ABSTRACT

This study describes the state of the art in the measurement of intangible capital and its contribution to economic growth, with a focus on an international comparison of intangible investment intensity and intangible capital deepening among eleven advanced economies. *By employing a broad measure of intangibles, including computerized information, innovative property and economic competencies, we find a relatively large impact on growth. Intangible capital explains about a quarter of labour-productivity growth in the US and larger countries of the EU. The continental West-European countries show a distinction between countries with significant contributions from intangible capital deepening and a group of laggards. Catching-up countries such as the Czech Republic, Greece and Slovakia show much larger contributions from tangible capital deepening than from intangibles, and also larger multi-factor productivity (MFP) growth rates related to the restructuring of those economies.*

Bart van Ark (bart.vanark@conference-board.org) is Chief Economist of The Conference Board, New York and Professor of Economics at the University of Groningen. **Janet X. Hao** and **Carol Corrado** are, respectively, Economist and Research Director Economics at The Conference Board. **Charles Hulten** is Professor of Economics at the University of Maryland and Senior Advisor at The Conference Board.

The authors are grateful to comments from members of the COINVEST consortium. This article, in part, builds on earlier work with colleagues at The Conference Board, in particular Vlad Manole, and on work by the authors together with Daniel Sichel. Finally, the authors are grateful to Jonathan Haskel and Annarosa Pesole for their updates of the UK estimates of intangible investments. The authors remain solely responsible for the results and analysis presented in this study.

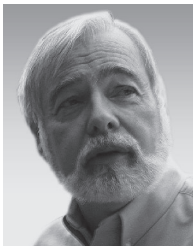
Measuring intangible capital and its contribution to economic growth in Europe

1. Introduction

Bart van Ark

Janet X. Hao

Carol Corrado



Charles Hulten

The recent economic downturn has changed the current debate on economic growth from one that emphasizes the long-run need for productivity and innovation to one that stresses economic recovery, particularly in employment. The focus on job growth is an inevitable aspect of any recession, and the deeper the recession, the greater the concern. This recession, however, is somewhat different because it has unfolded against the backdrop of the job losses and labour force restructuring brought about by the globalization of the world economy. One way to accomplish both short- and long-term objectives is to promote investment where the high-wage economies of Europe and the US have their greatest comparative advantage – the creation of knowledge. As the knowledge-content of the products and services that economies produce gradually increases, investment in knowledge production becomes the key source of economic growth. Moreover, the creation of knowledge both raises investment opportunities in the short run while creating the rewards of higher income and productivity growth in the future.

Knowledge creation is part of a wide-ranging process of investment in intangible capital. This investment includes expenditures for human capital, in the form of education and training, public and private scientific research, and business expenditures for product research and development, market development, and organizational and management efficiency. These are strategic investments in the long-run growth path of individual companies and of the economy as a whole. They are increasingly seen by policy makers as essential for the sustained economic health of the economy as witnessed, for example, by the European Lisbon Strategy to revitalize growth, competitiveness and sustainable development and the America Competes Act in the United States.

In order to manage intangibles both as a source of growth at the macroeconomic level, and as a driver of value creation for individual firms, it is important to measure them well. While nobody would disagree with their long-lasting benefits, the costs of most intangibles are still expensed in company financial statements and in national income and product accounts, implying that they detract from value-added growth rather than increasing it. To paraphrase Solow's quip about the computer revolution, one could say that today "the knowledge economy is all around us, but where can we see it in the official statistics?"[1] One answer is that much of the activity we associate with knowledge creation, especially by businesses, isn't there. Conventional measures of investment in the accounts consist primarily of tangible assets such as plant and equipment, vehicles, office buildings and other commercial structures. In reality, as the reported estimates in this article show, investment in intangibles in many advanced economies approaches the value of investment in tangible assets, and in some cases (such as in the United Kingdom and the United States) it even exceeds tangible investment.

In recent decades, the accounting treatment of intangibles has begun to change, with the decision to capitalize software expenditures and treat the result as a contribution to GDP. Software is a major category of intangibles and a primary means of transforming knowledge (or "blueprints") into computerized information. More recently, it has been proposed to extend the capitalization of intangibles to expenditure on research and development (R&D). For example, the US Bureau of Economic

1 The Solow productivity paradox states that "you can see the computer age everywhere but in the productivity statistics" (Solow 1987), which subsequently led to a surge of studies to improve the measurement of ICT and their contribution to economic growth.

Analysis will count R&D as investment in its headline GDP measure in 2013, and in a satellite account until then. These moves are supported by recent decisions by the United Nations to do likewise in its System of National Accounts.

The full range of spending on intangibles is not likely to get treated as investment in the national accounts.

Still, the full range of value-building intangible assets is not likely to be accorded the same treatment as software and R&D in the national accounts, even though economic research and surveys show that assets such as management capability, marketing and employee-training expenditures are important co-investments with R&D and information and communication technologies (ICT). The challenges concerning the conceptualization of intangible capital, its measurement on the input and output sides, and their integration into a production function or growth accounting framework are substantial indeed (van Ark 2002; van Ark and Hulten 2007).

In this study we discuss the state of the art in the measurement of intangible capital and its contribution to economic growth, with a focus on international comparisons currently available. In Section 2, we discuss some of the conceptual and theoretical issues in relation to the capitalization of intangible capital. Section 3 provides a brief overview of the methodology used to obtain measures of intangibles, and reports estimates for a wide range of European countries and the United States. We combine estimates from a new study by Corrado and Hulten (2009) that updates previous studies by Corrado, Hulten and Sichel (CHS 2005; 2009) for the United States with updated figures from Marrano, Haskel and Wallis (MHW 2007; 2009) for the United Kingdom, estimates from The Conference Board's previous empirical study for Germany, France, Italy and Spain (Hao *et al.* 2009) and new estimates for five additional European countries (Austria, Czech Republic, Denmark, Greece and Slovakia). In Section 4 we integrate these measures in a growth accounting framework. Finally, as we gradually grow the number of countries for which intangible capital can be measured and integrated in growth analysis, Section 5 provides a first attempt to study the role of intangibles from a broader perspective of economic growth and development using the results for our eleven countries in combination with estimates for five other countries from alternative studies, including Jalava *et al.* (2007) for Finland, van Rooijen-Horsten *et al.* 2008) for the Netherlands, Edquist (2009) for Sweden, Barnes and McClure (2009) for Australia and Fukao *et al.* (2007 and 2009) for Japan. In the concluding section we identify some key issues for further reflection and research.

2. Why capitalize intangibles?

Empirical studies of economic growth have traditionally focused on the contribution of capital in terms of plant and equipment, vehicles, and buildings. These are tangible assets that can be seen and touched, and their historical role as sources of economic growth is beyond dispute. Their status as capital is indisputable because they are created using current resources in order to increase future production and consumption. However, CHS (2005; 2009) point out that this criterion applies equally to all expenditures on product and market development (that is, including, but not limited to, R&D), worker training, and organizational development, which also aim to increase future output and consumption.

CHS (2009) formalize how intangible may be incorporated into the conventional GDP/GDI national accounting identity. The key to this extension is that the flow of new intangibles must be included *both* on the product side of the accounts and on the input/income side via the flow of services from the intangible stock (a point sometimes missed in the literature on R&D):

(1) $$P^Q(t)Q(t) = P^C(t)C(t) + P^I(t)I(t) + P^N(t)N(t) = P^L(t)L(t) + P^K(t)K(t) + P^R(t)R(t)$$

Here, aggregate output is denoted by *Q*, consumption by *C*, tangible investment goods by *I*, intangibles by *N*, and their respective prices by *P* with the appropriate superscript. On the input side labour *L*, tangible capital *K*, and intangible capital *R* represent the inputs that are allocated to the production of all three output components. This formulation is distinctly different from the current national accounts' definition of GDP, which treats *N* as an intermediate input to the production of *C* and *I*.

Taking intangible assets into account eliminates most of the large discrepancy between market- and book values of listed companies.

Treating intangible expenditures as investment also makes economic sense from a business strategy point of view. Outlays on software, R&D, advertising, training, organizational capital *etc*., are critical investments that sustain a firm's market presence in future years by reducing cost and raising profits beyond the current accounting period. For example, the development of software for on-line banking has provided customers with 24/7 financial services and hence massively reduced labour cost in retail banking. Similarly, R&D is carried out with the expectation that it will increase the future profit of a firm, an expectation that is validated on average by the positive correlation between R&D and patents, on the one hand, and stock prices, on the other (Hall 1999). Moreover, marketing intangibles (brand equity, customer satisfaction) determine whether or not a firm is competitive in the long run.[2] The value of these intangibles is reflected in the market value of a company. In a sample of 617 companies drawn from the COMPUSTAT data base for the year 2006, Hulten and Hao (2008) find that the book value of conventionally reported equity explains only a small fraction of its market value (around 30 percent), but this fraction increases to 75 percent when the capitalized cost of intangibles is added to the balance sheets of these companies.

Capitalizing intangibles is thus an important step in its own right. It is also an important step towards measuring its contribution to economic growth. CHS (2009) expand the conventional Solow-Jorgenson-Griliches sources-of-growth (SOG) model to include intangible input and output. The expanded model leads to the following equations:

$$(2) \qquad g_Q(t) = s_C(t)g_C(t) + s_I(t)g_I(t) + s_N(t)g_N(t)$$
$$= s_L(t)g_L(t) + s_K(t)g_K(t) + s_R(t)g_R(t) + g_A(t)$$

This formulation links the growth rate of output $g_Q(t)$ first to the weighted contributions of the growth of consumption ($g_C(t)$), tangible investment ($g_I(t)$) and intangible investment ($g_N(t)$), and second, to the supply-side of the economy where $g_Q(t)$ equals the weighted contributions from the growth in labour ($g_L(t)$), tangible capital ($g_K(t)$) and intangible capital ($g_R(t)$) and multifactor productivity ($g_A(t)$). In both cases the weights sum up to one.

The inclusion of intangibles in the $g_Q(t)$ framework means that the labour share is smaller than in the traditional growth accounting equation because of the expanded capital base. CHS also note that when intangible investments are increasing as a share of output, the measured multifactor productivity residual will tend to be smaller than the corresponding MFP estimate calculated without intangibles.[3]

2 A survey of manufacturing firms in the UK identifies eight marketing practices that determine long-run competitiveness, including the use of the experience curve-concepts in marketing and the ability to offer superior quality products (Brooksbank *et al.* 2003). Training has reduced the cost of introducing flexible production systems in automobile firms across the world (McDuffie and Krafcik 1992). And apprentice training contributes to the productivity of a firm during and beyond the apprentice period, according to a survey of Swiss firms (Wolter *et al.* 2006). Management practices also appear highly correlated with firm-productivity. For example, Bloom and Van Reenen (2007) link the intangible of corporate management practices to productivity and show significant cross-country differences, with US firms on average better managed and more productive than European firms. In particular, it is suggested that US multinationals are organized in a way that allows them to use new technologies such as ICT more efficiently than non-US firms (Bloom *et al.* 2009)

3 However, the smaller MFP residual is not an inevitable consequence of adding intangibles. See the recent survey of growth accounting by Hulten (2009a) for further discussion.

The need to capitalize intangibles is evident but there are formidable measurement challenges.

Despite the evident need to capitalize intangible assets, estimating the magnitude of the investment flows (the $P_N N$), separating these flows into price (P_N) and quantity (N) components, and determining the service lives of the assets to enable the compilation of net asset stocks (R), are formidable measurement challenges. Moreover, all relevant assets must be identified and measured. The literature has discussed these measurement and identification challenges from alternative points of view: some regard the challenges as a wall that is virtually impossible to scale (perhaps even fraught by theoretical impossibility), while others stress the importance and policy-relevance of updating empirical growth accounts to reflect modern business realities.[4] All told, and as indicated by CHS (2009), "the real issue of whether intangibles should be classified as intermediates or as capital depends on the economic character of the good … and not on the ease with which it can be measured" (p. 667). In the remainder of this section we discuss these challenges – both measurement and theoretical – as they pertain to the growth accounting framework and its implementation.

