For Official Use **DSTI/EAS/IND/WPIA(2011)2**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development **03-Nov-2011**

English - Or. English

DIRECTORATE FOR SCIENCE, TECHNOLOGY AND INDUSTRY
COMMITTEE ON INDUSTRY, INNOVATION AND ENTREPRENEURSHIP

For Official Use DSTI/EAS/IND/WPIA(2011)2

Working Party on Industry Analysis

INTANGIBLE ASSETS AT THE SECTORAL LEVEL

OECD, Paris 9-10 November 2011

This document takes stock of the existing evidence on investment in intangible assets and addresses a number of modelling and empirical issues related to quantifying intangible assets and to estimating the relationship between investment in intangibles and productivity. It further proposes empirical methods for determining the extent to which investment in intangibles in a particular sector relates to investment in intangibles in related sectors, both upstream and downstream; the productivity of the sector considered; and the productivity of other sectors in the same country, particularly upstream and downstream.

This document is proposed for discussion under item 3.3 of the Draft Agenda.

Delegates are invited to:
- comment on the methodological issues raised, and suggest possible solutions and analytical strategies;
- mention relevant ongoing work and data collections that could be used in the analysis;
- express their interest in joining the OECD Secretariat on this work.

Contact: Mariagrazia SQUICCIARINI (OECD/STI/EAS); Tel: (+33-1) 45 24 15 08;
E-mail: mariagrazia.squicciarini@oecd.org;
Chiara CRISCUOLO (OECD/STI/SPD), Tel: (+33-1) 45 24 79 68; E-mail: chiara.criscuolo@oecd.org

JT03310539

Document complet disponible sur OLIS dans son format d'origine
Complete document available on OLIS in its original format

English - Or. English

INTANGIBLE ASSETS AT THE SECTORAL LEVEL

1. Introduction

1. In recent years, intangible assets have increasingly drawn the attention of researchers and policy makers alike, as their importance as a source of growth has become more apparent. However the very nature of these assets makes them hard to measure and consequently it is difficult to design evidence-based policies aimed at exploiting such investments to enhance productivity growth, and to evaluate their effectiveness. This is true at all levels of analysis. Firms - especially small and medium sized enterprises - might not be fully aware of their intangible capital or able to suitably measure it. In addition, firms might not always take into account the possible complementarities that may exist between different types of intangibles assets, and between intangible and tangible assets. Even at the sectoral and economy-wide level, it is difficult to construct aggregate figures, in the absence of common guidelines and harmonized measurement strategies. The most developed harmonized approach to measure intangibles and account for their contribution to productivity growth is based on a growth accounting framework. This approach cannot adequately provide insights into what determines the growth of these investments, nor the full extent of their economic impact, as the complementarities and synergies between different factors and any associated spillovers cannot be accounted for. Accounting for possible spillover mechanisms adds a further layer of complexity to any assessment, but may prove helpful to direct policies, especially in times of budgetary constraints.

2. A first step in the direction of addressing these policy relevant questions needs to start with a better measurement of how levels of investments in intangibles differ across sectors and with the analysis of the relationship between investment and the performance at a sectoral level. Sectoral analyses have the advantage of being able to account for the diverse technologies and activities that distinguish different industries in the economy. Furthermore, firms belonging to the same sector are more likely to share a common environment – such as market structure, regulatory framework and technological frontiers - than firms outside that sector. This can be captured by sector-specific indicators and be helpful to understand the implications of policies, many of which are designed at the industry level.

3. The aim of this report is threefold: firstly to take stock of the existing evidence on investments in intangible assets; secondly, to address a number of modelling and empirical issues related to quantifying intangible assets and to estimating the relationship between investment in intangibles and productivity; and finally, the report proposes empirical methods for determining the extent to which investment in intangibles in a particular sector relates to:

- Investment in intangibles in related sectors, both upstream and downstream;
- The productivity of the sector considered;
- The productivity of other sectors in the same country, particularly upstream and downstream.

4. The report is organised as follows: section 2 describes the growth accounting framework and the way in which intangibles have been measured at the economy level and presents the results of the few analyses that have measured intangible assets at the sectoral level. Section 3 discusses how the researchers have accounted for sectoral spillovers and complentarities between the different types of intangible assets. Section 4 highlights the main analytical challenges and measurement issues that need to be addressed when measuring and modelling investments in intangibles at the industry level, and propose some very initial ideas on how to empirically implement the analysis. Finally, Section 5 discusses the possible sources of data that could be used to estimate investments in intangible assets and to measure the other industry-specific features, characteristics and framework conditions that the analysis may rely upon.

2. Intangible assets and growth at the sectoral level

The growth accounting framework

5. Since the seminal papers of Corrado, Hulten and Sichel - henceforth CHS (2005, 2009) - increasing emphasis has been put on the need to capitalise expenditures on intangible assets beyond R&D and software - such as training, design and branding - in national accounts - rather than considering them as intermediate inputs - and to better measure intangibles more generally. Consensus now exists about the importance of intangible capital and the CHS growth accounting framework has been extended to a number of countries. Table 1 lists the countries for which estimates of intangible assets exist and highlights the main projects and studies in which they are proposed. These studies generally look at how the growth in total output at the national level can be accounted for by the growth in factors of production, with unexplained growth attributed to Total Factor Productivity (TFP) growth. A common result is that accounting for previously omitted intangible capital significantly changes previous measurements of productivity growth, with both a change in output growth (since now output includes investment in intangibles) and a shift away from TFP towards capital deepening as the source of productivity growth.

6. Corrado, Hulten and Sichel (2005, 2009) provided a taxonomy of business expenditures that should be capitalised as investment in intangible capital. This has been adopted by most of the studies presented in Table 1. Intangible capital is divided into three categories, each comprised of different assets: firstly investment in **computerised information** consists of business software, both externally purchased or internally developed, and databases; secondly **innovative property** consists of both scientific and non-scientific R&D; thirdly **economic competencies** include both "spending on strategic planning, spending on redesigning and reconfiguring existing products in existing markets, investment to retain or gain market shares and investment in brand names" and investment in firm-specific human and structural resources. Growth accounting has typically used data from National Accounts (NA) to measure total output, labour inputs and capital inputs, and complemented these with measures of intangible assets from labour surveys and business surveys on business investments or R&D expenditures. Table 2 lists the data sources used by CHS (2009) in their growth accounting analysis for the United States, as an example.

