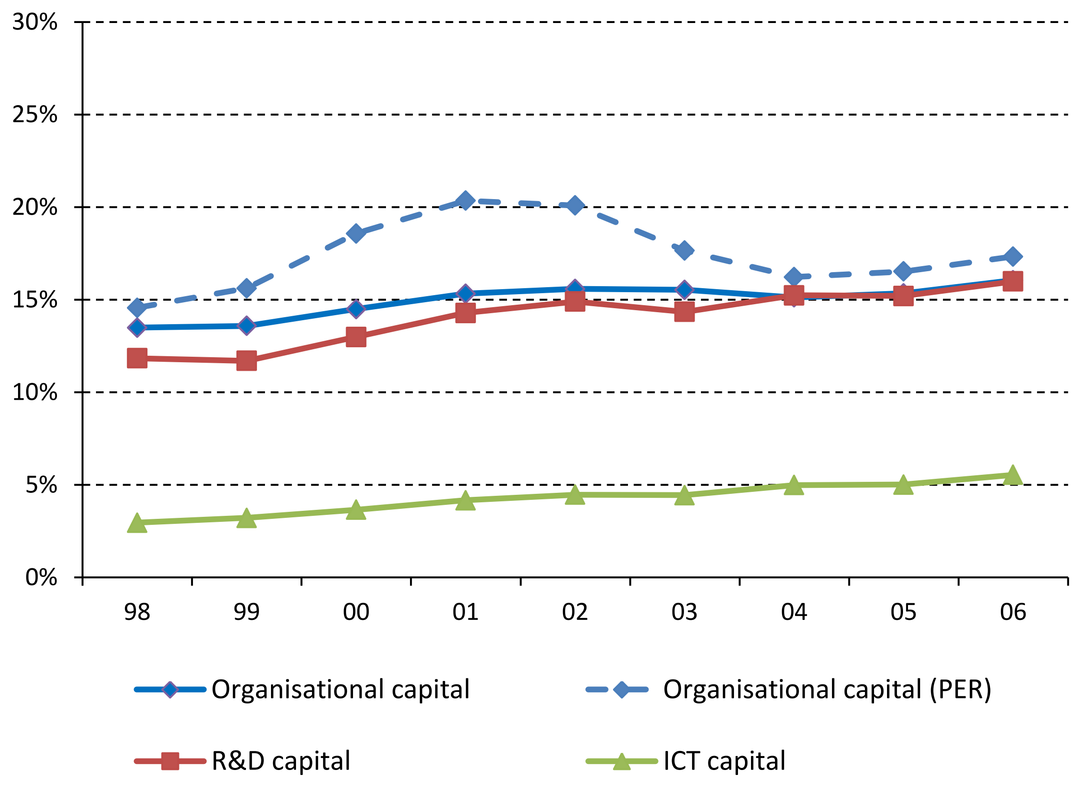

Figure 13. Organisational, R&D and ICT capital per value added in the UK

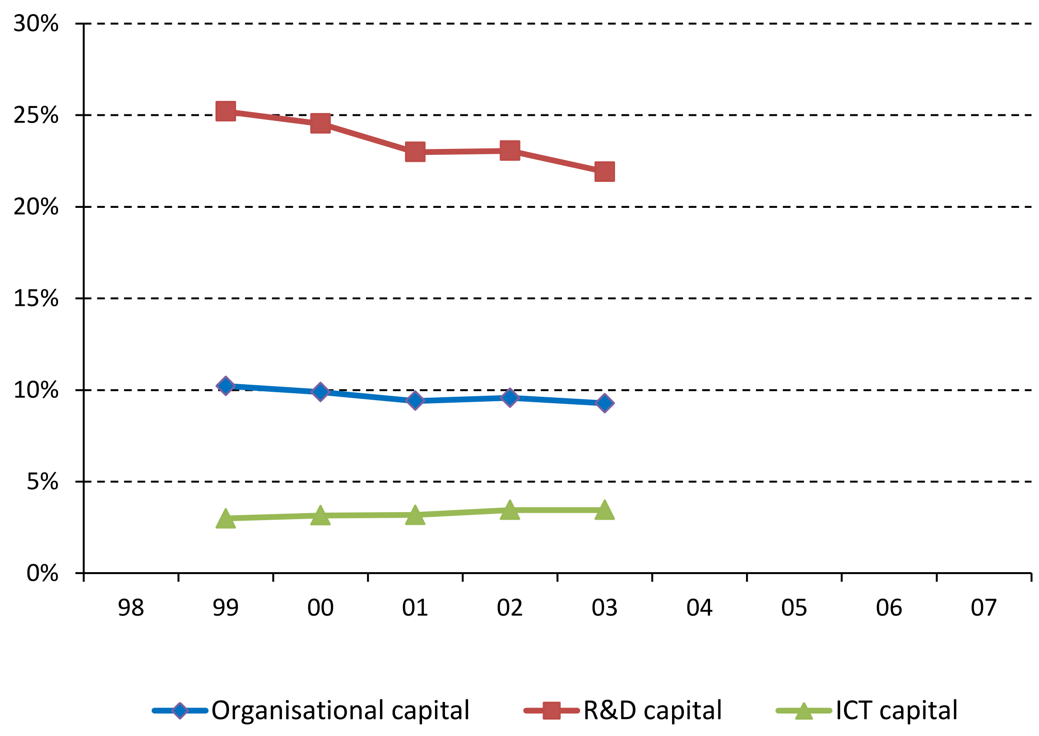

Figure 14. Organisational, R&D and ICT capital per value added in Germany

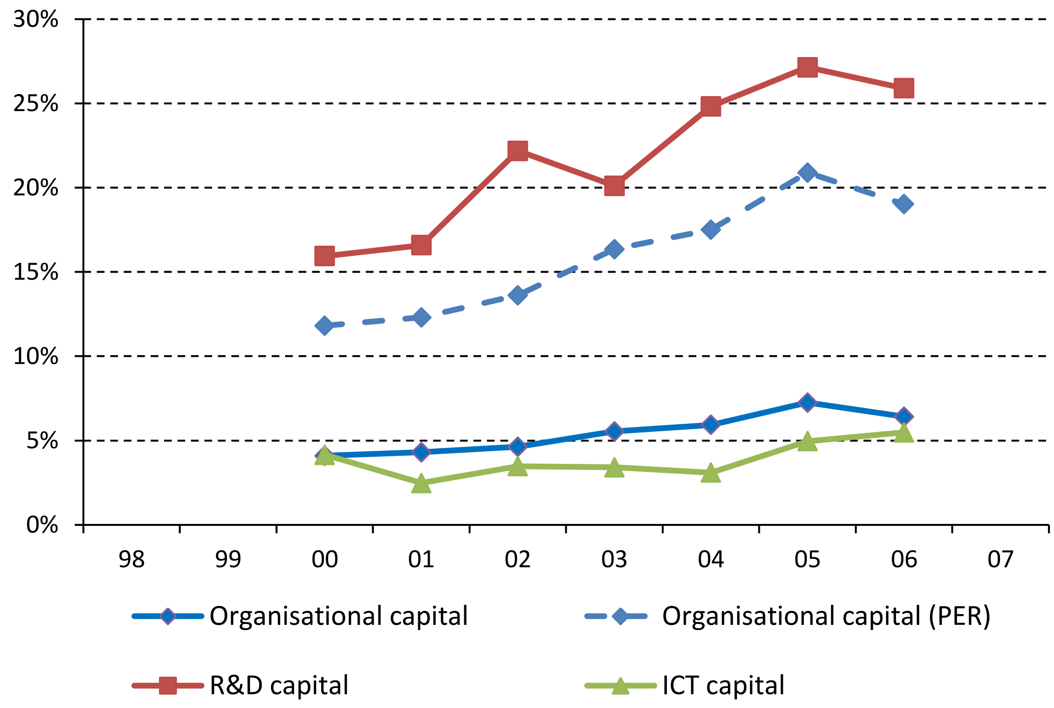

Figure 15. Organisational, R&D and ICT capital per value added in the Czech Republic