First, with regard to the scale and scope of intangible investment ($P_N N$) their presence is primarily recognized by the resources the firm spends to acquire the knowledge-based assets through, for example, R&D, licenses, patenting, *etc.*, as well as their spending on co-investments to R&D and ICT (including those related to changes in business models and practices). There are various ways of getting at these investments. For example, measures of organizational capital used in this article are based on estimating managers' time devoted to organizational innovation tasks and expenses on external management consultancy contracts. A more precise measurement would translate firms' documentation in performance tracking, target time horizon, human-capital management, and the rewarding of high performance, *etc.*, into dollar values. From a practical point of view, the emerging survey work on measuring intangible investment in the United Kingdom (Clayton *et al.* 2009) and business activity by business function in the United States (Sturgeon and Gereffi 2009; Brown 2008) offers promising methods for greatly improving the measurement of intangible investment.

Second, intangible investment and capital in real terms – the measurement of N – is the most vexing challenge: Units of knowledge cannot be defined *per se,* a problem akin to defining prices for business or medical services and for which no consensus solution exists.[5] Other than for software and some other small items already included in the national accounts, CHS (2005; 2009) used the overall output price as the price for intangible investment. The Bureau of Economic Analysis (BEA) has offered an R&D-specific output price in its preliminary R&D satellite account. In this study we maintain the CHS assumptions, but note, as they did, its "place-holder" nature until a more satisfactory solution emerges (see also Annex 1).

Third, both the measurement and conceptualization of net stocks of intangibles (R) is complicated by the fact that intangibles are largely non-rival and returns on investment are not fully appropriable. Patent protection and business secrecy may give the innovator a degree of protection, but the value of the investment to the innovator is limited to the returns on the investment that can be captured, which in turn provides the conceptual basis for measuring depreciation and calculating net stocks (Pakes and Schankerman 1984). The decision to invest a dollar in an innovation is presumably based on the expectation that, on average, at least a dollar's worth of value can be appropriated. This is not, however, a precise calculation. In fact, the return on a specific intangible dollar may be zero or a multitude of output dollars. Innovation usually involves experimentation and uncertainty, in which

4 For discussions of these issues, see for example, Howitt (1996), Lev (2001), Nakamura (2001), van Ark (2002), van Ark and Hulten (2007) and CHS (2005; 2009).

5 Corrado and Lane (2009) consider the measurement of innovation within firms and suggest that the "project" be the unit of analysis and measurement. Notwithstanding practical issues, such an approach opens potential for measuring productivity of a business function, much as Diewert (2008) suggests that productivity for certain medical services can be measured by isolating "procedures" as a unit of analysis.

winners and losers are sorted out over time in a Schumpeterian process of "creative destruction". Ultimately, the benefits from an innovation diffuse to other users. This process of knowledge diffusion is the source of at least a part of MFP growth at the aggregate level. Indeed, MFP measures the costless gains in the efficiency of production. The diffusion of knowledge from the original investor/innovator is one way the costless gains are achieved. For example, estimates of the Bureau of Labor Statistics suggest that somewhere between a fifth and a quarter of the growth rate of MFP in the US non-farm business sector is due to R&D spillovers.

MFP measures the costless gains in the efficiency of production, notably through the diffusion of knowledge from innovators.

Fourth, several theoretical considerations are central when using available measures to obtain estimates of the contribution of intangibles to economic growth. Intangibles are often not a direct or continuous input to current production but represent an upfront cost to the production process with substantial uncertainty whether or not they will actually produce an output in terms of a new product or service delivery. Uncertainty does not only apply to the R&D going into a new product (which may or may not lead to an actual decision to manufacture the product) but also to the marketing of, in particular, a service output.[6] Adding these indirect inputs to the SOG model shifts it away from a purely production-function model of growth in which technology improves the processes of production to a more Schumpeterian approach that puts emphasis on the actual product or service output created. Hulten (2009b) develops a model that reconciles the technology-oriented nature of the Solow residual with the broader innovation-based nature of intangible inputs at the firm level. This research also highlights the fact that measured MFP growth may come through improvements in quality of products and services, which can be integrated in the accounting framework by linking the intangible investment to prices on the output side. Thus, while intangibles may not necessarily refer to technology-oriented processes, they can be handled in the current SOG accounting framework, provided data are available to develop adequate measures of quality change in inputs and outputs.

Finally, the assumptions behind the version of the Solow residual in Equation (2) are not necessarily applicable to a world in which intangibles are important. The assumptions of perfect competition and foresight do not easily apply to the situation in which a firm's intangible assets create market share and in which control over the property rights is associated with an innovation. One result is that the factor shares in Equation (2) do not necessarily equal the output-elasticity as required by the Solow framework. However, Hulten (2009b) shows that this is not necessarily a disabling problem when passing from the micro to the macroeconomic level of activity. Deviations in capital and labour compensation shares from their required theoretical values may cancel out when passing from the micro to the macroeconomic level of analysis. In any event, van Ark and Hulten (2007) note that growth accounting remains essentially the only game in town as far as a comprehensive empirical growth analysis involving all inputs and output in production is concerned, and that the inclusion of intangibles does not diminish that claim.

3. Measures of intangible investment

Various definitions of intangible capital are possible, but most definitions are offshoots of Schumpeter's classification, which includes product and process development, organizational change, management, marketing and finance (Schumpeter 1934). Some studies focus on structural characteristics of particular types of intangibles related to innovation, human resources or organizations (Lev 2001) or to the

6 For example, Campbell-Kelly (1995) describes the example of Lotus 1-2-3 which was the dominant spreadsheet program in the 1980s, developed by Mitch Kapor in 1982. The biggest challenge was the marketing of Lotus 1-2-3. Kapor spent USD 1 million developing the software and USD 2.5 million marketing it. With the successful launch, 850,000 copies of Lotus 1-2-3 were sold, making it the most popular spreadsheet software. The price of Lotus 1-2-3 was USD 495, and 40% of that price covered marketing.

We distinguish between computerized information, innovative property and economic competencies, valuing them at investment cost.

investment characteristics of intangibles (Nakamura 2001). Other studies use functional characteristics on the output side, such as the measurement of the stock market value of output (Hall, 2001) or the projected future value of output (van Bekkum 2009). The approach adopted here follows the work of CHS (2005; 2009), which uses a combination of structural characteristics combined with functional (investment-related) characteristics on the input side, *i.e.* the value of investment at cost and distinguishing between business investment in three categories, *i.e.* (1) computerized information, (2) innovative property, and (3) economic competencies:

(1) Computerized information is already largely included in the national accounts, as computer software for both purchased and own-account components. However, this category also includes databases which are often not included in the national accounts today.

(2) Innovative property includes both scientific property and "non-scientific" R&D.[7] Until recently, neither scientific nor non-scientific R&D has been included in national accounts, although this will change in 2013 with the implementation of the 2008 System of National Accounts in most countries, which recommends the inclusion of (mainly) scientific R&D. Non-scientific R&D is a somewhat "under-defined" category in the R&D statistics because it is unclear whether it belongs to R&D and what is actually included in this category.[8] The estimates of this study follow CHS (2005; 2009) and include the cost of developing new motion picture films and other forms of entertainment, investments in new designs, and a crude estimate of the spending for new product development by financial services and insurance firms. CHS report that, by the late 1990s, investment in non-scientific R&D was as large as investment in scientific R&D.

(3) Economic competencies are the largest category and include two sub-categories, brand equity and firm-specific competencies. Investment in brand names is measured as a fraction of advertising spending to reflect that not all advertising may be seen contributing to the building of brands. We adopt the estimate by CHS (2005; 2009) that about 60 percent of total advertising expenditures has long-lasting effects rather than short-term expenditure focused on, say, "this week's sale". Investment in firm-specific capital and human resources includes the costs of employer-provided worker training and an estimate of management time and expenditure on external consultants devoted to enhancing the productivity of the firm. The estimates for firm-level training are based on a mix of data from statistics on vocational training and cost data from employment statistics. Expenditure on organizational changes is derived from revenues for the management consultant industry in combination with trends in the cost and number of persons employed in executive occupations. It is assumed that managers spend 20 percent of their time on improving organizational structures. While these numbers are imprecise, even on the basis of this modest assumption they represent the largest type of business intangible investment.

We use the same methodology as CHS (2005; 2009) for the United States and MHW (2007; 2009) for the United Kingdom to examine intangible investment in continental European countries. In Hao *et al.* (2009), we estimate intangible investment for France, Germany, Italy and Spain. For the purpose of the current article, we develop five additional estimates for other European countries, including Austria, Denmark, Greece, Czech Republic and Slovakia. Those countries include both old and new member

7 Innovative property should not to be confused with intellectual property which refers to creations of the mind, including inventions, literary and artistic works, symbols, names, images, and designs used in commerce. There is a significant overlap between the two concepts, but the innovative property exclusively focuses on the investment and output characteristics. The labelling of "non-scientific" R&D is somewhat misleading because the development of new financial products and architectural modelling is mostly conducted by personnel with scientific degrees.

8 The Frascati Manual on the collection and use of R&D data explicitly includes social science R&D and Eurostat explicitly includes it. The United States launched a new R&D survey in which data on social science R&D will be collected for 2008 for the first time. Previously, social science R&D was explicitly excluded from US R&D.

states of the European Union (EU), so we can learn the patterns of intangible investment in economies at different stages of development.[9]

Table 1 shows the investment in the market sector of the economy as a percentage of total GDP in the US and the UK as well as for the four large continental European countries. In the continental European countries the market sector results were obtained by excluding the entire government, health and education sector. Real estate activities are also excluded due to the problems in measuring their productivity (EU KLEMS 2008). In the US, the private non-farm business sector invested 11.5 percent of conventionally measured GDP in intangible assets in 2006. In the same year, the private sector invested 10.5 percent of GDP in intangibles in the UK, 7.2 percent in Germany, 7.9 percent in France, 5.0 percent in Italy and 5.5 percent in Spain.

Intangible investment exceeds 10 percent of GDP in the US and the UK, is below that mark in France and Germany and hovers around 5 percent in Italy and Spain.

Table 1. Intangible investment in the market sector in Germany, France, Italy, Spain, UK and US (percent of GDP, 2006)

Type of Investment	Germany 2006	France 2006	Italy 2006	Spain 2006	UK 2006	US 2006
1. Computerized information	**0.73**	**1.42**	**0.64**	**0.79**	**1.55**	**1.61**
a) Software	0.71	1.37	0.63	0.76	0.00	
b) Databases	0.02	0.05	0.01	0.03	0.00	
2. Innovative property	**3.59**	**3.18**	**2.21**	**2.78**	**3.16**	**4.37**
a) R&D, including social sciences and humanities	1.72	1.30	0.58	0.63	1.07	} 2.25 (a+b)
b) Mineral exploration and evaluation	0.01	0.04	0.09	0.04	0.04	
c) Copyright and license costs	0.21	0.31	0.10	0.18	0.22	
d) Development costs in financial industry	0.75	0.60	0.58	0.52	0.07	} 2.12 (c+d+e)
e) New architectural and engineering designs	0.90	0.93	0.86	1.41	1.74	
3. Economic competencies	**2.84**	**3.30**	**2.19**	**1.90**	**5.84**	**5.50**
a) Brand equity	0.56	0.99	0.71	0.42	1.15	1.47
Advertising expenditure	0.41	0.73	0.47	0.19	0.91	
Market research	0.15	0.26	0.24	0.23	0.24	
b) Firm-specific human capital	1.29	1.51	1.02	0.81	2.54	
Continuing vocational training	0.65	1.25	0.71	0.71		} 4.03 (b+c)
Apprentice training	0.64	0.26	0.32	0.10		
c) Organizational structure	1.00	0.81	0.45	0.68	2.14	
Purchased	0.54	0.32	0.15	0.27	0.51	
Own account	0.46	0.49	0.3	0.41	1.63	
Total Investment	**7.16**	**7.90**	**5.04**	**5.47**	**10.54**	**11.48**
pro memoria						
Total Spending	**7.55**	**8.51**	**5.43**	**5.70**	**11.56**	

Sources: Hao *et al.* (2009) for Germany, France, Italy and Spain; CHS (2009) for the US and MHW (2009) for the UK. They all have updated their results to 2006.

Notes: 60 percent of expenditure on advertisement, 80 percent of expenditure on own-account organizational structure and 100 percent of all the other expenditure are considered as investment (CHS 2005). GDP here is conventionally-measured GDP (including software and mineral exploration but excluding other intangibles). MHW (2009) estimate item 2(d) using the wages of research occupations of financial industry, and estimate item 2(e) using the wages of designers and engineers.