7. While growth accounting at the economy-wide level is available for all the countries listed in Table 1, growth accounting at a relatively aggregated sectoral level (the economy is split in 2 sectors: manufacturing and services) is available for Australia. For the UK, Gil and Haskel (2008) estimate the intangible assets investment series for six different industries, namely: Agriculture, fishing and mining; Manufacturing; Electricity, gas and water; Construction; Wholesale and retail, hotels and restaurants and transport and communications; Financial intermediation and business services, but they do not construct a measure of intangible capital stock, nor do they perform a growth accounting exercise.

Table 1: List of countries for which intangible capital stock has been calculated

Country	Data Sources/ Studies
Australia	Barnes and McClure (2009); Barnes (2010)
Austria	InnoDrive, Hao, Manole, and van Ark (2008)
Belgium	InnoDrive
Bulgaria	InnoDrive, CoInvest
Canada	Belhocine (2009)
Cyprus[1]	InnoDrive
Czech Republic	InnoDrive, Hao, Manole, and van Ark (2008)
Denmark	InnoDrive, Hao, Manole, and van Ark (2008)
Estonia	InnoDrive
Finland	InnoDrive, Jalava, Aulin-Ahmavaara, and Alanen (2007)
France	InnoDrive, CoInvest, Hao, Manole, and van Ark (2008), EIB
Germany	InnoDrive, CoInvest, Hao, Manole, and van Ark (2008), EIB
Greece	InnoDrive, Hao, Manole, and van Ark (2008)
Hungary	InnoDrive
Ireland	InnoDrive
Italy	InnoDrive, Hao, Manole, and van Ark (2008)
Japan	Fukao et al. (2009)
Korea	Chun, Pyo and Rhee (forthcoming)
Latvia	InnoDrive
Lithuania	InnoDrive
Luxembourg	InnoDrive
Malta	InnoDrive
Netherlands	InnoDrive, van Rooijen-Horsten, van den Bergen, and Tanriseven (2008)
Norway	InnoDrive
Poland	InnoDrive
Portugal	InnoDrive, CoInvest
Romania	InnoDrive
Slovakia	InnoDrive, Hao, Manole, and van Ark (2008)
Slovenia	InnoDrive
Spain	InnoDrive, Hao, Manole, and van Ark (2008) EIB
Sweden	InnoDrive, CoInvest, Edquist (2011)
United Kingdom	InnoDrive, CoInvest, Gil and Haskel (2008); Marrano, Haskel, and Wallis (2009)
US	Corrado, Hulten, and Sichel (2009)

8. The UK study uses business investment surveys from a number of sources to estimate the different type of assets listed in CHS (2005)[2]. For Australia, Barnes and McClure (2009) and Barnes (2010) go a step further and actually estimate the different contributions of investment in intangible assets to sectoral productivity, in manufacturing and the services sector. In particular, Barnes (2010) shows these two sectors to be characterised by significantly different investment behaviours, and these in turn to have

1. Cyprus
The following note is included at the request of Turkey:
"The information in this document with reference to « Cyprus » relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognizes the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the « Cyprus issue »".
The following note is included at the request of all the European Union Member States of the OECD and the European Commission:
"The Republic of Cyprus is recognized by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus".

2. This data are available online, on the COINVEST website: www.coinvest.org.uk

implications for the TFP of both manufacturing and services. In addition, a team of Korean researchers are currently putting together a database on investments in intangible assets at the sectoral level for Korea (Chun, Pyo and Rhee, forthcoming).

Table 2: Data sources for the United States used in Corrado, Hulten, and Sichel (2009)

Measure/ Variable		**Data-Sources**
Computerised Information	Investment in Software	NIPA[3] Series for Business Investment in Software
Innovative Property	Scientific R&D	National Science Foundation (NSF) Industrial R&D series
	Non-Scientific R&D	Census Bureau's Services Annual Survey (SAS)
Economic Competencies	Brand Equity	Coen Report (Advertising data by Bob Coen for Universal-McCann)
	Firm Specific Human Resources / Worker Training	Bureau of Labour Statistics (BLS) surveys American Society for Training and Development (ASTD) Surveys
	Firm Specific Organizational Investments	Revenue for Management Consultancy, from SAS

9. The CHS framework has proved very helpful in changing the perception of spending in intangible assets from pure expenditures to investment in productive capital and in improving our ability to quantify the magnitude of the investment in intangible assets and the contribution of intangible capital to productivity growth. However, the framework can be further extended to address some of the methodological features of these types of models, and the assumptions they rely upon.

10. Firstly, the very useful taxonomy developed in CHS (2005) assumes depreciation rates to vary with the asset considered, but to be constant across sectors and over time. Refining the growth accounting framework in this respect would entail using depreciation rates that better mirror sector-specific features, such as differences in the economic obsolescence (e.g. R&D in the software industry is likely to depreciate faster than R&D in the chemical industry), and in the way it changes over time (e.g. the rate of depreciation might increase over time in more dynamic sector), sectoral linkages, and the structure of the economy considered. Likewise, the expenditures-based approach to quantifying intangibles could be further refined by testing the sensitivity of the estimates to the assumptions made on the ratio of capitalised assets over intermediate expenditures (e.g. the share of total marketing expenditure that is capitalised as brand equity) and the use of price deflators.