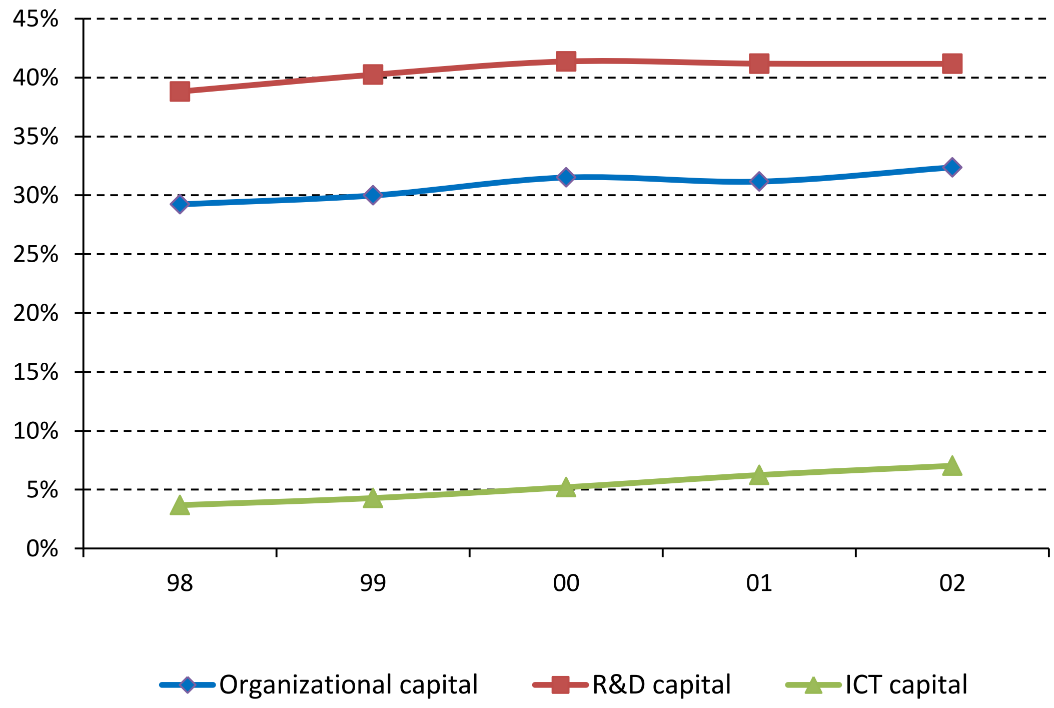

Figure 16. Organisational, R&D and ICT capital per value added in Slovenia

In most of the countries, intangible capital is around 40% of new value added. Intangible capital intensity has increased only in new member states. However, intangible investment is already close to investment in machinery and equipment.