9 Other recent studies include intangible intensity measure for Finland (9.1 percent of GDP according to Jalava *et al.* 2007), the Netherlands (8.3 percent of GDP between 2001 and 2004; van Rooijen-Horsten *et al.* 2008), Sweden (10.6 percent of GDP according to Edquist 2009), Australia (9.6 percent of market-sector value added in 2005-2006; Barnes and McClure 2009) and Japan invested 7.5 percent of GDP from 1995 to 2002 (Fukao *et al.* 2007; 2009).

We present new estimates for Austria, Czech Republic, Denmark, Greece and Slovakia.

Table 2 shows the new results for five smaller European economies in 2006. The estimate for Denmark (7.9 percent) is comparable to that of Germany and France but considerably lower than in three other small countries, Finland, Sweden and the Netherlands. The estimates for Austria are lower than for France and Germany, but still above those for Italy and Spain. The Czech Republic and Slovakia are also closer to the lower end, with the former more intensive in intangibles than the latter. The big outlier is Greece, which suggests intangible investment is only 1.6 percent of GDP, much lower than in any other country. While the results for Greece require more research, the outcome is surprisingly close to the estimate from Jona-Lasinio *et al.* (2009), which also shows Greece as extraordinarily low in terms of intangible investment intensity. The difference between Greece and the other countries is largest in all areas of economic competencies.

Table 2. Intangible investment in the market sector in Austria, the Czech Republic, Denmark, Greece and Slovakia (percent of GDP, 2006)

Type of Investment	Austria 2006	Czech Republic 2006	Denmark 2006	Greece 2006	Slovakia 2006
1. Computerized information	**0.89**	**0.71**	**1.87**	**0.34**	**0.37**
a) Software	0.85	0.71	1.85	0.33	0.37
b) Databases	0.04	0.01	0.03	0.01	0.00
2. Innovative property	**3.14**	**2.8**	**3.06**	**0.62**	**1.76**
a) R&D, including social sciences and humanities	1.74	1.03	1.68	0.18	0.21
b) Mineral exploration and evaluation	-	-	-	-	-
c) Copyright and license costs	0.10	0.04	0.16	0.02	0.04
d) Development costs in financial industry	0.63	0.55	0.54	0.16	0.37
e) New architectural and engineering designs	0.66	1.18	0.69	0.27	1.15
3. Economic competencies	**2.42**	**2.93**	**2.93**	**0.63**	**2.39**
a) Brand equity	**0.25**	**1.37**	**0.63**	**0.15**	**1.04**
Advertising expenditure	0.15	0.94	0.36	0.08	0.46
Market research	0.11	0.43	0.27	0.06	0.59
b) Firm-specific human capital	**0.79**	**0.63**	**1.49**	**0.19**	**0.51**
Continuing vocational training	0.46	0.63	1.07	0.17	0.51
Apprentice training	0.33	0.00	0.42	0.02	0.00
c) Organizational structure	**1.38**	**0.93**	**0.81**	**0.29**	**0.83**
Purchased	0.93	0.26	0.45	0.06	0.25
Own account	0.44	0.67	0.36	0.23	0.58
Total Investment	**6.46**	**6.45**	**7.86**	**1.59**	**4.53**
pro memoria					
Total Spending	**6.67**	**7.24**	**8.19**	**1.70**	**4.98**

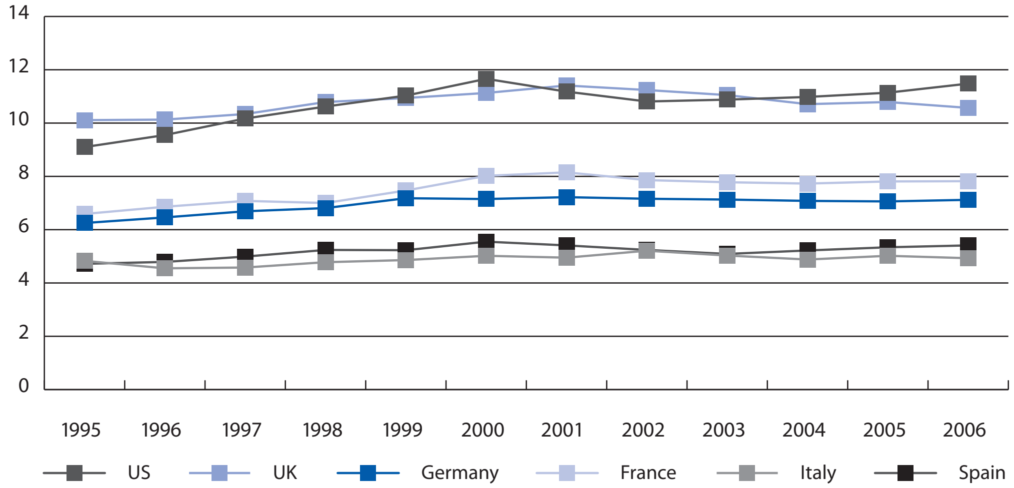
Sources: See Annex 1

Notes: 60 percent of expenditure on advertisement, 80 percent of expenditure on own-account organizational structure and 100 percent of all the other expenditure are considered as investment (CHS 2005).
GDP is conventionally measured (including software and mineral exploration but excluding other intangibles).

The results of Table 2 are portrayed graphically in Figure 1b along with the updated time series for the countries from previous studies (Figure 1a). Interestingly, while we generally find a slowdown or stabilization in the intensification of intangibles in the countries included in previous studies (notably in the US, but also in the UK, France and Germany), we find a continuation or even a slight pickup in the trends for Austria and Denmark, though less so in the other countries.

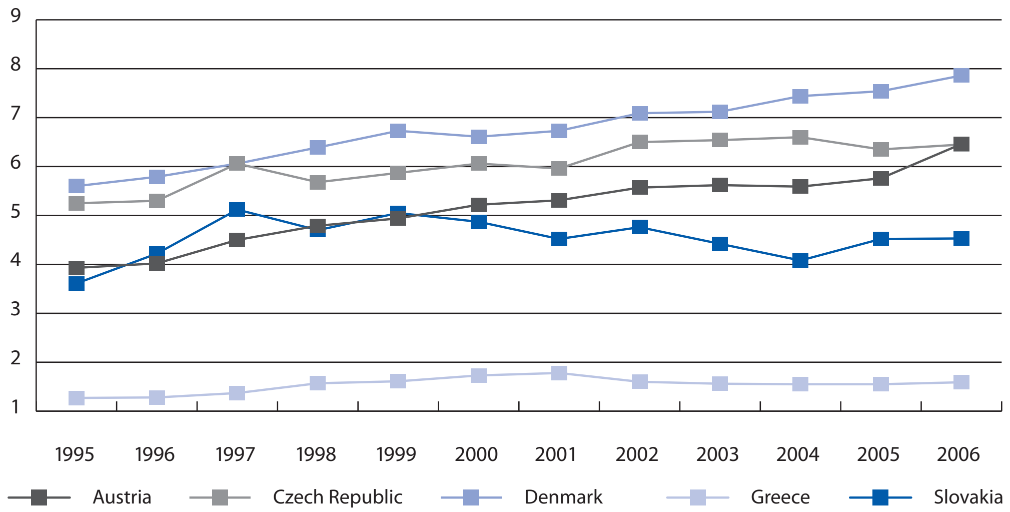
Intangible investment is trending up in Austria and Denmark.

Figure 1a. Intangible investment in France, Germany, Italy, Spain, the UK and the US (percent of GDP)



Source: See Table 1
Note: GDP is conventionally measured (including software and mineral exploration but excluding other intangibles).

Figure 1b. Intangible investment in Austria, Czech Republic, Denmark, Greece, and Slovakia (percent of GDP)



Source: See Table 2 and Annex 1
Note: GDP is conventionally measured (including software and mineral exploration but excluding other intangibles).

Table 3 provides the time series dimension associated with Table 2. It shows that the shares of economic competencies in the Central European countries have in fact been relatively high for the whole period 1995-2006, which might also reflect the legacy of a less-technology intensive economy leading to lower shares of computerized information and innovation property.

Table 3. **Composition of intangible investment (percent of total intangible investment)**

year	Austria			Czech Republic			Denmark			Greece			Slovakia		
	Comp Info	Innov Prop	Econ Comp	Comp Info	Innov Prop	Econ Comp	Comp Info	Innov Prop	Econ Comp	Comp Info	Innov Prop	Econ Comp	Comp Info	Innov Prop	Econ Comp
1995	8	49	44	10	47	44	16	39	45	10	44	46	8	43	50
1996	8	46	46	10	45	45	18	38	44	15	40	45	9	48	42
1997	10	51	40	7	40	52	21	37	42	18	39	43	8	50	41
1998	12	49	38	9	43	48	22	38	40	20	40	40	9	44	48
1999	13	50	37	13	40	48	24	37	39	20	41	39	8	41	52
2000	14	49	36	14	40	47	22	39	38	24	38	37	8	40	53
2001	17	48	36	14	40	46	20	42	38	25	39	37	10	39	52
2002	16	51	33	14	40	46	23	41	36	19	40	41	8	40	53
2003	16	52	32	12	41	47	22	42	36	18	41	41	10	39	51
2004	15	52	32	13	41	47	25	39	36	19	41	40	9	41	50
2005	14	54	32	11	43	46	23	40	38	19	40	40	9	40	51
2006	14	49	37	11	43	45	24	39	37	22	39	39	8	39	53
Average	13	50	37	12	42	47	22	39	39	19	40	41	9	42	50

Sources: See Annex 1
Note: The average is the simple average of percentages from 1995 to 2006.

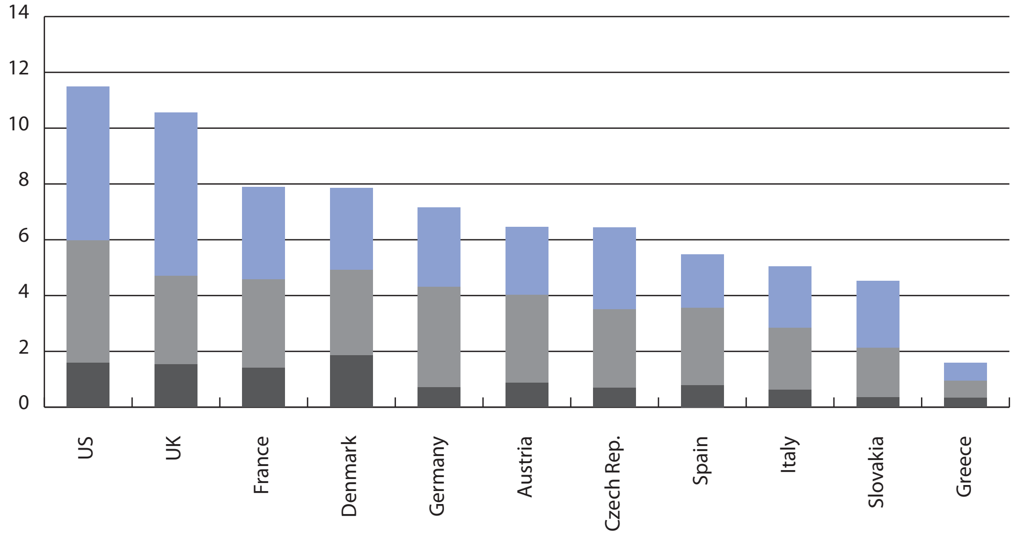
The bottom-line results of Tables 1 and 2 are shown graphically in Figure 2. The US and UK are the clear leaders by this metric, with intangible investment of the US almost double that of the median country in the comparison (Austria). There is also substantial variation in the composition of intangible assets. The differences in GDP shares are smallest for computerized equipment, where the US and Germany have a relatively high share (perhaps related to a relatively large contribution of high and medium-tech manufacturing industries). The UK shows a particularly strong result for economic competencies, which may be related to the large share of business services in the UK.

The US and the UK spend more on intangible than on tangible capital.

Perhaps the most striking result is shown in Figure 3, which compares the ratio of intangible investment (including software and other intangibles already included in the current national accounts) as percentage of GDP relative to tangible capital (excluding software and other intangibles already included in the current national accounts). Two countries, the United States and the United Kingdom, show a higher GDP intensity for intangibles than for tangibles. In the lower-income countries (Czech Republic, Spain, Italy, Slovakia and Greece) where intangible investment is still relatively low, the ratio of tangible capital to GDP is the highest.