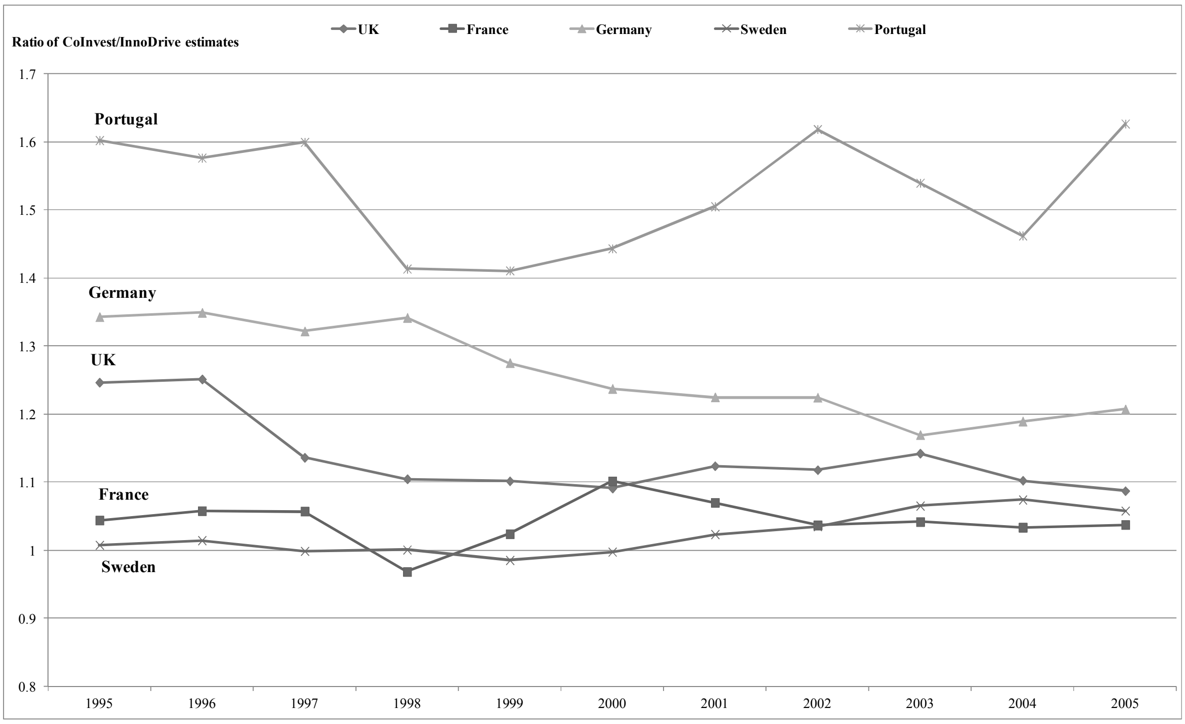
11. Finally, the growth accounting framework assumes the existence of perfectly competitive markets and of constant returns to scale, and it overlooks the potential linkages and spillover effects that may exist between sectors and the complementarities between different types of assets. The CHS growth accounting framework models technological progress as exogenous, and treats intangible capital as an input of production - similar to physical capital. The endogenous growth literature addresses this shortcoming by means of endogenising TFP growth and by trying to determine it within a model, rather than assuming it to be exogenous (see Jones, 2005 for a survey). This has a number of implications, especially with respect to modelling spillovers: the investment decisions of one firm are held to increase the pool of knowledge available to other firms and sectors, thus indirectly increasing their productivity (see *e.g.* Aghion, et al (1998); Romer (1994)).

3. National Income and Product Accounts (NIPA)

Box 1. Comparing the existing estimates on investment in intangibles

Two EU-funded research projects, CoInvest and InnoDrive, followed the CHS framework to estimate the amount of investment in intangible assets for some EU countries. The estimates differ according to the data used and the assumptions made about which expenditures to treat as proxies for investments in intangibles. For example, to construct the series for investment in advertising, InnoDrive uses data from Eurostat's Structural Business Survey (turnover for "K74-Other business activities") and from Zenith Optimedia, while CoInvest uses country specific data sources such as estimates from advertising associations for the UK, or from the Central Association of the German Advertising Industry (ZAW) and the Mannheim Innovation Panel (MIP) for Germany. For investment on training, InnoDrive uses the Eurostat Continuing Vocational Training Survey (CVTS) as main data source, while CoInvest uses country-specific sources like the National Employer Skills Survey for the UK, and the Mannheim Innovation Panel (MIP) data on training expenditures for Germany. Figure A plots the ratio of the estimates for total investments in intangibles using CoInvest and InnoDrive data. For instance, the CoInvest estimates for Germany are 1.2 to 1.3 times higher than the corresponding InnoDrive estimates. Moreover, with very few exceptions, CoInvest estimates are generally higher than those of the InnoDrive project.

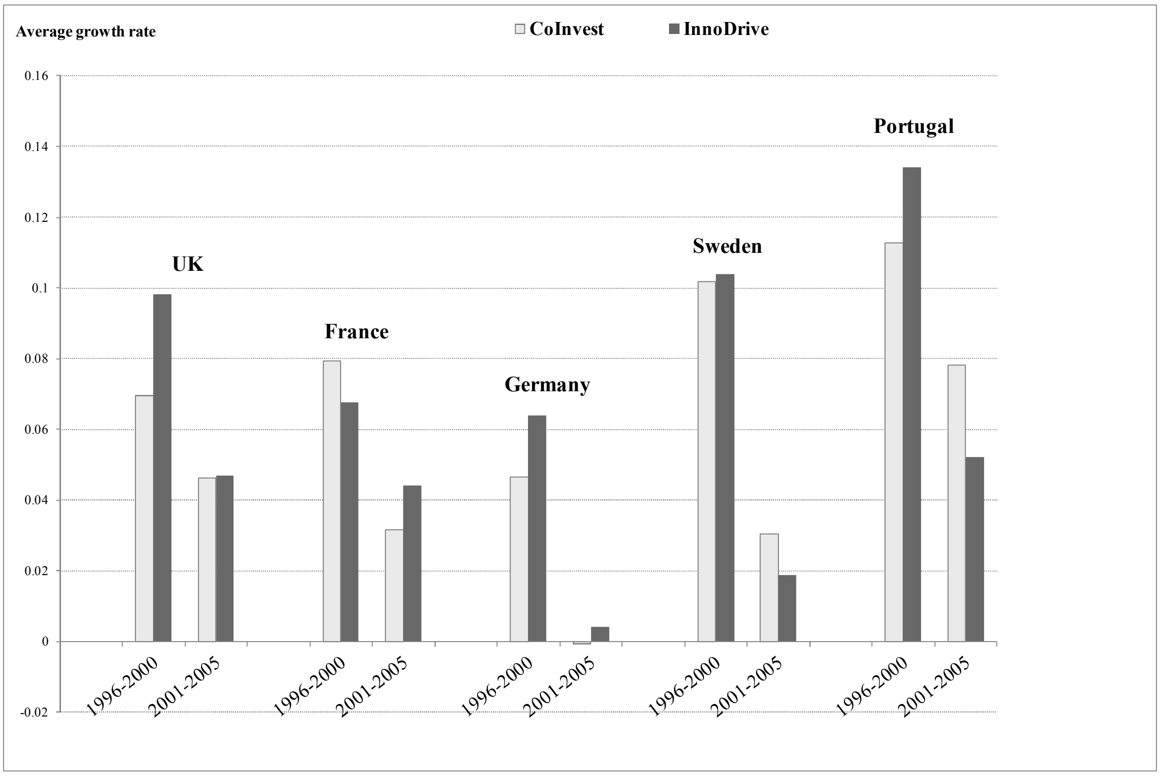
Figure A: Investment in intangibles – ratio CoInvest over InnoDrive estimates



Source: OECD calculations based on COINVEST and Innodrive databases

Figure B shows the average growth rate of these estimates for two five-year periods (1996-2000 and 2001-2005). These average growth rates differ between estimates from CoInvest and InnoDrive, but the systematic difference observed in the investment level estimates does not appear in the growth rates of those estimates. For example, growth rates estimates from InnoDrive are higher than those from CoInvest in the case of UK, Germany and Portugal for the period 1996-2000, while they are lower in the case of France for the period 1996-2000 and of Sweden and Portugal for the period 2001-2006.