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Appendix 1 Data description by country in the micro approach

Finland

LEED data are useful in an analysis relying on the operation of different tasks and occupations that have emerged in the new wave of globalisation. The labour data are from the Confederation of Finnish Industry and Employers, with 7.9 million person-year and 87,972 firm-year observations for the years 1995–2008. The data include a rich set of variables covering compensation, education and profession. Non-production employees receive salaries, and production workers, who constitute 45% of all workers, receive an hourly wage. There are 41 non-production worker occupations, which are listed in appendix 1. Employee data are linked to financial statistical data provided by the Suomen Asiakastieto to include information on profits, value added and capital intensity (fixed assets). Nearly two thirds of firms in the employee data can be matched to these financial balance sheets. To eliminate firms with unreliable balance sheets, we include in the analysis only firms that have, on average, sales exceeding €1.5 million (in 2000 prices). The final LEED data of 4.1 million person-year observations cover 2,933 firms with 20,115 firm-year observations after dropping the years 1995–97 (used to build up intangible capital). The employee data in the sample cover 379,000 employees annually on average (the original employee data cover 580,000 employees), or almost one fifth of the entire workforce in the private sector.

Employee compensation is estimated from monthly salaries multiplied by 12.5 and from the average figure for social security taxes over the years (30%). The occupational classifications are specific to the data of the Confederation of Finnish Employers and are transformed to those used by all project partners relying on ISCO-88 (see appendix 1). The occupational codes are adaptable to ISCO-88 using additional information on education level (for qualifications) and industrial codes because some occupations are industry specific. Most importantly, the occupations in manufacturing and services are separated. The occupational codes are available for all employees in the firms considered (6,139 firm-year observations). Organisational compensation is derived from occupations classified as related to organisational work (marketing, selling and administration with tertiary education).

Average sales are €95 million (in 2000 prices), and average sales growth has been a rapid 3.2%, although this value has varied between rapid growth of up to 9% in

2000 and moderate growth of 2% in 2002. In firms with operation-based accounting, selling, general and administration expenses account for, on average, 12.4% of sales (in contrast to 17.5% in Lev and Radhakrishnan (2003)). Some 60% of this value relates to administration. The summary tables in appendix 4 reveal that organisational compensation is double R&D compensation and four times ICT compensation.

Norway

All data used in the Norwegian part of the INNODRIVE project are obtained from databases maintained within Statistics Norway. Data on firms are obtained from the structural statistics and accounting statistics, including information on employment, income, costs, assets and liabilities. These data are available at the firm level (as opposed to the lower levels of plants or establishments). The data include the entire population of private, non-financial firms. Each firm has a unique and constant identifier (a firm ID), allowing us to track firms over time. The data may also be linked to surveys on ICT use and R&D.

The Norwegian Tax Directorate's Register of Wage Sums contains detailed information on almost all jobs in the economy, excluding self-employment. We know the start and end dates of each job, the average number of hours worked per week in the job and the sum of wages received by employees within each calendar year for each job. The data also include a unique person identifier (person ID) and the firm ID such that we can link these data to the firm data. Using the person ID, we can also add data on individual educational levels and track workers over time.

The final data source is the database with occupational codes for each job. These are obtained from the social security-linked employer–employee register, where firms report information on all employment relationships. The occupations are coded according to the EU standard ISCO-88(COM).

Hourly wages are not observed directly but have been calculated as the total wage for the job and year divided by the agreed-upon number of hours of work for the period during which the worker was employed in the job during that year.

The Norwegian data on occupations only begin in 2001. Other data are available before then, from 1995 or 1999, but we only use data for the period 2001–06 because the occupational information is central to the INNODRIVE project. The years 2001 and 2002 are used for calculating initial assets for 2003.

We restrict the sample to firms with an average turnover of at least €2 million (measured in year 2000 prices). We also condition a firm's inclusion in the sample on having at least 5 employees every year and at least 30 employees on average during the period of 2001-2006.

The final data contain a total of 23,719 firm-year observations for the period 2001–06. There are 3,834 firms and 468,119 jobs (workers) in our data for 2006. The firms in the final sample employ, on average, 109 employees.

Organisational workers make up 6.5% of employees, with managers accounting for 4.1% and marketing workers for 2.4%. These shares vary only slightly over time.

United Kingdom

Details of UK firms' employees, their occupations, earnings and hours worked are available from the Annual Survey of Hours and Earnings (ASHE). These employee data can be linked via the ONS's Inter-Departmental Business Register (IDBR) to firms in the Annual Business Inquiry (ABI), which holds information on firms' labour costs, output, capital investment, intermediate expenditures, and employment. However, because the ASHE is but a 1% sample of employees in UK businesses, we are only able to construct adequate occupational measures for the small sample of (very large) UK businesses that have sufficient employees included in the ASHE. For this reason we match the employee data to firms by detailed industry and size group (on average 270 linking cells per year) rather than by firm identifier.

The ASHE is a 1% random sample of employee jobs on the PAYE register held by the UK tax authorities, and contains detailed information on approximately 160,000 employees every year. Sample selection occurs on the basis of National Insurance numbers and is maintained over time, thus the ASHE contains longitudinal information on UK employees. The survey covers all sectors of the UK economy. Detailed information on pay and hours worked are collected from employers, as well as detailed occupation and industry category. It contains no information on employees' qualifications.

The ABI is a census of UK businesses with more than 250 employees and a stratified (by industry, region and employment size) sample of smaller tax-registered businesses. Sector coverage is almost complete; however there are a number of omissions and also a number of sectors where inputs are not thought to be directly comparable to the measured outputs. Typically, the latter consist of public sectors, such as education and health. Sectors that are not covered include certain industries within agriculture, public administration and defence, and the financial services sector is omitted completely. Together, industries included in the ABI account for approximately two thirds of the UK economy. The ABI contains employment and financial information on approximately 50 thousand UK enterprises every year since 1998. We use plant, machinery and equipment capital stock data provided by Richard Harris augmented with firms' leasing of these assets.