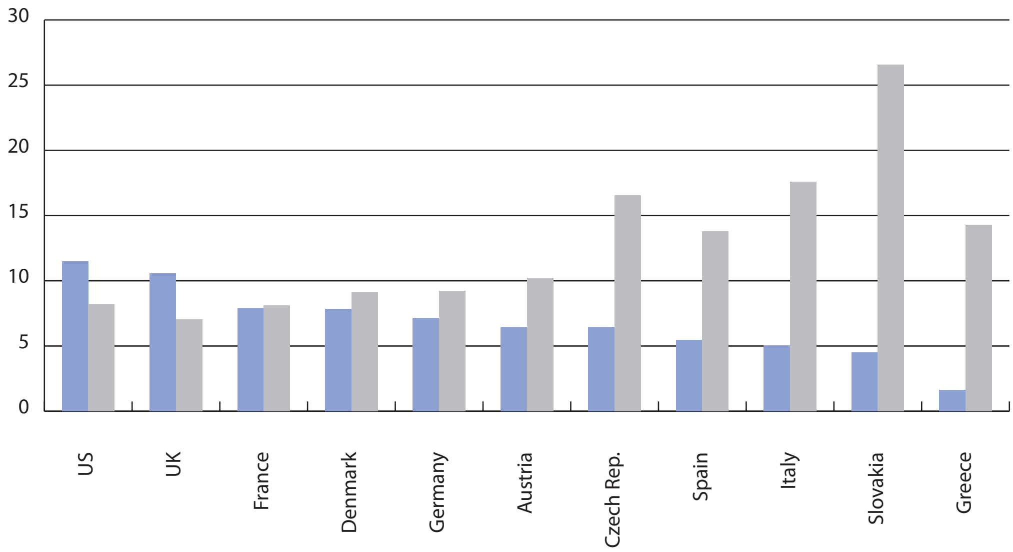
Finally, it should be stressed that the capitalization of intangibles not only creates more capital input, but also leads to more output. After adjustment for intangibles, the size of GDP is larger by the intangibles investment rates, which range from 1.59 to 11.69 percent of GDP conventionally measured. The inclusion of intangible investment also increases the growth rate of GDP when intangible investment is expanding rapidly, and decreases it when intangible investment is slowing down. From 1995 to 2006 – a period during which intangible investment was expanding rapidly in most countries – GDP growth rates were about 0.1-0.2 percentage points higher due to the inclusion of intangibles for all countries in our sample.

Figure 2. **Intangible investment in the market sector (percent of GDP), 2006**



Source: See Table 1
Note: GDP is conventionally measured (including software and mineral exploration but excluding other intangibles).

Figure 3: **Intangible and tangible investment in the market sector (percent of GDP), 2006**



Source: See Table 1
Note: GDP is conventionally measured (including software and mineral exploration but excluding other intangibles).

Before looking at the effects of intangible capital on growth, we stress that the investment measures in the tables and figures presented in this section are still relatively unrefined, and that there is much room for further improvements. Since this is a relatively new research field, statistical offices and other agencies often do not have comprehensive data on various intangible assets, and research is still scarce in most areas. For example, it is because of limited evidence that CHS (2005) assume that the financial industry spends 20 percent of their intermediate costs on developing new products and that managers

The estimates are partly based on assumptions, leaving room for future improvements.

spent 20 percent of their time improving organizational structure.[10] At this point we have no corroborating evidence that those percentages would hold in other countries, and once more detailed sources become available for individual countries we may see adjustments to these measures. Our estimates also lack information on imports and exports of intangible assets. Jalava *et al.* (2007) use imports and exports of R&D to adjust the business expenditure on R&D for Finland in 2005. They estimate that Finland invested EUR 4,275 million in R&D in 2005, which was EUR 399 million more than their unadjusted estimation. The updated estimates for the United States included here use the R&D investment estimates developed by the US Bureau of Economic Analysis, which defines R&D investment as domestic R&D investment plus imports minus exports.

We use a wide range of data sources including national accounts and surveys from statistical offices and trade associations.

It is also important to note that some of the national studies summarized in Tables 1 and 2 use more details from nationally available sources than others. Another distinction is the intensity by which use is made of national accounts-related sources. For example, Marrano and Haskel (2006) and Van Rooijen *et al.* (2008) rely heavily on the data from national accounts for the UK and the Netherlands, respectively. In contrast, the US estimates rely more strongly on survey data from the Census Bureau (for services industries), the Bureau of Labour Statistics (for training), as well as on trends in managerial and professional employment.[11] In this comparative study we use the widest possible range of data sources including national accounts and other surveys from national or international statistical offices (*e.g.* Eurostat). But we also intensively use data from trade associations which are often more broadly available across countries and for which no equivalents can be directly obtained from national accounts.

Our results can also be compared with those from a preliminary study by Jona-Lasinio *et al*. (2009) which provides a comparison of intangible investment for all EU-27 member states. While that study applies similar principles as the current one (exhaustiveness, international comparability, *etc*.), it creates more or less "point-in-time" estimates that rely very heavily on national accounts sources, and aim (as much as possible) to create maximum consistency with current national accounts measures. Then, intangibles are 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 as a share of labour costs), and subsequently "worked back" using their employment, output and cost shares. A tentative comparison suggests that this approach leads to overall somewhat lower measures of intangible investment by about 1.5 percentage points of GDP on average.[12]

4. Intangible assets contributed to labour productivity

Our results suggest that intangibles are an important component of output, and that their omission biases the GDP estimates that are important for the formulation of economic policy. In this section, we show that they are also an important source of economic growth. Using the investment estimates developed in the preceding sections, we now proceed to implement the modified Solow sources-of-growth model set out in Equation (2) of Section 2.

10 See Annex 1 for further details. Currently, with support from the National Science Foundation, The Conference Board is conducting research and designing a survey to determine the validity of these assumptions for the finance and insurance industry.

11 At the time the US estimates were developed, the industry accounts were undergoing a shift in classification systems and sufficient and up-to-date information was not available.

12 With thanks to Mary O'Mahony for sharing this comparison with us.

A number of steps are needed to transform the data on intangible investment into the capital stocks and capital service prices needed for Equation (2). First, we use a perpetual-inventory method to measure the stocks of intangible capital (a proxy for the flow of capital services). This step involves adding each year's investment in each type of intangible to the depreciated amount of the preceding year's capital stock. Unfortunately, relatively little is known about depreciation for intangibles, so we follow the assumptions by CHS (2005; 2009), which use an annual rate of 33 percent for computerized information, 15 percent for R&D, 60 percent for advertising and 40 percent for firm specific resources (see Table A.2 in Annex 2). In each case, we create initial capital stocks in the beginning year, which in our case is 1995, by cumulating investments over previous years.[13] Given the relatively high depreciation rates, most of each investment is depreciated away within five years, so it is sufficient to extrapolate the investment series back to 1990.

A number of steps are needed to make the intangible investment series usable in growth accounting.

The next step is to calculate the user cost of each asset type, including intangibles. The user cost is made up of the rate of return, the depreciation rate and a capital gains term. For the rate of return we may assume the same rate for intangible capital as for tangible capital, assuming that businesses arbitrage their investments across all types of capital, investing in each type until the rate of return for all assets is equal (CHS 2009, p. 677). The income accruing to each type of capital in each year is then found by multiplying the quantity of stock by the corresponding user cost, and the cost shares can then be calculated.

Table 4 summarizes the contributions of intangibles to the growth rate of labour productivity growth in the market sector for the eleven countries included in this study. The updated US estimates show that the growth in intangible capital per unit of labour ("intangible capital deepening") contributed an average 0.8 percentage points to the annual growth of US labour productivity from 1995 to 2006.[14] In the UK, intangible-asset deepening increased labour productivity by an average of 0.7 percentage points per year, from 1995 to 2006 (MHW 2009). In Germany, intangible assets contributed to labour productivity growth by 0.4 percentage points per year on average from 1995 to 2006, in France by 0.5 percentage points, in Italy and in Spain by 0.1 percentage points.

Table 4 also shows the estimates for the contribution of intangible assets to labour productivity growth in the market sectors of Austria, the Czech Republic, Denmark and Greece. In Denmark and the Czech Republic intangible assets contributed to 0.7 percentage points to labour productivity growth, compared to 0.6 percentage points in Austria and only 0.2 percentage points in Greece.[15]

13 The starting year is 1995 for most countries, but 1997 is the first year for the Czech Republic given available estimates on capital gains, and 2000 is the first year for which a stock of tangible capital could be produced for Slovakia.

14 Unlike the original CHS (2009) estimates and official MFP estimates for the United States, the estimates in Table 4 do not include contributions from land and inventory capital. We do this to strengthen the international comparisons made in this paper, as estimates of multi-factor productivity for most countries generally do not account for land and inventory capital.

15 For Slovakia, the growth accounts estimates start only in 2006, showing a contribution of about 0.2-0.3 percentage points to labour productivity growth

Table 4. Average annual change in labour productivity in the market sector and contribution of tangible and intangible capital deepening, labour quality and MFP growth, 1995-2006

	Germany	France	Italy	Spain	Austria	Denmark	**Average**	Czech Rep	Slovakia	Greece	UK	USA
	95-06	95-06	95-06	95-06	95-06	95-06	**95-06**	97-06	00-06	95-06	95-06	95-06
					Excluding Intangible Capital (percent)							
Labour productivity growth	1.61	1.83	0.26	0.36	1.99	1.54	**1.18**	4.50	6.30	3.21	2.90	2.75
Contributions												
ICT cap. deep. (ex. software)	0.23	0.14	0.12	0.21	0.29	0.50	**0.20**	0.38	2.85 (ICT and non-ICT combined)	0.46	0.74	0.47
Non-ICT cap deep.	0.57	0.37	0.31	0.56	-0.03	0.28	**0.39**	1.76		1.52	0.36	0.30
Labour quality	-0.16	0.44	0.24	0.68	0.24	0.19	**0.23**	0.34	0.49	0.73	0.26	0.20
MFP	0.98	0.88	-0.41	-1.10	1.49	0.57	**0.37**	2.02	2.97	0.51	1.54	1.78
					Including Intangible Capital (percent)							
Labour productivity growth	1.79	2.00	0.29	0.47	2.36	2.11	**1.32**	4.60	6.17	3.27	3.06	2.96
Contributions												
ICT-capital deepening	0.20	0.12	0.11	0.19	0.26	0.44	**0.17**	0.35	2.72 (ICT and non-ICT combined)	0.45	0.63	0.40
Non-ICT-cap deepening	0.48	0.31	0.29	0.49	-0.02	0.24	**0.34**	1.62		1.48	0.28	0.24
Intangible-cap. deepening	0.38	0.48	0.12	0.12	0.55	0.72	**0.30**	0.68	0.21	0.24	0.69	0.83
Computerized information	0.07	0.15	0.03	0.05	0.13	0.29	**0.08**	0.06	0.04	0.06	0.16	0.18
Innovative property	0.23	0.18	0.05	0.15	0.29	0.27	**0.16**	0.35	0.07	0.11	0.17	0.35
Economic competency	0.07	0.15	0.04	-0.08	0.13	0.17	**0.06**	0.27	0.10	0.07	0.36	0.29
Labour quality	-0.15	0.40	0.22	0.64	0.22	0.17	**0.21**	0.31	0.46	0.71	0.22	0.18
MFP	0.88	0.69	-0.45	-0.96	1.35	0.53	**0.29**	1.64	2.78	0.40	1.23	1.33

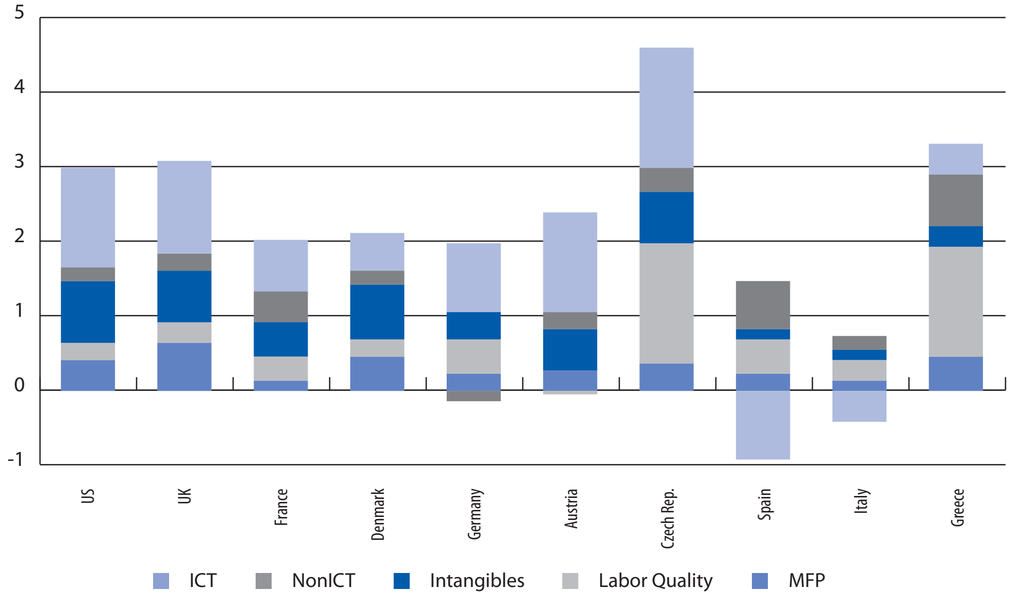
Sources: Employment, value added, and the stock of tangible capital for all countries from 1997 to 2005 from EUKLEMS, version March 2008 (www.euklems.net). EU KLEMS provides the deflators and depreciation rates of tangible assets and the depreciation rates of software and databases. CHS (2005) provides the deflators of all intangible assets and the depreciation rates of intangible assets excluding software and databases. For intangible investment in Austria, the Czech Republic, Denmark, Greece and Slovakia, see Annex 1;. for Germany, France, Italy Spain, the UK and the US, see Table 1.