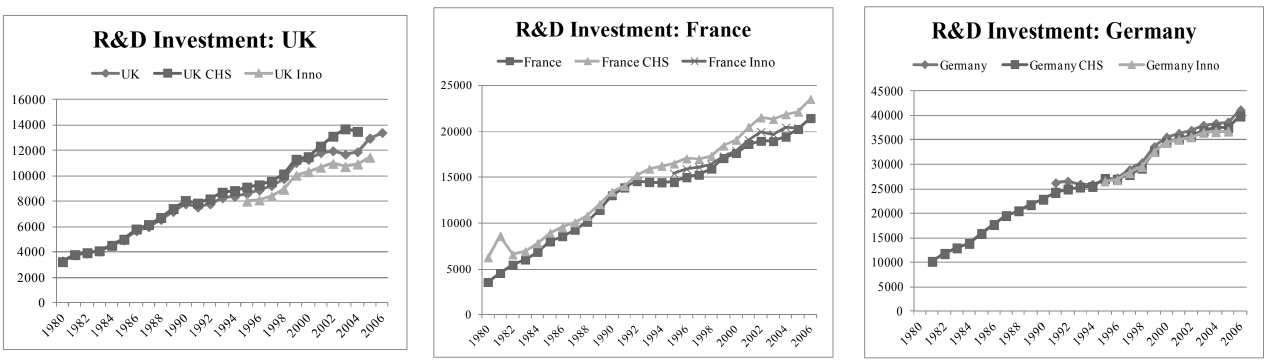
Figure B: Average growth rate of investment in intangibles

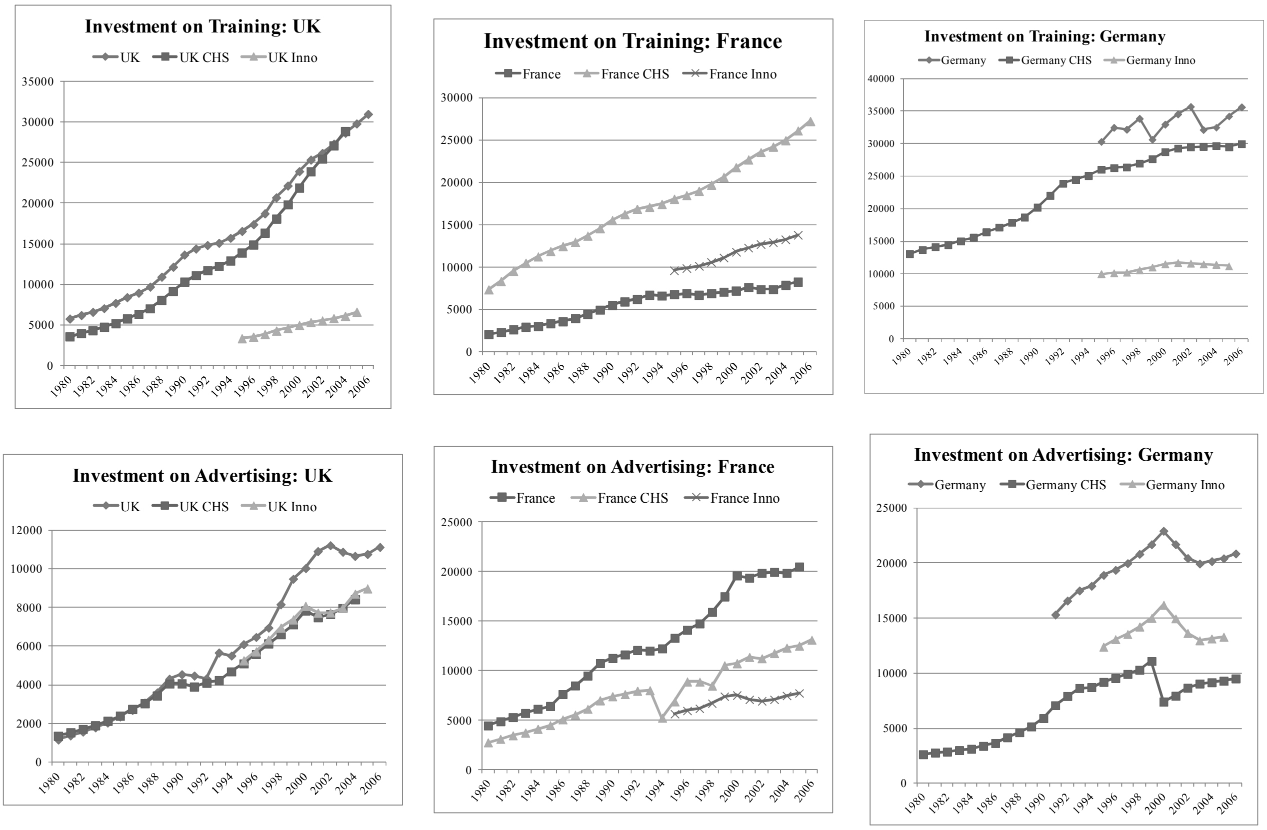


Source: OECD calculations based on COINVEST and Innodrive databases

The estimates of the two projects differ also when different types of intangibles are considered individually. In general such differences seem to be smaller in the case of intangible assets that have been widely studied (*e.g.* R&D), whereas for types of intangibles like brand-equity, firm-specific human capital and organisational improvements estimates may differ greatly between the two sources considered. Possibly, this might reflect the higher sensitivity of estimates for these intangibles on assumptions and data sources.

Figure C: Comparing estimates on investment by types of intangible assets





Note: InnoDrive estimates are marked as "Inno" in the charts. CoInvest data publishes two sets of estimates; which are shown as the name of the country (*e.g.* "UK") and "CHS".