As our approach is harmonised with a number of other European countries we make a number of restrictions on the data. We exclude firms with turnover less than €2million (averaged at 2000 prices) and/or employing less than 30 employees. In addition, we exclude firms in the agricultural and public sectors. We have already alluded to further constraints on the basis of the British data specifically. There is poor or incomplete coverage of the following sectors: mining and quarrying of energy producing materials; manufacturing of coke; refined petroleum products and nuclear fuel; electricity, gas and water supply; construction; financial intermediation; health and social work. In total, this leaves us with a sample of approximately 11,000 enterprises per annum 1998-2006.

Our data covers only Great Britain; i.e. the UK excluding Northern Ireland. However, when we weight up the firm-level data to be nationally representative of the industries in our sample, we weight to a published UK total. On average the firms in our sample account for a third of GVA in the industries we consider.

In weighting up the firm-level data to be nationally representative we aggregate to ABI broad industry totals published by the ONS (gross value added for financial items, employment for hours worked and employment items, labour costs for intangible items). We make an adjustment for differences in labour use between the smaller firms that are excluded from our sample and the larger firms included in the sample on the basis of the ASHE. We use the Business Structure Database, which holds information on turnover and employment for all UK tax registered businesses, in order to derive within industry weights by firm-size category.

Our classification of workers into "intangible" producing occupations is constructed on the basis of detailed occupational classification and information on workers' qualifications. We base our grouping of occupations on ISCO88 facilitating international harmonization. Look-up tables to the UK Standard Occupational Classification are available from the ONS. In the absence of information on workers' qualifications in the ASHE we evaluate the average skill content of individual occupations using the Labour Force Survey (LFS) and classify occupations accordingly. The change in UK occupational classifications between SOC90 and SOC2000 causes a discontinuity in our data between 2001 and 2002; given this, the data are not strictly comparable between the first 4 years and the latter 5 years of our sample. Using the LFS, which is coded to both SOC90 and SOC2000 in some years, we attempt to minimize this discontinuity.

Germany

The German LEED data are derived from the Social Security Dataset (SSD) provided by the Federal Employment Agency. The data cover about 35 million workers over three years and can be considered a true panel for the period 1999–2001. Eight characteristics are covered for each worker, providing detailed information on wage levels, sectoral affiliation, compensation, education and profession (Table A1).

Table A1. Information provided by the SSD

Information	Format
Beginning and end of employment	dd/mm/yy
Establishment ID	Region (county), industry (NACE 4-digit level)
Person ID	8-digit level
Type of occupation	3-digit level, see appendix 4
Full-time/part-time	40 hrs, >18 hrs, < 18 hrs
Education	Seven categories, adjusted to the ISCED classification*
Nationality	3-digit level, 215 nationalities
Wage	Gross compensation
Personal	Gender, date of birth

* Based on Schneider (2008).

Source: SSD (Author's compilation)

Because only employment relationships in the realm of the (largely mandatory) social security system are covered, certain persons and establishments, like the self-employed, are not included in the data. Additionally, high wages are top-coded using the upper limit for contributions to the social security system.

The wage level of each person is recorded as the average wage per day and employee.[27]

With respect to their industry, establishments are classified according to the sectoral code of the Federal Employment Agency following the NACE Rev. 3 structure in 54 category groups (see appendix 2).

There are 12,234 units at the NUTS 4 level and 439 at the NUTS 3 level in Germany. We aggregate NUTS 3 using also NUTS 4 level information up to 97 planning regions (*Raumordnungsregionen*). Typically, these include a major town and about three to five surrounding rural areas.

Worker occupations are listed in appendix 1. The occupational classification is specific to the data from the Federal Employment Agency and is transformed to that used by all partners relying on ISCO-88 (see appendix 1). The occupational codes are adaptable to ISCO-88 using additional information on education level (for qualifications) and industrial codes because some occupations are industry specific. Occupations in manufacturing and services are separated. The occupational codes are available for all employees in the firms considered. Organisational compensation is derived from occupations classified as related to organisational work (marketing, selling and administration requiring tertiary education) (see appendix 1).

Czech Republic

We use Czech micro data from two sources. First, we rely on a national employer survey, the Information System on Average Earnings (ISAE), from the first quarters of 2000 to 2007. The enterprise survey is conducted on behalf of the Czech Ministry of Labour and Social Affairs, and firm response is mandatory; the survey also represents the Czech version of the EU-wide Structure of Earnings Survey. For over 2,000 firms and over 1 million workers annually, it contains hourly wages, gender, education, age and a detailed occupational classification for each worker employed in the sampled firms, which also report their total employment, ownership and industry (using the NACE classification). The wage records are

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[27] The upper earnings limit in the statutory pension fund for the social security contributions is different in the East and West and changes according to the general level of income. Because individual remuneration varies with the number of employment days, the average wage level of an establishment has been calculated with wages standardised as average wage per day.

drawn directly from firms' personnel databases, and the definition of hourly wage is detailed and fully consistent across firms; it includes total quarterly cash compensation and bonuses divided by total hours worked for that quarter. The detailed occupational classification (ISCO-88 at the 4-digit level) is used to identify various occupational groups and their shares of total employment and compensation. We use weights corresponding to industry and firm size sampling probabilities to re-establish population moments.