Notes: We follow the EUKLEMS definition of market sector by excluding the following industries: public administration, health, education and real estate.
Measures of tangible capital exclude land and inventories.

Figures 4a and 4b reproduce the results from Table 4 graphically. In Figure 4a, we show that the average contribution of intangibles ranges from less than 10 percent of labour productivity growth in the case of Greece to 40 percent in Italy. However, overall labour productivity growth has been very low in Italy (as well as in Spain) due to a strong negative contribution from a decline in MFP. In Denmark, intangible-capital deepening accounts for 34 percent of labour productivity growth.

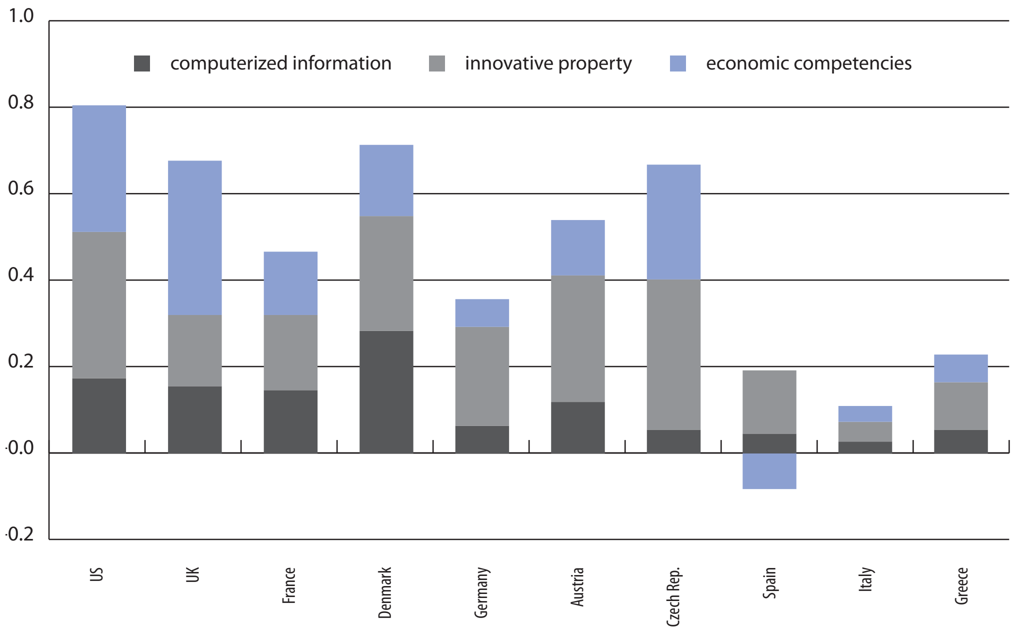
The contribution of intangibles to labour productivity growth ranges from about 10 to 40 percent.

Figure 4a. Contribution of inputs to labour productivity growth, annual average (percent), 1995-2006



Source: See Table 4
Note: GDP is conventionally measured (including software and mineral exploration but excluding other intangibles).

Figure 4b. Contribution of sub-components of intangibles to labour productivity growth, annual average (percent), 1995-2006



Source: See Table 4
Note: GDP is conventionally measured (including software and mineral exploration but excluding other intangibles).

Figure 4a also shows that in most Europeans countries the growth contributions from intangible capital deepening are smaller or at best close to the growth contribution of tangible capital (which includes ICT capital excluding software, and non-ICT capital which are mainly equipment and structures). Except for the United States, only one other European country (Denmark) is showing a much larger contribution from intangible capital deepening. Non-ICT capital tends to be dominated by traditional types of "brick and mortar" capital used in the manufacturing sector, suggesting the importance of structural differences in the economies in the comparison, although some of the brick-and-mortar capital may in fact be rather high in technology (*e.g.* advanced machine tools).

Figure 4b compares the absolute contributions of intangible capital to labour productivity as well as the breakdown into contributions from computerized information, innovative property and economic competency. The figure reveals that the largest differences in contributions are due to economic competencies. The countries are ranked in the same way as in Figure 2, that is, according to the share of intangible investment in GDP ("intangible intensity") in 2006. The comparison suggests that there is no perfect relationship between intangible intensity (as in Figure 2) and the growth contribution from intangible capital deepening (as in Figure 4). In particular, Denmark (showing a relatively high contribution from computerized information) and the Czech Republic (showing a large impact from innovative property) are among the most important outliers.

All in all, one may distinguish between four groups of countries in terms of their intangibles contribution to output and productivity growth: (1) the US and the UK, which show rapid labour productivity growth and high contributions of intangibles; (2) France, Denmark, Germany and Austria, which still show significant contributions against the backdrop of smaller growth rates of labour productivity; (3) catching-up countries such as the Czech Republic and Greece (and also Slovakia) which show much larger contributions from non-ICT-capital deepening than from intangibles, and – in some cases – also larger MFP growth rates related to the restructuring of those economies; and (4) laggard economies, such as Italy and Spain, which show small absolute contributions of intangibles coupled with slow growth of labour productivity and even negative contributions from MFP growth.

5. Intangible investment and levels of economic development

Intangible investment is concentrated on the world's richest countries, arguably because…

A look at international data on R&D spending and brand equity, as well as the location of the largest non-financial non-resource companies, suggests a high concentration of intangible capital in the richest countries of the world. For example, today five countries – the US, Japan, Germany, France and the UK – account for 75 percent of R&D spending in the world in 2005 (OECD 2008). One reason for this concentration may be that high-income countries tend to have more of everything that is economically valuable, including this particular kind of capital. However, there are other reasons for intangibles to be concentrated in these countries.

First, less-developed countries may be less likely to invest in intangibles because of their industrial structure. To the extent that they specialize in sectors where low wages provide a competitive advantage, they may be able to make do with technology developed elsewhere. Technology transfer and diffusion is less costly for them than domestic development programmes in R&D, knowledge creation and other intangibles. However, this tends to change as their production moves up the supply chain to higher-value-added activities. For example, Howitt and Mayer-Foulkes (2002) distinguish three groups of countries, of which only the first small group develops leading-edge R&D which accounts for most of the R&D spending in combination with the highest growth rates of output. The second group of countries primarily uses technology developed elsewhere, using a pool of skilled workers to absorb it. The third group is unable to develop their own technologies or even use other countries' technologies as they lack absorption capacity. Another factor is the larger share of service industries, which tend to rely more strongly on intangibles (van Ark *et al.* 2003).

A second reason for a concentration of intangibles and a strong intangible effect on growth is that lower-income countries may not be able to afford risky upfront investment in activities with an uncertain outcome, such as R&D or huge advertising expenses with uncertain results in the longer term. In a Schumpeterian competition environment (which has been identified earlier as relevant to the discussion on intangibles), there is often a "winner takes all" outcome (*e.g.* in packaged consumer software) or a few major rivals (*e.g.* in pharmaceuticals). In such an environment, small or under-resourced economies may lack the incentives to invest in intangible capital.

…they can afford risky upfront investment and have large high-skilled labour markets, deep stock markets and ample venture capital.

Third, innovations often require a mature and sizeable stock market and ample venture capital. Stock markets and venture capital are key financial sources of innovation. While traditional financial instruments, such as regular loans, often favour long-term tangible investment, using building and machines as collaterals, they tend not to finance risky R&D. In contrast, stock markets and venture capital are typically friendlier toward intangible investment. Investors in stock markets value R&D and other intangible investment. Hall (1999) shows that R&D and patents are strongly related to stock prices. Venture capital is seeking investment with high risk and high return.

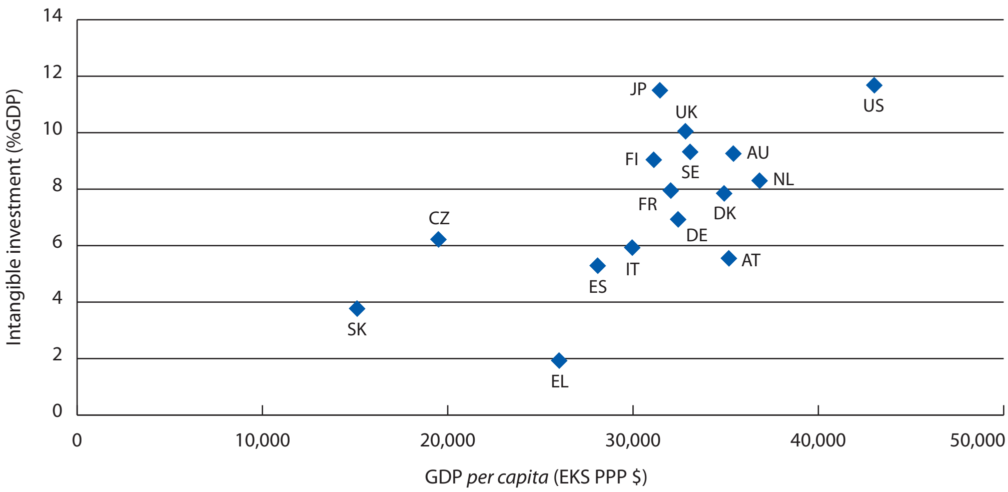
Finally, innovations driven by intangible investment might require a flexible labour market. Innovation projects are risky, and innovation programs are often discontinued because of a competitor's success or the programme's failure. In such cases, researchers may face layoffs, and require wage premiums or job guarantees in order to accept employment. These premiums and guarantees are less important when the market for researchers is relatively thick and flexible, giving an advantage to larger, richer, countries with bigger pools of highly-educated people and a tradition of job switching.[16]

Unfortunately, our sample is at this point not large or broad enough to fully address this issue. Despite important differences, the eleven countries we have dealt with so far are among the richest in the world. Nevertheless, we can have a look at our sample to see if there is evidence of a correlation between intangible investment and the level of income *per capita* and labour productivity. To do this, we combine our estimates for the eleven countries included in this study with the results on intangible investment analysis for five other countries, including Australia (Barnes and McClure 2009), Finland (Jalava *et al.* 2007), Japan (Fukao *et al.* 2007; 2009), the Netherlands (van Rooijen-Horsten *et al.* 2008), and Sweden (Edquist 2009). Figure 5a shows the relation between the relative levels of income *per capita* converted into purchasing power parities (PPP) and intangible investment as a percentage of GDP, for the period from 2001 to 2004. The figure shows a positive association between the two variables. As an additional control, Figure 5b shows the link between relative levels of income *per capita* (PPP-converted) and the ratio of intangible to tangible investment as a percentage of GDP, revealing a positive correlation, too. The latter confirms that the positive association appears to be limited to intangibles and does not apply to income and capital more broadly. However, the correlations are far from perfect, as the cases of Japan, Finland, and the UK show.

16 If a firm has to offer employees long-term employment contracts, it may be more likely to develop incremental technology than high technology. For example, it has been argued that the relatively rigid labour market in Germany has led to more success in traditional chemical industries rather than high-technology industries (Streeck 1992 and Katzenstein 1989).