Source: OECD calculations based on COINVEST and Innodrive databases

Intangible capital accumulation across sectors

12. Che (2009) addresses the different patterns of intangible capital accumulation in a model that sees the presence of two sectors, which differ in the intensity of intangible capital used in the production function. Within each sector, labour has to be allocated between the production of a final good and the production of intangible capital. The author is interested in explaining the share of total output and of total employment of the intangible intensive sector. This - she argues - is the result of two forces: the share of intangible capital in the production of the final good, and the productivity gains of the intangible capital production function. Her model - which does not envisage the existence of links between the two sectors - predicts that the sector where intangible capital is more intensively used in the production function, or where the production of intangible capital itself is becoming more efficient, will see an increase in its share of total output and total employment relative to the other sector. The second result of interest is that productivity of labour assigned to the production of the final good is higher in the intangible intensive sector than in the non intangible intensive sector.

13. To test the model the author builds a database that includes firms' financial statements from COMPUSTAT North America, Bureau of Economic Analysis (BEA) industry accounts data, Bureau of Labour Statistics (BLS) data on capital income and IT investment by industry and education level data from the Current Population Survey. The author uses firms' Sales, General and Administrative expenditure (SG&A) as a proxy for intangible capital investment, as this includes R&D spending, marketing expenses, management fees and software expenditure. Intangible capital intensity is then constructed as the ratio of SG&A expenditure over sales. The author simulates the evolution of the output and employment shares of

the two sectors derived from the model using both firm and industry level data, which she then compares to the patterns emerging when using real data. Her results support the predictions of the model and suggest that investment in intangible capital leads to higher output growth, all the more so in the intangible intensive sector. The effect of intangible capital investment on employment is only significant in the intangible intensive sector.

3. Sectors, complementarities and spillovers

14. The growth accounting literature has typically aggregated the three different types of intangible assets defined in CHS (2005) - namely computerised information, innovative property, and economic competencies - into a single category, assuming these assets to be perfectly substitutable at the national level. Micro-level studies have conversely analysed the different types of assets (R&D, ICT, organization capital, skills training and human capital, brand equity) individually and their possible complementarities. Spurred by the Solow paradox concerned with the inability to suitably measure the impact of ICT on productivity (*"You can see the computer age everywhere but in the productivity statistics"*, Solow, 1987), many studies have focused on ICT as a sector and explored the link between investment in ICT and economic performance. The studies generally suggest that investment in ICT - both tangible and intangible - is a source of productivity growth at the national as well as the sectoral level. Below are presented a few studies dealing with ICTs as a sector, and in particular analyses concerned with the use of ICT by other sectors and its impact on productivity growth. Evidence that firm level productivity benefits from complementarities between ICT capital and other types of intangible assets, namely organisational structure and human capital is also discussed. Finally, several papers addressing the measurement of (transaction-based) inter-industry spillovers and rely on Input Output (I-O) tables are mentioned. These papers do not explicitly focus on the capitalisation of intangibles but provide evidence that suggests that knowledge spillovers, from R&D and organisational capital, exist between upstream and downstream sectors.

ICT as a sector and its linkages

15. Oliner, Sichel and Stiroh (2007) augment traditional growth accounting models by allowing for variations in factor utilisation, adjustment costs, cyclical influences on productivity gains, and intangible assets. The data they use - from the US National Income and Production Accounts (NIPA) and the Bureau of Labour Statistics (BLS) - lack direct measures of intangible capital apart from investment in computer software. They assume intangible capital to be a complement to ICT capital (considered as a sector), compute the level of investment in intangibles based on this assumption, and look at the link between industry level productivity growth and ICT intensity. To this end, they regress the change in productivity growth (i.e. productivity acceleration) on ICT intensity at the industry level. They find that the productivity growth of the period 1995 to 2000 in the US is stronger once investment in intangibles is accounted for, as is the post 2000 fall in productivity growth.

16. Dahl, Kongsted, and Sorensen (2011) empirically test an intuition similar to Oliner, Sichel and Stiroh's (2007) by using sectoral-level cross-country panel data from the EUKLEMS Growth and Productivity Accounts, over the period 1970-2004. The authors estimate the industry-specific relationships between labour productivity growth and ICT intensity, and between the growth rate of real output and ICT intensity. They account for a number of variables, including the technological change that happened at the beginning of the 1990s. The specifications used allow the authors to distinguish between the effect of capital deepening and the effect of exogenous technological change. They find that the post-1995 macroeconomic slowdown in productivity growth in Europe can be explained by a large productivity decline in non-ICT intensive sectors, which has been only partially mitigated by the growth in ICT-intensive sectors.

17. Oulton's (2010) two sector growth model investigates the importance of ICTs as a source of growth. His model sees an ICT-producing sector selling its output to a consumer good producing sector, and allows countries that do not produce ICTs to benefit from falls in relative prices through an improvement in the terms of trade. He suggests that the main boost in growth comes from ICT use and not from ICT production, and that the fall in relative prices of ICTs boosts GDP growth as well as consumption, since it induces a faster accumulation of ICT capital. Oulton relies on EUKLEMS data to estimate the total effect of ICTs on productivity growth for 19 countries (15 European and 4 non-European). His measure of ICT capital includes computers, software and communications equipment - that is, both the tangible and the intangible part of ICT capital. He estimates the average output effect of ICTs on growth to be 0.24% points per year, and the average use effect to amount to 0.54% points per year, during the period 1970-2007.

Complementarities

18. Oliner, Sichel and Stiroh's (2007) assumption about the complementarity of the different types of intangibles relies on an extensive body of evidence documenting the existence and quantifying the magnitude of these complementarities. The methodology involved relies on firm level data and often calculates both the correlation between investments in different types of assets and a firm level production function, whereby the presence of complementarities can be directly interpreted from the regression coefficients. Milgrom and Roberts (1990, 1995) argue that complementarities exist at the firm level, both in the use of various types of inputs, but also between different types of practices and activities, which is often referred to under the umbrella term of organisational capital.