The second source of micro data is the Creditinfo/Aspekt database, which is a Czech source for the EU-wide AMADEUS database. It provides company-level balance sheet information from the Czech Republic during 1999–2006. It covers various financial indicators and NACE codes as well as regional codes, but no information on R&D spending is included. Although NUTS 4 locations are not included, this distinction can be made using postcodes. Financial data are available for about 5,000-9,000 distinct companies, depending on the subset of financial variables considered, which makes in total about 60,000 firm-year observations. These data include 25 balance sheet items (e.g., total assets, fixed assets, financial investments, equity, capital funds, profit and loss of the current year, liabilities), 14 income items (e.g., production and sales, value added, staff costs, operating profit or loss, financial profit or loss) and 6 cash flow items (e.g., profit sharing, net cash flow from operations). They come from various kinds of financial statements. No operation-based accounting is available in the Czech Republic.

Table A2 shows the numbers of firms in our two main sources of micro data (together with the Aspekt database's coverage of fixed assets (FA) in the economy, as reported by the Czech Statistical Office (CZSO)). The last column gives the number of firms in a merged file where we combine the employment structure information from the ISAE data with the balance sheet information from the Aspekt data.

Table A2. The number of firms included in the Czech data

	ISAE	ASPEKT		Merged
	Firms	Firms	Coverage by FA (vs. CZSO) (%)	Firms
1999	–	9,277	21.91	974
2000	2,095	8,681	20.61	1,184
2001	2,640	6,682	17.87	1,474
2002	3,086	7,469	12.69	1,617
2003	3,006	7,964	13.28	1,688
2004	3,596	7,899	12.45	2,046
2005	4,073	7,141	12.22	2,154
2006	5,848	5,186	8.75	1,814
2007	6,660	–	–	–

Source: ISAE, ASPEKT

Slovenia

In building the INNODRIVE micro database for Slovenia, three main data sources were merged: (1) balance sheets for Slovenian firms; (2) income tax statements at the individual level; and (3) a statistical registry of the labour force (SRDAP). The INNODRIVE micro database for Slovenia was created by merging the data sets in a secure room at the Statistical Office of the Republic Slovenia (SORS).

The balance sheets include data on Slovenian firms and contain the key information needed for economic analysis at the firm level: firm-level sales, tangible and intangible capital, material costs, labour costs, number of workers based on the aggregate number of working hours and industry at the NACE 5-digit level. These data are available for the firms in all economic sectors, including services. For our purpose, the following variables were especially relevant: capital formation, investment, employees (number and hours worked), labour costs, intermediate inputs, operating surplus and mixed income, sales, imports and exports of goods, value added, and assets (various categories).

The income tax statements data contain information on annual income earned by all workers who filed a personal income tax (PIT) report, which amounts at present to more than 500,000 employees. The following data categories are available for persons liable for PIT: (1) labour income; (2) income from short-term contracts; (3) income from land ownership; and (4) dividends. For our purpose, the following labour income variables were especially relevant: gross salaries, social contributions, personal income tax (withheld and paid), allowance for annual vacation, severance payments, and annual bonus.

The statistical registry of the labour force data (SRDAP) contains various information available by worker and firm. It is a data subset as it does not include individuals whose only source of income is short-term contracts. It therefore only includes employees who earn wages and salaries. For each worker, the SRDAP includes relevant information on gender, age, job title (occupation), tenure, educational attainment (field and degree) and location of work, as well as spans of employment by worker and firm. The information on tenure is available for each worker only from 1986 onwards, though this is a relatively stable category in Slovenia at the firm level and should not cause any major difficulties.

Several issues emerged when building the micro database for Slovenia and working with the data that needed to be resolved. First of all, the quality of data was problematic in the balance sheets for smaller firms; therefore, a thorough review was needed. The hours worked in the balance sheets are in part standardised, i.e., without overtime, which had to be imputed. There were missing data in the income tax statements, e.g., for managers, which had to be imputed. There was also a problem of duplicated data in the SRDAP, where some individuals were registered multiple times for the same event, which made, e.g., the employment spells problematic (months of employment). As already mentioned, the SRDAP excludes individuals on short-term contracts as the only source of income. Furthermore, between 1999 and 2000, the classification of occupations in Slovenia changed when the previous Standard Classification of Occupations (SCO) was replaced by the International Standard Classification of Occupations (ISCO-88). For this reason, the occupations had to be back-casted for worker observations before 2000, which was possible due to the longitudinal nature of the data.

The INNODRIVE micro database for Slovenia covers the complete NACE industry classification for the period of 1994–2004. After merging the data sets, restricting and aggregating industries from C to N, and adjusting our dataset as described above, our full sample of data consisted of some 30,000 to 40,000 firms and some 430,000 to 450,000 employees, depending on the analysed year. This amounted to between 419,472 observation-years in 1994 and 468,583 observation-years in 2004. The estimation sample covered, depending on the analysed year, from 32.2 to 35.6 per cent of persons employed in Slovenia and from 32.8 to 34.2 per cent of the Slovenian economy in terms of value added.