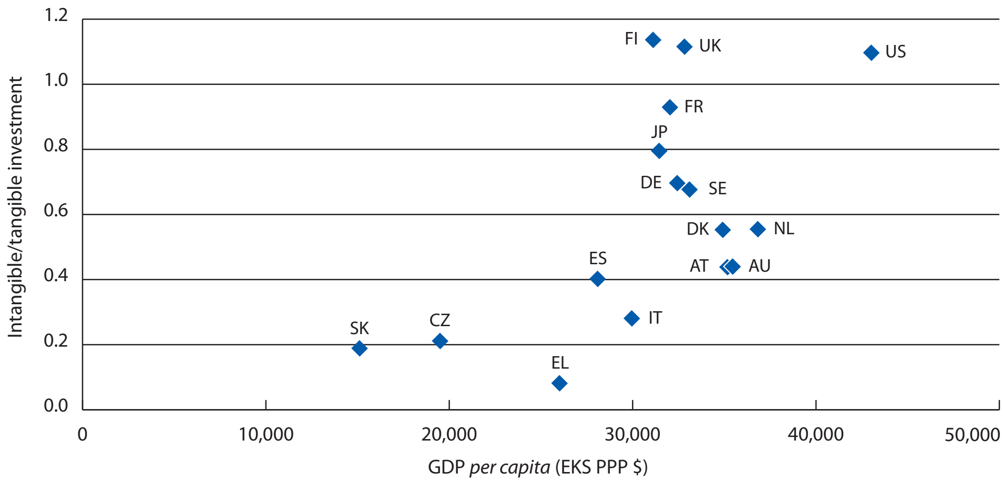
Intangible-investment intensity is correlated with the level of economic development, whether measured by per-capita income…

Figure 5a. Intangible investment and GDP *per capita* (2001-04)



Source: See Figure 5b
Notes: See Figure 5b.

Figure 5b. Intangible investment and GDP *per capita* (2001-04)



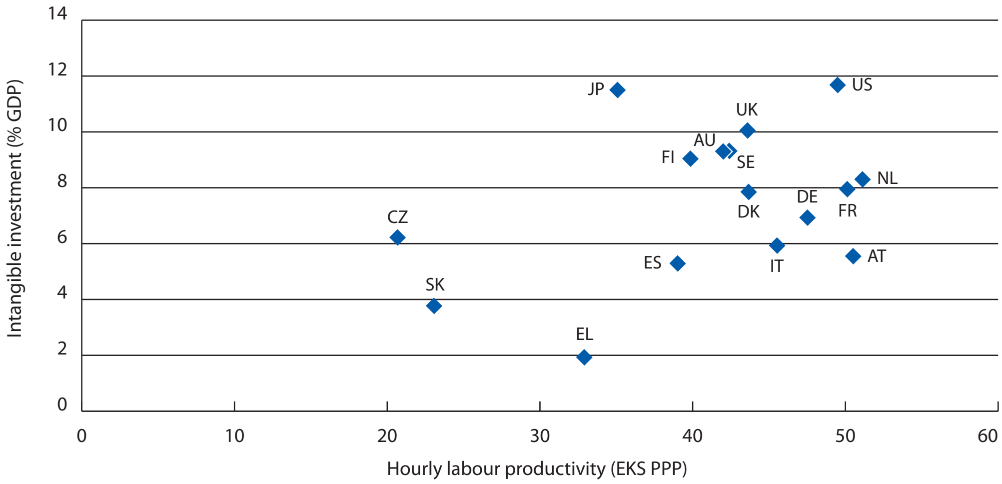
Source: GDP *per capita* is from the The Conference Board, Total Economy Database, version June 2009. For intangible investment, sources are Jalava *et al.* (2007) for Finland, Fukao *et al.* (2009) for Japan, Edquist (2009) for Sweden, Van Rooijen-Horsten *et al.* (2008) for the Netherlands and Barnes and McClure (2009) for Australia. For the other countries see Figures 1a and 1b.

Notes: The 16 countries are Australia (AU), Austria (AT), Czech Republic (CZ), Denmark (DK), Finland (FI), France (FR), Germany (DE), Greece (EL), Italy (IT), Japan (JP), the Netherlands (NL), Slovakia (SK), Spain (ES), Sweden (SE), the UK and the US. Intangible investment is the average investment from 2001 to 2004 for all countries, except the US (2000-2003), Finland (2000 and 2005) and Sweden (2004).

Figures 6a and 6b show that the correlation is weaker when the *per-capita*-income variable is replaced with the level of labour productivity. However, if the relationship between the ratio of intangible to tangible investment and a living-standards variable is fit with an exponential trend, the strength of the relationship does not vary substantially according to which measure of living standards is used.

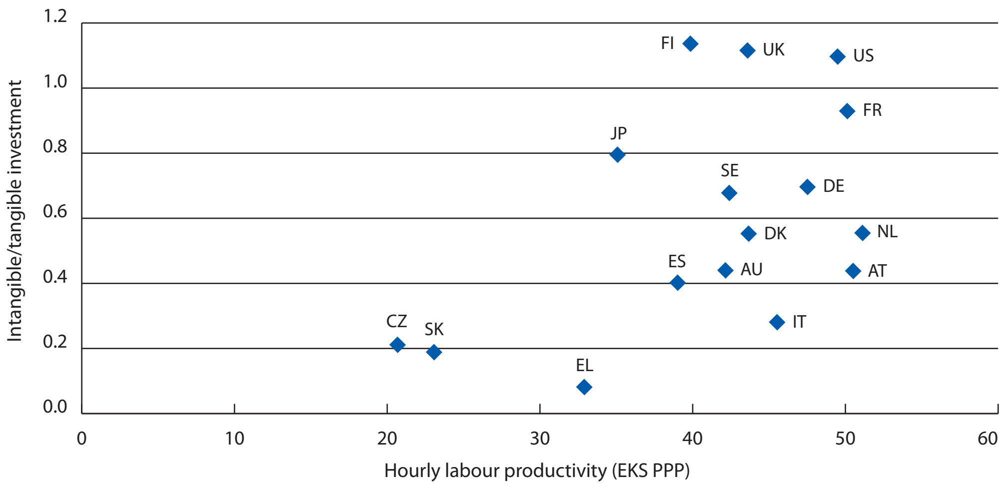
Figure 6a. Intangible investment and labor productivity (2001-04)

...or hourly labour productivity.



Source: See Figure 5b
Notes: See Figure 5b.

Figure 6b. Intangible/tangible investment and labour productivity (2001-04)



Source: See Figure 5b
Notes: See Figure 5b.

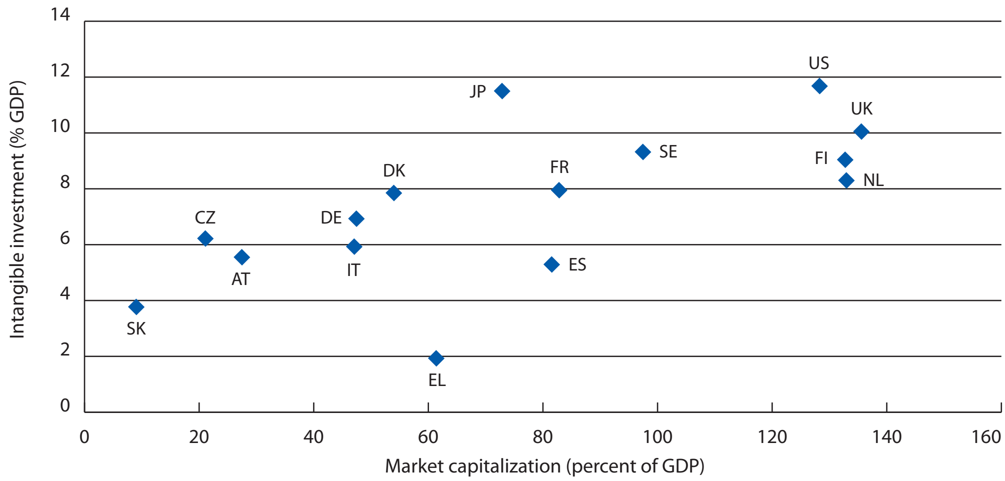
Figures 7a and 7b examine the link between stock market capitalization and venture capital, on the one hand, and investment in intangible assets on the other. Figure 7a shows that the size of stock markets as a percentage of GDP is strongly related to the level of intangible investment over the period 2001-2004. Figure 7b shows that venture capital (early stage and expansion and replacement stage) as a percentage of GDP is also strongly related to the level of intangible investment.

Finally, we have already noted that the non-rival nature of knowledge capital implies a theoretical link to MFP growth *via* the diffusion of knowledge. For example, in the case of R&D, US estimates suggest that between a fifth and a quarter of business sector MFP may be due to R&D spillovers.

If this spillover result can be generalized, there should be a positive association between the importance of intangibles as a source of labour-productivity growth and the size of MFP growth. This positive association is evident in Figure 8. Even though additional research is needed to establish their importance, these results suggest that spillovers from intangibles may exist beyond the well-researched effects from R&D.

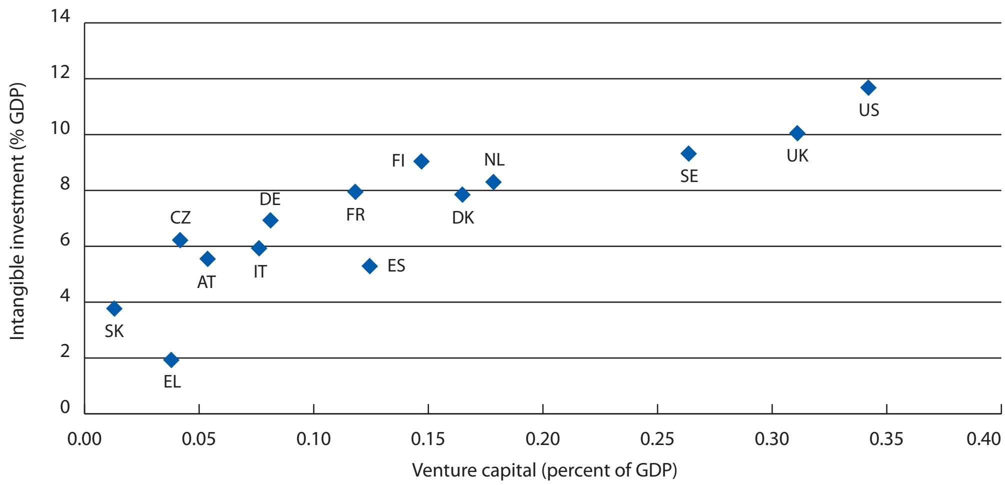
Intangible investment is strongly related to the size of stock- and venture capital markets.

Figure 7a. Intangible investment and market capitalization (2001-04)



Source: See Figure 5b
Note: Market capitalization is the value of the stock market as a percentage of GDP. We use the average percentage from 2000 to 2006.

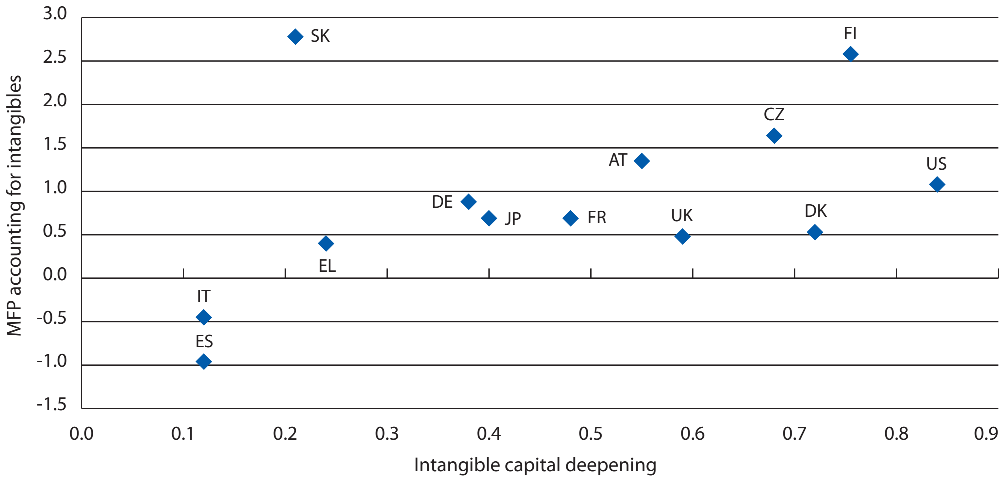
Figure 7b. Intangible investment and venture capital (2001-04)



Source: See Figure 5b
Note: We include venture capital for the early stage, expansion and replacement, and average the values from 2000 to 2006.

While the link between intangibles and economic development may be blurred by conditional factors and endogeneity issues, there are theoretical reasons to believe that it exists and that it is important. Our sample is too small to pin down the size of the effect, but the various pieces of evidence we have presented suggest that the importance of intangible capital as a source of growth is large and it increases with the level of economic development.