19. Evidence of complementarities is strongest when considering ICT capital in combination with other types of intangible assets, especially human capital and organisational capital. Athey and Stern (1998) find evidence that the returns to investment in ICT capital, at the firm level, are increased in the presence of training and vice versa. Building on this, Bresnahan, Brynjolfsson, and Hitt (2002) explore for the presence of complementarities between ICT capital and organisational structure by means of investigating firms' investment decisions concerning ICT capital, organisational structure and human capital and estimating a production function equation that includes cross terms in IT, organisational and human capital. They use a panel of 300 American firms containing detailed IT capital (levels and mix) data, Compustat measures of other inputs and outputs, and a survey of organisational practices and labour force characteristics. The authors find evidence of complementarities between investment in ICT capital,[4] investment in human capital and decentralised work practices, and new products and services. They further remark the importance of IT-enabled organisational change and suggest the overall computing capacity of a firm to be a good predictor of investment in human capital.

20. The relationship between investment in human capital, skills and organisational practices has proven more difficult to estimate, given the breadth of the concepts and the difficulty in measuring them. Studies such as Black and Lynch (1996), Caroli and Van Reenen (2001) and Dearden, Reed and Van Reenen (2006) find a positive relationship between investment in training or organisational practices and productivity at the firm level, but a more limited evidence on the complementarities between these types of activities.

21. Although complementarities between different types of intangibles assets are likely to exist and to be important at the firm level, modelling and estimating complementarities at the sectoral level is far from straightforward, as sectoral level data is not well adapted to this.

4. They only measure the tangible aspect of investment in ICT, as their data does not include software expenditures.

I-O tables and inter-industry spillovers

22. Input-Output tables have traditionally been used to address inter-sectoral linkages, as they map out the backward and forward linkages of each sector in an economy via inter-industry transactions of goods and services (see Miller and Blair (2009) for an extensive discussion). The effect of an industry on total economic activity can in fact be subdivided into three main components:

- a direct effect on final demand from selling output to consumers;
- backward linkages, or a demand multiplier effect: as each sector uses inputs from multiple sectors, an increase in the production of a sector leads to higher demand for the output of other sectors, through its need for more inputs;
- forward linkages, or a supply multiplier effect: the goods and services of a sector increase the possibility of downstream sectors to offer new products and services.

23. I-O tables have proven very useful to trace the effects of sectoral behaviours – such as R&D intensity, CO_2 emissions, presence of foreign direct investment, or policy reforms – on other sectors linked through input-output relationships.

24. In the case of R&D, Wolff (2011) empirically tests for the importance of spillovers from R&D expenditures across sectors using US I-O tables. He seeks to explain industry-level TFP growth with a measure of direct R&D and a measure of indirect (or embodied) R&D, constructed using the technical coefficient and the sales coefficient[5] calculated from I-O tables. The author relies on I-O tables produced by the BEA covering 85 industries in the years 1958, 1967, 1977, 1987, 1997 and 2007, to determine if spillovers have strengthened over time thanks to ICTs. He in fact holds that ICT penetration would speed up technology transfer and make it more effective. Comparing his 2011 results with previous work (Wolff and Nadiri (1993); Wolff (1997)), Wolff finds evidence in support of the existence of inter-industry spillovers, and of its strengthening over time. He further argues that the knowledge transmitted by the R&D embodied in a certain input depends on how important that very input is for the (buying) industry considered, rather than how much of that input is sold to the industry.

25. The presence of spillovers from organisational practices has been tested using foreign direct investment data, based on the assumption that multinational firms arrive with organisational know-how which they transmit to other firms through their interactions with suppliers and customers. Javorcik (2004) tests this hypothesis using panel data of Lithuanian manufacturing firms from 1996 to 2000. The author estimates the relationship between firm-level productivity and measures of multinational presence in backward, forward and horizontally linked sectors. Sectoral linkages are calculated at the industry level, using the sales and technical coefficients of the Lithuanian 1996 I-O matrix. The author finds evidence that an increase in the foreign presence in downstream sectors is associated with a rise in output of supplying domestic firms, which is interpreted as a spillover from the organisational capital of the foreign customer. On the contrary, there is little evidence to support the presence of horizontal spillovers between firms in the same industry, or of spillovers taking place through forward linkages between foreign suppliers and domestic customers. Using a similar methodology, Javorcik and Spatareanu (2011) find that spillovers from FDI through backward linkages in Romania are more pronounced when foreign firms have to rely more on local suppliers, for geographic or tariff-related reasons.

---

5. The technical coefficient corresponds to the ratio of the value of inputs bought by industry *j* from industry *i* over the total production of industry *j*. The sales coefficient is the proportion of industry *i*'s output bought as input by *j*.

26. I-O tables have also been used to evaluate the effects of certain policy reforms in particular sectors on the performance of other sectors. Bourlès et al (2010) estimate the impact of anticompetitive regulation in upstream sectors on the productivity of downstream sectors. Using panel data for 15 OECD countries and 20 industries over the period 1985-2007, they estimate the relationship between the change in sectoral productivity on a weighted index of anti-competitive regulation in upstream sectors, with weights calculated based on the technical coefficients of the I-O tables. The authors find that product market regulations in upstream markets have significantly reduced the productivity of downstream sectors. Similarly, using firm level data from the Czech Republic, Arnold, Javorcik and Mattoo (2011) find that liberalisation in the services sectors is positively correlated with the performance of domestic firms in downstream manufacturing sectors.

27. Spiezia (OECD, 2008) offers a different approach to using I-O data for the estimation of the contribution of a sector to overall economic performance. He estimates the multiplier effect of the ICTs sector on output growth, in a number of countries, by combining the OECD Input-Output database with data from the OECD Structural Statistics for Industry and Services database, the OECD STAN database and the BLS commodity by industry tables, and calculates the impact of ICTs on growth. To this end, he compares the actual level and growth of output 1995-2000 and 2000-2006, with the (counterfactual) level and growth of output if no output had been produced in the ICT sector. He finds that on average, ICT sectors accounted for 2.4% points a year of total output growth in 1995-2000 and 2.1% points a year in 2001-2006, in the 14 OECD countries for which data is available. This type of methodology, while useful to uncover those industries that most contribute to economic growth, only accounts for the impact of ICT on total economic activity and not on sectors individually.

4. Estimating intangible assets at the sectoral level

Analytical challenges

28. The literature related to intangible assets typically seeks to explain and estimate the relationship between intangible assets as an input and a set of outcomes - most often productivity, but also increased output, value added or new products. These analyses are generally carried out at the macro (i.e. economy) or at the micro (i.e. firm) level. A few micro-data based studies, for example Crépon, Duguet, and Mairesse (1998) and OECD (2009), also make explicit the intermediate mechanisms whereby inputs (for example R&D expenditures) are converted into outputs (*e.g.* patents), and then estimate the relationship between innovative output (*e.g.* patents) and final outcome (*e.g.* productivity).