Appendix 2 Occupational classifications of non-production workers in the micro approach

	Occupation of Non-Production Worker	Organization Worker	R&D Worker	IT Worker
Manufacturing	Management	Management		
	R&D		x	
	R&D superior		x	
	Supply transport non-prod			
	Supply transport non-prod superior			
	Computer			x
	Computer superior			x
	Safety quality maintenance non-prod			
	Marketing purchases non-prod	Marketing		
	Marketing purchases non-prod superior	Management		
	Administration non-prod	Administration		
	Administration non-prod superior	Administration		
	Finance admin non-prod			
	Finance admin non-prod superior	Management		
	Personnel management non-prod	Administration		
	Cleaner garbage collectors messengers			
Services	Media			
	Computer processing services			x
	Computer processing services super			x
	Salesperson contract work services			
	Warehouse transport services			
	Maintenance gardening forest servi			
	Teacher counceling social science professionals			
	Hotel restaurants			
	Hotel restaurants superior			
	Social and personal care			
	Health sector			
	Forwarder services			
	Purchases and sales services			
	Insurance worker			
	Insurance worker superior			
	Small business manager			
	Finance services			
	Finance services superior	Management		
	Marketing services			
	Marketing services superior	Marketing		
	R&D worker services		x	
	Personnel project manag serv	Administration		
	Personnel project manag serv super	Management		
	Administration services			
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ASSESSMENT OF THE EFFECTS OF INTANGIBLE CAPITAL ON GENDER WAGE GAPS IN THE CZECH REPUBLIC, FINLAND AND NORWAY

Rita Asplund, The Research Institute of the Finnish Economy (ETLA)
Sami Napari, The Research Institute of the Finnish Economy (ETLA)

1 Background

A number of studies have presented evidence showing that intangible capital has boosted both labour productivity growth and GDP growth rates in recent decades (e.g., Corrado et al. 2009; Marrano et al. 2007; Jalava et al. 2007). This finding has motivated researchers to investigate whether intangibles have affected wage formation as well. Several papers exploring the effect of information and communication technologies (ICT) on wage structures have shown that ICT has, indeed, affected wage formation through, inter alia, increased returns to education (e.g., Kirby and Riley 2007).

An important aspect of the effects of intangible capital on wage formation concerns its potential impact on the gender wage gap. Although there are several theoretical reasons why intangible capital might be of relevance in this context, there is very little empirical research on the topic. One noticeable exception is the paper by Moreno-Galbis and Wolff (2008). Our study adds to this literature by comparing gender wage differentials across occupation groups among white-collar manufacturing workers using comparative data from three European countries: the Czech Republic, Finland and Norway.

2 Data and methodology

The data for the Czech Republic come from a national employer survey, The Information System on Average Earnings (ISAE), directed to for-profit firms. The Finnish data are based on the administrative records of the member firms of the Confederation of Finnish Industries (EK), which is the central organisation of employer associations in Finland. The Norwegian dataset comes from Statistics Norway. Information on wages and human capital endowments, apart from education, is obtained from the Norwegian Tax Directorate’s Register of Wage Sums. Data on education come from the National Education Database. For all three countries, we use data from 2006 that are confined to individuals aged 18 to 64.

The analysis is restricted to white-collar manufacturing workers. One reason for this restriction is that the occupational classification of this particular worker group allows a fairly straightforward and systematic allocation of individuals into two broad occupation groups that differ with respect to intangible capital. In particular, white-collar workers performing either ICT- or R&D-related job tasks, as well as those involved in the production of organisational competencies, i.e., management and marketing, are labelled innovation workers (INNO-workers). All other white-collar workers are classified as non-innovation workers (non-INNO workers).

We apply a wage decomposition method based on unconditional quantile regressions developed by Melly (2005a, 2005b, 2006). This method allows us to decompose the observed wage gaps along the whole range of the wage distribution and not merely at the mean, as is the case with the more traditional decomposition methods. More specifically, our estimation method comprises three distinct steps. First, conditional wage distributions are estimated by using quantile regression techniques. The second step includes estimation of the corresponding unconditional distributions by integrating the first-step conditional wage distributions over the full range of background characteristics accounted for in the quantile regressions. The final step decomposes the differences in the estimated counterfactual wage distributions across occupation groups and genders into two components: one that captures the contribution of differences in estimated coefficients (i.e., the price effect) and one that measures the contribution of differences in the characteristics considered (i.e., the composition effect). The characteristics accounted for in the decomposition analysis include the traditional measures of human capital: years of schooling, years of potential work experience and seniority (years in current employment relationship).

3 Descriptive results of gender wage gaps across occupation groups

Table 1 gives descriptive statistics for the average total hourly wage of white-collar manufacturing workers broken down by country, occupation group and gender. In all three countries, innovation workers earn, on average, higher hourly wages than non-innovation workers, with the average wage gap being largest (1.41) in the Czech Republic and smallest (1.20) in Finland. When it comes to the average gender wage gap and its variation across occupation groups and countries, we see, first of all, that the average gender wage gap is slightly higher among innovation workers than among non-innovation workers in both the Czech

Republic and Finland, whereas the opposite holds true for Norway. Table 1 also reveals that the average gender wage gap is smallest in Norway and largest in the Czech Republic, irrespective of the occupation group considered. Finland falls in between but seems to settle closer to the Czech Republic than to Norway with respect to average gender wage gaps among white-collar manufacturing workers.

Table 1. Average total hourly wage of white-collar manufacturing workers, 2006

	Czech Republic		Finland		Norway	
	INNO	**non-INNO**	**INNO**	**non-INNO**	**INNO**	**non-INNO**
All	6.39	4.52	20.73	17.21	29.68	23.61
INNO/non-INNO	1.41		1.20		1.26	
Males	6.82	5.03	22.34	18.55	30.00	24.40
Females	5.08	3.86	17.33	15.16	27.50	21.60
Females/Males	0.75	0.77	0.78	0.82	0.92	0.89

Notes: INNO refers to innovation workers and non-INNO to all other white-collar manufacturing. Wages are in euros.

Figure 1 analyses the gender wage gap at various points of the occupation-specific wage distributions. The results show that there is considerable variation in the gender wage gaps along the wage distribution in all three countries under study. The results for non-innovation workers reveal a clear tendency of increasing gender wage differentials when moving up through the wage distribution. This tendency is outstanding for Finland and especially outstanding for Norway.