Figure 8. Intangible capital and spillover effects



Source: See Figure 5b

Note: The 13 countries are Austria, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Japan, Slovakia, Spain, the UK and the US.

6. Conclusion

The current economic downturn has distracted attention away from long-term value-building investments in intangibles, which are the ultimate key to recharging our knowledge economy, to providing higher rewards to labour and capital and to raising productivity in a sustainable manner. Investments in intangibles are also the "foundation" on which short-term stimulation measures are anchored. Companies will not commit resources to significant near-term expansion unless it is consistent with their overall business model – a model that is supported by intangible capital.

In this article we have discussed the state of the art in the measurement of intangible capital and its contribution to economic growth, with a focus on international comparisons currently available. Our core group of eleven countries for which we have been able to build measures of intangible investment intensity and of intangible capital deepening shows that intangibles have a large impact on growth. To omit intangibles from the analysis of growth is therefore to present a biased picture of the growth process.

Intangible capital explains about a quarter of labour-productivity growth in the US and in the larger EU countries.

Intangible capital explains about a quarter of labour-productivity growth in the US and larger countries of the EU. However, the growth patterns of individual countries in the EU vary considerably. Notably the continental West-European countries show a distinction between countries with significant contributions from intangible capital deepening (although less than in the US and the UK, the lead countries) and a group of laggards (Italy and Spain) that show small absolute contributions of intangibles, slow growth of labour productivity and even negative contributions from MFP growth. Catching-up countries such as the Czech Republic, Greece and Slovakia show much larger contributions from non-ICT capital deepening than from intangibles, and – in some cases – also larger MFP growth rates related to the restructuring of those economies.

Our analysis suggests that higher rates of investment in intangibles (as a share of GDP) are often associated with higher growth rates of GDP *per capita*, which might be attributed to a higher propensity to invest in higher-income (and productivity) countries. Returns to scale in innovation and possibly the tendency for smaller economies to compete in established market niches may also be other factors. Moreover, the non-rivalry in the use of knowledge capital may make across-the-board competition for the development of new technology non-optimal, since new technology in the follower countries can more often be obtained by technology transfer and diffusion.

Many in the business community assert that brand equity and human capital are at least as important as R&D.

This study has identified several areas for further refinement of intangible capital concepts and more precise measurement. The best evidence that there is a need to significantly broaden the concept of capital as a source of growth is made by many who are associated with the business community asserting that brand equity and human capital are at least as important as R&D to most businesses. From the narrow standpoint of economic self-interest, policy-makers in high-income countries should encourage investment in intangibles to protect their country's advantage in the globalized world.[17] On the other hand, policy-makers in emerging economies may see the promotion of this form of investment as a way of laying the foundations of higher long-term growth and faster convergence to the technological frontier.

17 This objective is all the more important in this period of economic downturn, since intangible investments may have been hit harder than other components of GDP, and R&D and other non-production workers have experienced steeper employment losses. See for example, Michael Mandel in Business Week of November 9, 2009.

Annex 1. Sources and methods to measure intangibles in Austria, the Czech Republic, Denmark, Greece and Slovakia

This annex gives an overview of the sources and methods to obtain estimates of intangible capital for the five new European countries that have been added in this study.[18] They largely follow the methodology laid out by Corrado, Hulten and Sichel (CHS 2005 and CHS 2009), which also represents the sources for the US figures used in this study. For the UK we rely on Marrano, Haskel and Wallis (MHW 2007; 2009) while for France, Germany, Italy and Spain, results are based on Hao *et al.* (2009).

1. Computerized information

The major component of computerized information is software. The data source for Austria, Czech Republic and Denmark from 1995 to 2005 is EU KLEMS which is an internationally comparative database on growth and productivity accounts currently housed at the University of Groningen (www.euklems.net). The capital account of EU KLEMS provides estimates of the investment and stocks of eight assets – (1) software, (2) computing equipment, (3) communications equipment, (4) transport equipment, (5) other machinery and equipment, (6) total non-resident investment, (7) residential structures, and (8) other assets. Since EU KLEMS does not provide software investment in 2006, we use national accounts to extend our estimates from 2005 to 2006. We use the estimates of software investment by industry in 2006 for Czech Republic, and use the growth rates from 2005 to 2006 of "intangible investment" provided by national accounts for Austria and Denmark. "Intangible assets" in national accounts include only a small fraction of intangible assets as defined in our research. For example, 90 percent of "Intangible assets" in Danish national accounts are software investment and 10 percent are exploratory drilling and copyrights[19].

For Slovakia, no data source provides software investment, so we have to roughly estimate software investment. Our data source is IT Association Slovakia and EU KLEMS. IT Association Slovakia provides the domestic sales of software in Slovakia in 2000 and 2003. We average the ratio of domestic sales to the output of the software industry, assuming that domestic sales equal software investment, and use that ratio to estimate the software investment for the other years.

For Greece, the data source for the period from 1980 to 2004 is Timmer *et al.* (2003, updated to 2005). They calculate an average ratio of software to office and computer equipment for France, Italy and the UK, and multiply that ratio with investment in office and computer equipment in Greece. We estimate year 2005 using the growth rate of the gross output of industry "computer and related activities" (NACE 72, version 1), which is taken from EU KLEMS. We estimate year 2006 using the growth rate of the turnover of NACE 72 (National Statistical Service of Greece).

The other component of computerized information is databases. Database activities include the following four activities (The Encyclopedia for Classification Codes, 2007): (1) on-line database publishing, (2) on-line directory and mailing list publishing, (3) other on-line publishing, and (4) web search portals. We argue that companies increase their productivity by accessing data online, so we treat the revenues of Database Activities as companies' investment in databases.

---

18 Further details are available from the authors upon request.

19 National Accounts, sources and methods, 2003. Available at http://www.dst.dk/HomeUK/Guide/documentation/NatAcc/methods2003.aspx

We approximate database investment with the output of the database industry (NACE 74 "other business activities", according to NACE codes list). The data source is EU KLEMS for the years 1995 to 2004, and we update the data to 2005 and 2006 using national accounts. For Austria, the Structural Business Survey of Eurostat provides the output of NACE 724 ("database activities") in 2006. We average the output of 2004 and 2006 to estimate the output in 2005. For the Czech Republic, we use a time trend to estimate database investment in 2005 and 2006. For Denmark, we assume that the output of NACE 724 grew at the same rate as the output of NACE 72 in 2005 and 2006. The national accounts of Denmark provide the output of NACE 72 from 2004 to 2006. For Greece, we estimate year 2005 using the growth rate of the gross output of NACE 72 (EU KLEMS). We estimate year 2006 using the growth rate of the turnover of NACE 72 (National Statistical Service of Greece). For Slovakia, we estimate database investment using the growth rate of intangible investment in 2005 and 2006 provided by the national accounts.

2. Innovative property

Innovative property includes both scientific and non-scientific innovation. The components of innovative property are (1) R&D in natural science and social science, (2) mineral explorations, (3) copyright and license costs, (4) development costs of new products in the financial industry, and (5) new architectural and engineering designs.

R&D. The data source is Eurostat. Eurostat provides R&D expenditure from 1981 to 2004, including both natural science and social sciences. The R&D data are, *inter alia* broken down by institutional sector: business enterprise sector, government sector, higher education sector, and private non-profit sector. To measure how much market sectors spend on R&D, we exclude expenditure by government and higher education sector.

Mineral explorations. We have no data for mineral exploration, but that is unlikely to impact our estimates. Existing literature shows that mineral exploration is less than 0.04 percent of GDP for countries with intangible estimates other than the US.

Copyright and license costs. We approximate copyright and license costs at three times the production cost of movies. The data source for year 2000 to 2005 is Screen Digest (2007).[20] Screen Digest provides production costs of movies for 59 countries from 2000 to 2005. For the year 2006, the turnover of motion picture, music and publishing from the Short-term Business Statistics provided by Eurostat is used to estimate production costs for Austria, Denmark and Slovakia while a time trend is used for the Czech Republic and Greece. A drawback of this estimation method is that some countries have a small movie industry, and we would underestimate copyright and license costs for those countries.

Development costs of new products in the financial industry. The data are intermediate costs in the financial industry provided by EU KLEMS from 1995 to 2005. We update the data to 2006. For Austria, Denmark and Slovakia, the information is taken directly from the national accounts. Since this is not possible for the other two countries, we assume the (unreported) growth rate of intermediate costs to equal the 2006 growth rate of output (Czech Republic) or that of value added (Greece) of the financial sector.

We assume that the financial industry invested 20 percent of the intermediate costs in developing new products.

20 Available at www.screendigest.com

New architectural and engineering designs. For the years 1995-2004, the data source is the output of NACE 742 ('architectural, engineering and other technical activities') and is taken from EU KLEMS. We update output measures to 2006 using national accounts and Eurostat. For Austria, the data source is Structural Business Statistics 2006 provided by the national accounts (*www.statistik.at*). We use the average of 2004 and 2006 as an estimate of year 2005. For the Czech Republic, Denmark and Slovakia, we use the turnover index of architectural and engineering of 2005 and 2006 from the Short-term Business Survey provided by Eurostat. For Greece, we estimate year 2005 using the growth rate of the gross output of NACE 74 provided by EU KLEMS. We estimate year 2006 using the growth rate of the turnover of NACE 74 provided by the National Statistical Service of Greece.

We estimate investment as half of the gross output coming from NACE 742.

3. Economic competencies

Economic competencies include brand equity, firm-specific human capital and organizational capital.

Brand equity. Firms can increase their brand equity by advertising their brands or by researching the market. The data sources for advertisement are EU KLEMS, World Magazine Trends and national accounts. EU KLEMS provides the gross output of the advertising industry (NACE 744, "advertising") from 1970 to 2004. We update the output to year 2005 and 2006 using national accounts. For Austria, the data source is Structural Business Statistics 2006 provided by Eurostat.[21] We use the average of 2004 and 2006 to estimate year 2005. For the Czech Republic, Denmark and Slovakia, we use the advertisement index in 2005 and 2006 from the Short-term Business Survey of Eurostat. For Greece, we estimate year 2005 using the growth rate of the gross output of NACE 74 provided by EU KLEMS. We estimate year 2006 using the growth rate of the turnover of NACE 74 provided by the National Statistical Service of Greece.
We assume that 60 percent of spending on advertisement is investment. Some of the advertising expenditure increases current sales but not sales after one year, so part of the advertising costs is current expenditure rather than investment. Classified advertisement is unlikely to form brands. We exclude half of newspaper advertisement. World Magazine Trends provide the percentages of advertisement on newspapers.[22]
The data source of market research is the Structural Business Statistics of Eurostat. It provides the turnover of Market Research and Public Opinion Polling (NACE 7413).

Firm-specific human capital. We measure how much firms spend on firm-specific human capital, using spending on initial vocational training and continuing vocational training. Initial vocational training relates to apprentice training (AT), whereas continuing vocational training (CVT) includes training courses, training at work places, training through job rotation, self-learning and learning at conferences, lectures and workshops. Initial vocational training includes apprentice training and full-time schooling. Since firms do not pay for full-time schooling, we exclude it.

Our major data sources of AT and CVT are the Labour Cost Survey (LCS) 2004 provided by Eurostat, Continuing Vocational Training Survey (CVTS) 2005 provided by Eurostat, labour compensations provided by EU KLEMS before 2006 and national accounts in 2006.

21 Available at http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/
22 Available at http://www.warc.com/LandingPages/Data/MagazineTrends/

Organizational structure. There are two major ways to improve organizational structure. Managers spend time on making firms more efficient (own-account organizational capital), or firms purchase management consultancy services to solve problems of organizational structure.

The data sources of own-account organizational capital are EU KLEMS, national accounts, and the Structure of Earnings Survey (SES) 2002 from Eurostat. We assume that managers spend 20 percent of their time on improving organizational structures. Following CHS (2005), we assume that 4 percentage points of those efforts improve current organizational structure and 16 percentage points improve future organizational structure, so investment in own-account organizational capital is assumed to equal 16 percent of manager compensation.