29. Estimating and modelling investment in intangible assets and the way intangibles relate to outputs and outcomes entails addressing a number of issues, which apply to both micro- and meso- level analyses such as the sectoral approach. Output and investment decisions may be endogenously determined, and it may be difficult to establish the direction of causality. In the case of innovation related investment and outcomes it is not trivial to account for uncertainty or to identify and quantify the various inputs to the innovation process. The use of certain functional forms (*e.g.* constant returns to scale) may often be a simplification made in order to make problems tractable, but it may lead to biased estimates. Models become very complex and difficult to estimate when trying to account for possible complementarities between the different intangible (and tangible) assets and for spillover effects, but ignoring them may imply overlooking policy relevant mechanisms. Other policy relevant features that should be considered in intangible related analyses but that may be difficult to model are sectoral concentration, trade openness, access to finance, tax rates, skilled labour supply, and barriers to entry.

30. The economic growth in a neo-classical framework can come from two sources: by expansion of inputs or by growth in output per unit of input. The input-expansion based output growth is subject to diminishing returns and thus does not have lasting effects on per-capita-income. But input-productivity growth (which includes labour productivity growth) generally results in higher per-capita-income. Griliches (1979) mentions the difficulties involved in disentangling the mechanisms by which R&D investment affects the output. He acknowledges that the contribution of R&D to output goes through a direct channel and an indirect channel that includes induced changes in the use of other inputs (capital or labour) due to R&D. Ornaghi (2006) tries to identify the two effects separately by estimating a production equation (direct effect of R&D through productivity gains) and a demand equation (indirect effect of R&D through increased demand).

31. Investment in intangible assets can contribute to output growth via channels such as the commercialisation of innovative property through licensing, the creation of new products and markets, or by means of inducing changes in consumer preferences. Similarly, investment in intangible assets can spur productivity growth through: changed organisational structure and improved processes; complementarities with labour and capital inputs; enhanced product quality; learning by doing and efficiency gains. When estimating the effect of intangible assets only on output growth, efficiency improvement and demand-side mechanisms cannot be disentangled. But such mechanisms can be separated by estimating the effect on productivity growth as well.

Box 2. Intangible assets and their possible effects

Analysing the relationship between intangible assets and output growth requires identifying the possible mechanisms at play, i.e. whether investment in intangible assets are likely to affect output growth directly (*demand-driven growth*, *e.g*. the replication of previously designed artistic originals) or by increasing factor productivity (*input productivity growth*, *e.g*. R&D and innovation shifting the production possibility frontier). Some intangibles may increase firm output without affecting the productivity of workers, while other intangible assets do affect labour productivity directly.

Understanding the mechanisms by which intangible assets may affect output growth becomes important in the light of the possible policy choices that can be made. For example, even though productivity growth (which usually leads to per-capita-income growth) is desirable for the long-term prosperity of an economy, the generation of employment (input-expansion based growth) can be a more pressing concern in the short term.

Investments made in intangibles can also affect the growth of other sectors via spillovers. Some of the channels of such spillovers can be improved quality of intermediates (output of one industry is used by other industries) and price reduction or cost savings (innovation in one sector affecting the linked sectors).

The table below shows the different types of intangibles included in the CHS taxonomy and points out the possible direct effects they may have on output growth (input expansion, input productivity, or both). Column 4 of the table mentions some of the possible mechanisms the affect the output growth of the industry making the investment. Column 5 lists the likelihood of intangible investments generating the economy-wide or inter-industry spillovers and thus affecting the growth in other industries as well.

CHS asset type	Demand-driven growth	Input-productivity growth	Mechanisms of output growth for investor in the asset	Economy-wide or Inter-industry Spillovers
Computerised information				
Software	Yes	Yes	Improved process efficiency, optimised vertical and horizontal integration	Yes
Databases	Yes	Yes	Better market segmentation and appropriation of consumers' rent, Optimised vertical and horizontal integration.	Yes
Innovative property				
R&D	Yes	Yes	New products and services. Quality improvements to existing ones. Better ways of producing output. New technologies.	Yes
Mineral explorations		Yes	Fixed cost leading to production in future periods. (Price reductions due to) increased supply.	Yes
Copyright and license costs	Yes	Yes	Knowledge diffusion (inventions and innovative methods).	Yes
New product development in the financial industry		Yes	More accessible capital markets. Reduced information asymmetry and monitoring costs.	Yes.
New architectural and engineering designs	Yes	Yes	Fixed cost leading to production in future periods. Quality improvements, novel designs, enhanced processes.	Yes.
Economic competencies				
Brand-building advertisement		Yes	Price premium. Increased market share. Changes in consumers' preferences.	
Market research		Yes	Targeted products and services. Increased market share.	
Workers' Training	Yes		Improved production capability of workers. Increased skill levels.	Yes.
Management consulting	Yes		Faster and better decision making. Improved production processes.	
Own organizational capital	Yes		Faster and better decision making. Improved production processes.	Yes

Measurement issues

32. The data that can be used to proxy investments in intangible assets typically need to be converted into "quantity" series or "constant price" series, in order to be consistent over time and across countries. Researchers have used various assumptions to derive deflators for new investment in intangibles, but there are several measurement issues that need being addressed when doing so, in particular, for price deflators and depreciation rates.

Price indexes

33. Using the right price indexes to deflate expenditures on intangibles is more than a simple statistical issue (Oulton, 2010). The fall in the price of an asset, such as ICTs, can itself be a source of growth, through its impact on the productivity of downstream sectors. Corrado, Goodridge, and Haskel (2010) discuss the two more widespread deflating methodologies, both of which are incorporated in the growth accounting framework. The first is used by national accounting offices and calculates the price of R&D from the prices of the inputs in the R&D-producing sector. The authors argue that this leads to a biased measure of the price of R&D in the presence of productivity gains in the production of knowledge. They propose an alternative approach for calculating the price of R&D from the R&D-using sector. Under the assumption that the R&D-using sector is a price-taker, the price of R&D can be derived from the final output price, factor costs and the sector's TFP.