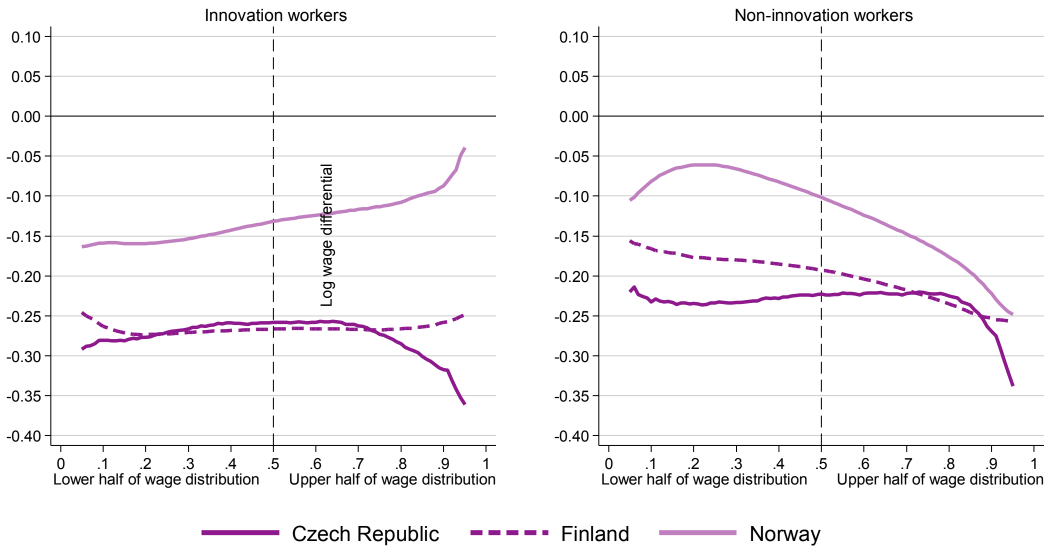

Figure 1. Variation across the wage distribution in the female-over-male wage ratio, 2006, by occupation group and country

In Norway, for instance, the gender wage gap varies between 5 and 10 per cent in the lower half of the wage distribution but is as high as 25 per cent at the top end of the wage distribution. In Finland, the gender wage gap among non-innovation white-collar workers increases steadily towards the upper tail of the wage distribution, where it settles at approximately the same level as in Norway. In the Czech Republic, finally, the gender wage gap among non-innovation white-collar manufacturing workers is more or less constant up to the 80th percentile but increases substantially after this point. However, there are few females represented in the top-end calculation.

The results are, for the most part, quite different for innovation workers. In Norway, instead of observing increasing gender wage differentials when moving up through the wage distribution, the profile of the gender wage gap among innovation workers is actually the opposite, with much smaller wage gaps observed for the upper half of the wage distribution. In Finland, on the other hand, the gender wage differentials among innovation workers do not vary much across the wage distribution. In contrast to Finland and Norway, the overall patterns of gender wage differentials in the Czech Republic are quite similar for innovation and non-innovation workers; that is, the gender wage gap remains fairly constant, or even decreases somewhat, when moving up through the wage distribution but suddenly starts to increase quite markedly at some high percentile. As already noted, these findings are primarily driven by a small number of female observations at the top end of the wage distribution.

Sources underlying the gender wage gaps

Figures 2 and 3 display the decomposition results for the gender wage gaps separately for innovation workers and non-innovation workers. When it comes to the major sources underlying the gender wage gaps, the results for the three countries under study are quite similar. Focusing first on innovation workers, in all three countries differences in basic human capital endowments between men and women account for only a small part of the total gender wage gap. This result suggests that the wage differentials prevailing between male and female white-collar innovation workers in manufacturing are mainly driven by women being less rewarded than men for similar human capital endowments. However, whereas the dominance of the price effect over the composition effect strengthens even further in Finland and Norway when moving up through the wage distribution, the opposite holds true in the Czech Republic.

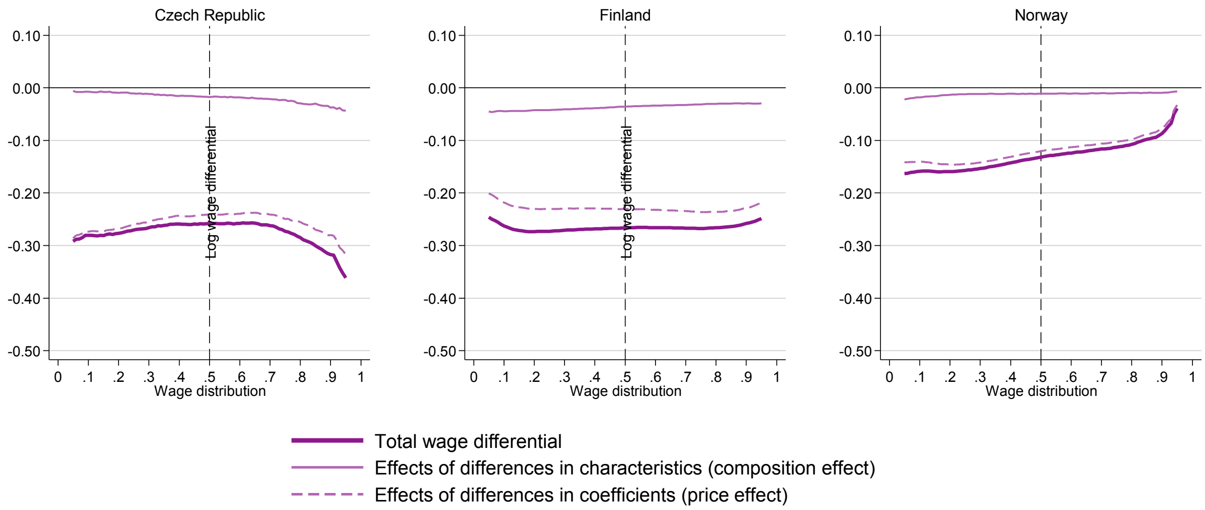

Figure 2. Decomposition of gender wage gaps for innovation workers by country, 2006