The data source of management consultancy is the Annual Survey of the European Management Consultancy Market, provided by the European Federation of Management Consultancies Associations (FEACO). The survey covers five classes of management consultancy – operations management, information technology, corporate strategy services, human resources management and outsourcing services – for eleven private sectors and three public sectors. FEACO provides the market size of management consultancy from 1998 to 2006 for Austria, Czech Republic and Denmark, and from 1998 to 2004 for Greece and Slovakia. We update the data to 2005 and 2006. For Greece, we estimate year 2005 using the growth rate of the gross output of NACE 74 (EU KLEMS) and year 2006 using the growth rate of the turnover of NACE 74 (National Statistical Service of Greece). For Slovakia, we estimate year 2005 and 2006 using the turnover index of management consulting from the Short-term Business Survey provided by Eurostat.

Annex 2. Sources and methods to develop growth accounts including intangibles for Austria, the Czech Republic, Denmark, Greece and Slovakia

Value-added and labour input. EU KLEMS provides the real value-added (double-deflated, *i.e.* gross output deflate with output deflators and intermediate inputs deflated with input deflators) and labour input by industry from 2000 to 2005. National accounts provide value-added and labour input for 2006. EU KLEMS provide eight variables of labour input: (1) total hours worked, (2) hours worked of high-skilled labour, (3) hours worked of medium-skilled labour, (4) hours worked of low-skilled labour, (5) total labour compensation, (6) compensation of high-skilled labour, (7) compensation of medium-skilled labour, and (8) compensation of low-skilled labour.

Investment and stock of tangible assets. For Austria, the Czech Republic and Denmark, the data sources are EU KLEMS from 1995 to 2005 and national accounts in 2006. For Greece, the data sources are Timmer *et al.* (2003, updated to 2005) for 1995 to 2004 and national accounts for 2005 and 2006. For Slovakia, the source is national accounts from 2000 to 2006.

We measure two groups of tangible assets for Austria, the Czech Republic, Denmark and Greece. ICT tangible assets include computing equipment and communication equipment. Non-ICT tangible assets include non-residential buildings and other tangible assets. We exclude residential structures because they are not used in production. For Slovakia, we do not separate ICT assets from non-ICT assets because the national accounts of Slovakia provide no data on the division between them.

Investment and stock of intangible assets. EU KLEMS provides data on the investment and stock of software for Austria, the Czech Republic and Denmark. The investment in other intangibles is our own estimate. Furthermore, we estimate the stock of each intangible asset using the perpetual inventory method (PIM), a method to calculate capital stock from investment flows. The capital stock of the current period is the capital stock of the previous period minus depreciation and plus new investment.

Deflators and capital gains. EU KLEMS provides the deflator of tangible assets. We use the deflator of aggregate market-sector value-added as the deflator of intangible assets, following CHS (2005). Also following the method of CHS (2006), we use a three-year average of deflators to calculate the capital gains of each asset.

Depreciation rates. EU KLEMS provides the depreciation rates of tangible assets, software and databases. CHS (2005) provide the depreciation rates for other types of intangible assets. Table A1 below lists the values of depreciation rates.

Table A1. Depreciation rates for intangible capital estimates

Assets	Depreciation rates
Intangible assets	
Software	0.315
Databases	0.315
R&D	0.2
Mineral exploration and evaluation	0.2
Copyright and license costs	0.2
Development costs in the financial industry	0.2
New architectural and engineering designs	0.2
Advertising expenditure	0.6
Market research	0.6
Firm-specific human capital	0.4
Organizational structure	0.4
Tangible assets	
Computing equipment (IT)	0.315
Communications equipment (CT)	0.115
Transport equipment	0.182
Other machinery and equipment	0.119
Non-resident structures	0.032
Other assets	0.119

Source: EU KLEMS and CHS (2005)

References

Barnes, P. and McClure, A. (2009). "Investments in Intangible Assets and Australia's Productivity Growth". Productivity Commission Staff Working Paper, Productivity Commission, Canberra, Australia.

Bloom, N. and Van Reenen, J. (2007). "Measuring and Explaining Management Practices Across Firms and Nations". *Quarterly Journal of Economics*, (122:4), pp. 1351-1408.

Bloom, N., Sadun, R., and Van Reenen, J. (2009). "The organization of firms across countries". NBER Working Paper No. 15129, National Bureau of Economic Research.

Brooksbank, R., Kirby, D., Tompson, G. and Taylor, D. (2003). "Marketing as a determinant of long-run competitive success in medium-sized U.K. manufacturing firms". *Small Business Economics*, (20), pp. 259-272.

Brown, S.P. (2008). "Business Processes and Business Functions: a new way of looking at employment". *Monthly Labor Review*, (131:12), pp. 51-70.

Campbell-Kelly, M. (1995). "Development and Structure of the International Software Industry, 1950-1990". *Business and Economic History*, (24:2), pp. 73-109.

Clayton, T., Franklin, M., Stam, P. and Haskel, J. (2009). "Interviews with Firms on Innovation Investment". Paper prepared for the conference, Advancing the Study of Innovation and Globalization, Nürnberg, Germany, May 29-30, 2009.

Corrado, C.and Hulten, C. (2009). "How do you Measure "Technological Revolutions"?". Paper to be presented at the 2010 AEA meetings, Atlanta, Georgia, USA.

Corrado, C., Hulten, C. and Sichel, D. (2005). "Measuring Capital and Technology: An Expanded Framework", in Corrado, *et al.* (eds.), *Measuring Capital in the New Economy*, National Bureau of Economic Research Studies in Income and Wealth volume 65, pp. 11-45. The University of Chicago Press, Chicago and London.

Corrado, C., Hulten, C. and Sichel, D. (2009). "Intangible Capital and US Economic Growth". *The Review of Income and Wealth*, (55:3), pp. 661-685.

Corrado, C. and Lane, J. (2009). "Using Cyber-enabled Transaction Data to Study Productivity and Innovation in Organizations". Paper for the conference, "Advancing the Study of Innovation and Globalization," Nürnberg, Germany, May 29-30, 2009.

Diewert, W.E. (2008). "The Measurement of Nonmarket Sector Outputs and Inputs Using Cost Weights". Discussion Paper 08-03, Department of Economics, University of British Columbia, Vancouver, B.C., Canada.

Edquist, H. (2009). "How Much does Sweden Invest in Intangible Assets?". IFN Working Paper No. 785.

EU KLEMS (2008). *EU KLEMS Growth and Productivity Accounts*, March 2008 Release. Available at www.euklems.net.

Fukao, K., Hamagata, S., Miyagawa, T. and Tonogi, K. (2007). "Intangible Investment in Japan: Measurement and Contribution to Economic Growth". Research Institute of Economy, Trade and Industry (RIETI) Discussion paper No. 07034.

Fukao, K., Hamagata, S., Miyagawa, T. and Tonogi, K. (2009). "Intangible Investment in Japan: Measurement and Contribution to Economic Growth". *The Review of Income and Wealth*, (553), pp. 717-736.

Hall, B.H. (1999). "Innovation and Market Value". NBER Working paper No. 6984. National Bureau of Economic Research.

Hao, J.X., Manole, V. and van Ark, B. (2009). "Intangible Capital and Economic Growth – an International Comparison, August.

Howitt, P. (1996). "On Some Problems in Measuring Knowledge-Based Growth", in Howitt, P. (ed.), *The Implications of Knowledge-Based Growth for Micro-Economic Policies*, University of Calgary Press, Canada.

Howitt, P. and Mayer-Foulkes, D. (2005). "R&D, Implementation, and Stagnation: A Schumpeterian Theory of Convergence Clubs". *Journal of Money, Credit and Banking*, (37:1), pp. 147-177.

Hulten, C. (2006). "The "Architecture" of Capital Accounting: Basic Design Principles", in Jorgenson, D.W., Landefelf, J.S. and Nordhaus, W.D. (eds.), *A New Architecture for the U.S. National Accounts*, The University of Chicago Press, Chicago and London, pp. 193-214.

Hulten, C. (2009a). "Growth Accounting". NBER Working Paper No. 15341.

Hulten, C. (2009b). "Decoding Microsoft: Intangible Capital as a Source of Company Growth". Paper presented at the National Bureau of Economic Research Summer Institute, July 15, (forthcoming as TCB working paper).

Hulten, C. and Hao, J. (2008). "Intangible Capital and the 'Market to Book Value' Puzzle". NBER Working Paper No. 14548.

Jalava, J., Aulin-Ahmavaara, P. and Alanen, A. (2007). "Intangible Capital in the Finnish Business Sector, 1975-2005". *ETLA discussion papers No. 1103*.

Jona-Lasinio, C., Iommi, M. and Roth, F. (2009). "Intangible Capital and Innovations: Drivers of Growth and Location in the EU". INNODRIVE, Deliverable No. 15, WP9.

Katzenstein, P. (1989). "Stability and Change in the Emerging Third Republic, in Katzenstein, P. (ed.), *Industry and Politics in West Germany*. Cornell University Press Ithaca, NY, USA.

Lev, B. (2001). *Intangibles: Management, Measurement, and Reporting,* Brookings Institution Press, Washington D.C., USA.

McDuffie, J.P. and Krafcik, J. (1992). "Integrating Technology and Human Employer-Centered Training / 477 Resources for High Performance Manufacturing: Evidence from the International Auto Industry", in Kochan, T.A. and Useem, M. (eds.), *Transforming Organizations,* Oxford University Press, New York, USA.

Marrano, M.G. and Haskel, J. (2006). *How Much Does the UK invest in Intangible Assets?* Available at http://www.econ.qmul.ac.uk/papers/doc/wp578.pdf

Marrano, M.G., Haskel, J. and Wallis, G.. (2007). "What Happened to the Knowledge Economy? ICT, Intangible Investment and Britain's Productivity Record Revisited." Working paper No. 603. Queen Mary University of London.

Marrano, M.G., Haskel, J. and Wallis, G. (2009). "What happened to the knowledge economy? ICT, intangible investment and Britain's productivity record revisited". *The Review of Income and Wealth*, (553), pp. 686-716.

Nakamura, L. (2001). "What is the US Gross Investment in Intangibles? (At least) One Trillion Dollars a Year!". Federal Reserve Bank of Philadelphia Working Paper No. 01-15.

OECD (2008). *OECD Science, Technology and Industry Scoreboard*, Paris.

Pakes, A. and Schankerman, M. (1984). "The Rate of Obsolescence of Patents, Research Gestation lags, and the Private Rate of Return to Research Resources" in Griliches, Z. (ed.), *R&D, Patents, and Productivity.* The University of Chicago Press, Chicago, USA, pp. 73-88.

Schumpeter, J.A. (1934). *The Theory of Economic Development*, Harvard University Press, Cambridge. (New York: Oxford University Press, 1961.) First published in German, 1912.

Streeck, W. (1992). "On the Institutional Preconditions of Diversified Quality Production", in Streeck, W. (ed.), *Social Institutions and Economic Performance*, Sage, London, UK.

Solow, R.M. (1987). "We'd Better Watch Out", *New York Times Book Review*, July 12.

Sturgeon, T. and Gereffi, G. (2009)." Measuring success in the global economy: international trade, industrial upgrading, and business function outsourcing in global value chains". *Transnational Corporations*, (18:2), pp. 1-36.

Timmer, M.P., Ypma, G. and van Ark, B. (2003). "IT in the European Union: Driving Productivity Divergence?". Groningen Growth and Development Centre Research Memorandum GD-67, Groningen: University of Groningen, Appendix Tables, updated June 2005.

van Ark, B. (2002). "Understanding Productivity and Income Differentials Among OECD Countries: A Survey", in Sharpe, A. *et al.*(eds.), *The Review of Economic Performance and Social Progress*. *Towards a Social Understanding of Productivity*, CSLS/IRPP, pp. 69-92.

van Ark, B. and Hulten, C. (2007). "Innovation, Intangibles and Economic Growth: Towards a Comprehensive Accounting of the Knowledge Economy". *Yearbook on Productivity 2007*, Statistics Sweden, pp. 127-146.

van Bekkum, S. (2009). "Do intangible investments create value? Comparing capitalization rates of listed firms". The Conference Board Economic Working Paper EPWP08-05. Available at http://www.conference-board.org/economics/workingpapers.cfm

van Rooijen-Horsten, M., van den Bergen, D. and Tanriseven, M. (2008). *Intangible Capital in the Netherlands: A Benchmark*. Available at http://www.cbs.nl/NR/rdonlyres/DE0167DE-BFB8-4EA1-A55C-FF0A5AFCBA32/0/200801x10pub.pdf

Wolter, S.C., Mühlemann, S. and Schweri, J. (2006). "Why Some Firms Train Apprentices and Many Others Do Not". *German Economic Review*, (7), pp. 249-264.