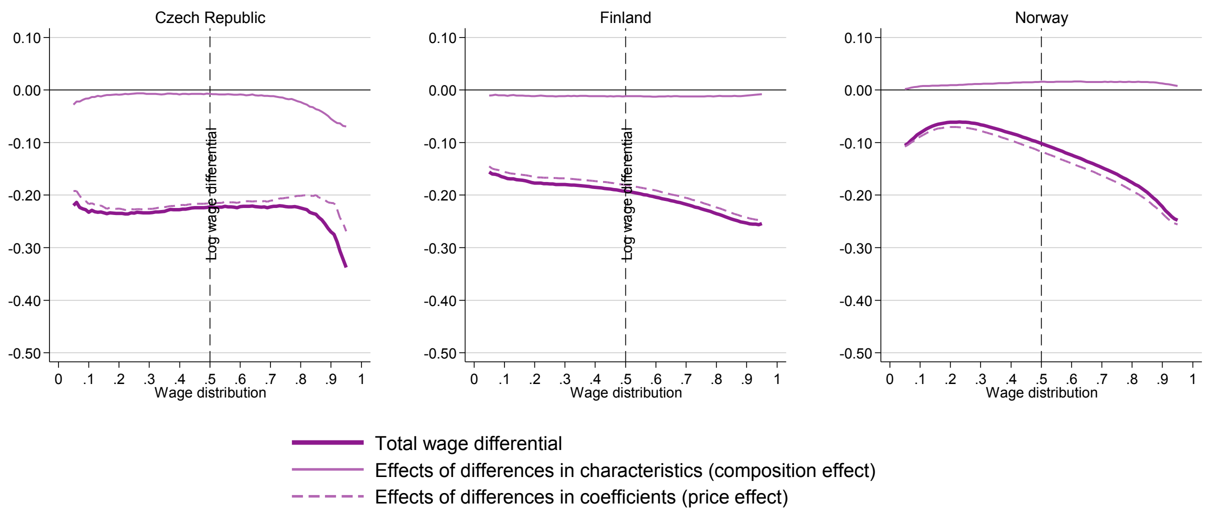

Figure 3. Decomposition of gender wage gaps for non-innovation workers by country, 2006

For non-innovation workers, it is evident from the decomposition results displayed in Figure 3 that the factors contributing most strongly to the gender wage gaps observed within this particular occupation group are the same as those for innovation workers. In particular, the wage differentials across genders are almost entirely due to male and female non-innovation workers' being differently rewarded for similar basic human capital endowments. In the Czech Republic, the price effect is slightly less important at the top end of the wage distribution than further down the wage scale but, nonetheless, is also strongly dominant over the composition effect among the highest-paid workers. This result is similar to our finding for the country's innovation workers. For Finland, the relative importance of the price effect is even more outstanding than in the case of innovation workers. Indeed, the price-effect curve is almost identical to the overall wage-gap curve, implying that the gender wage gaps observed among non-innovation workers are almost 100 per cent explained by different rewarding of basic human capital endowments. For Norway, finally, the outcome is very similar to what is observed for Finland in the sense that the total wage-gap and price-effect curves are almost identical. However, in Norway the price-effect curve is located below (and not above, as in Finland) the total wage-gap curve. This is due to the fact that, in Norway, the differences in basic human capital endowments between male and female non-innovation workers turn out to have a weak positive effect on the gender wage gap. In other words, with no price effect influencing the gender wage gap, women would, in effect, earn more than men.

4 Summary

We find that the average gender wage gap is larger among innovation workers than among non-innovation workers in the Czech Republic and Finland, whereas the opposite holds true for Norway. We also observe that the average gender wage gap in both occupation groups is lowest in Norway and highest in the Czech Republic, with Finland falling in between.

A closer look at the gender wage gaps along the whole range of the wage distribution reveals that these average wage gaps hide substantial variation across the wage distribution. Furthermore, there are also considerable country differences in this respect. For Finland and Norway, there is a clear tendency for gender wage gaps to increase when moving up through the wage distribution of non-innovation workers, whereas the wage gap between male and female non-innovation workers in the Czech Republic is practically constant across the wage distribution, except for its top end. The results for innovation workers are mostly quite different. In Norway, instead of observing increasing gender wage gaps along the wage distribution, as in the case of non-innovation workers, the gender wage gap among innovation workers is actually much smaller in the upper tail of the wage distribution than further down the wage scale. In Finland, the gender wage gap among innovation workers shows only slight variation across the wage distribution, compared with increasing wage gaps among non-innovation workers. The strongest similarity in gender wage-gap profiles between innovation and non-innovation workers is found for the Czech Republic, where the male–female wage differentials in both occupation groups increase markedly when approaching the top end of the wage distribution despite being practically constant up to that point.

When it comes to the main sources underlying the observed gender wage gaps, our results are remarkably similar for all three countries. In both occupation groups, the wage differentials across genders are driven by smaller rewards for women with similar basic human capital endowments.

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