34. Following this last approach, Corrado, Goodridge and Haskel (2010) construct an industry database for the UK that comprises both gross output-based TFP estimates and R&D performance statistics for 29 UK market sector industries from 1985 to 2005, relying on EUKLEMS data and data from the Office of National Statistics R&D surveys. They suggest that the real price of R&D has fallen dramatically in the UK from 1985 to 2005, which in turn indicates that real investment in R&D is much higher than previously measured.

Depreciation rates[6]

35. There also exists research seeking to quantify the depreciation rate of R&D, using an interpretation of depreciation that differs from that used in the case of traditional physical capital (Huang and Diewert, 2011). The depreciation of R&D capital comes from the discovery of new knowledge and technology that makes the existing R&D capital stock obsolete. In their model, R&D investment is used to increase the stock of knowledge and affects the technology frontier of the production function. They find depreciation rates of R&D to be linked to the nominal interest rate, the mark-up of prices on marginal costs and the evolution of the price index of R&D.

36. Huang and Diewert (2011) use price and quantity data for industrial input and output obtained from the BLS, and price and quantity series for R&D investments from the National Science Foundation (NSF), and calculate the depreciation rate of R&D over the period 1953-2000. Their analysis covers the entire US manufacturing sector, as well as four specific technology-intensive industries, namely chemical and allied products, non-electrical machinery, electrical products and transportation equipment. They calculate the R&D price index using an input price approach and find that the estimated R&D depreciation rate is 39% for manufacturing as a whole, 1% for chemical products, 3% for non-electrical machinery, 14% for electrical products and 27% for transport equipment. These results suggest that assuming a common rate of depreciation for all R&D spending probably hides important sectoral dynamics. However, depreciation rates and the price index of R&D cannot be estimated simultaneously, and therefore the model cannot be identified without making assumptions about at least one of the two variables.

6. For a complete review of the literature on R&D depreciation rate, see (Mead, 2007)

Variations in asset prices and depreciation rates, and double counting issues

37. The use of a common deflator for several industries can be justified by the fact that these industries may get their input factors from the same markets, and should thus face the same prices. But this fact does not hold universally for all types of intangible assets. For example, it is quite likely that different industries have the same advertising costs but they do not have the same R&D costs. Similarly, using the same set of depreciation rates across industries is also controversial. As Huang and Diewert (2011) show, R&D depreciation rates are different for different industries.

38. Another issue that deserves attention is that of double-counting. Generally output data would need to be adjusted in order to adjust for output used as intermediate input by other industries, which should instead be treated as an investment. In addition, not all intangible assets are of the same quality, and some sort of hedonic quality adjustment may be needed to get the volume series of intangible investment in terms of efficiency units.

39. Finally for numbers to be internationally comparable, especially if the analysis entails comparing intangible capital levels or intensities, data series might need to be adjusted for the price level differences that exist among countries. However, this might be less of an issue if inputs are bought in global markets.

Possible empirical strategy

40. A growth accounting framework modified in order to include intangible assets typically specifies the output of industry *i* in country *c* at time *t* given by a production function that accounts for traditional inputs like labour (L_{ict}), tangible capital (K_{ict}) as well as for a measure of intangible capital (R_{ict}) and a variable (A_{ict}) that represents the state of technology and other residuals.

$$Y_{ict} = f\,(A_{ict}, K_{ict}, L_{ict}, R_{ict})$$

The relationship above is used to derive the sectoral sources of growth equation in Barnes (2010).

41. The notion of spillovers can be incorporated into this framework by allowing for the possibility that output of industry *i* can be affected by intangible assets in other industries. This procedure is analogous to the R&D spillover framework in Griliches (1979). Thus, the modified production function is given by:

$$Y_{ict} = f\,(A_{ict}, K_{ict}, L_{ict}, R_{ict}, R_{-ict})$$

where, $R_{-ict} = \sum_k w_{kct} . R_{kct}$ is the weighted measure of the stock of intangible assets that the sector *i* indirectly uses (via spillovers) from other industries *k* and the weights w_{kct} are some measures of the distance between sector *i* and sector *k*. National I-O tables can provide a metric to estimate this distance.

42. The above setup can be generalized to keep different types of intangible assets like R&D, brand-equity, training etc. separate. Thus R_{ict} can be a vector of intangible capital inputs ($R_{ict}{}^1, R_{ict}{}^2, \ldots, R_{ict}{}^M$). Similarly, intangibles from other industries (via spillovers) R_{-ict} can also be considered individually as ($R_{-ict}{}^1, R_{-ict}{}^2, \ldots, R_{-ict}{}^M$).

43. Following Griliches (1998), this general relationship can be represented as follows by assuming Cobb-Douglas functional form:

$$Y_{ict} = A_{ict} \cdot \prod_{m=1}^{M} (R_{ict}^{m})^{\gamma_m} \cdot \prod_{m=1}^{M} (R_{-ict}^{m})^{\delta_m} \cdot \; (K_{ict})^{\alpha_1} \cdot (L_{ict})^{\alpha_2}$$

where, *m* denotes various types of intangible assets. The coefficients γ_m denote the elasticity of output with respect to the stock of various types of intangible assets. The estimated values of these coefficients can indicate the importance of these intangibles in facilitating the output growth.

44. A possible approach that can be used to estimate the differential impact of policies on sectoral investment in intangibles and productivity growth is the Difference-in-Difference approach used for example in the seminal paper of Rajan and Zingales (1998).

45. An additional consideration that has been taken into account by a number of studies is the time lag that can exist between an investment and its effect on productivity. Studies such as Bourlès et al (2010) and Tybout (2003) suggests using an autoregressive specification to resolve this issue.

5. Creating a dataset of investment in intangible assets by sector

46. The depth of an analysis investigating the role of intangible assets on industrial performance crucially depends on data availability. To this end, industry-level data on investment in intangibles, along with gross output or value-added, labour input and price figures are needed. Moreover, adding data on industrial characteristics (*e.g.* market concentration) and on policy variables (*e.g.* index of regulation) would allow providing additional policy relevant insights. The impact of policies on investment decisions and returns to this investment in terms of sector performance can be studied using a multi-country sectoral database of intangible investments.

47. Table 4 lists the possible sources of data that can be used to construct intangibles investment series by asset type as in the CHS framework, by industry and by country. At present, data is directly available only for a few asset types, namely software and databases, and R&D. For the other asset types, the sources mentioned in Table 4 would only provide proxy series. Under certain assumptions, these could be used to estimate the necessary investment series. Most of the series - with the exception of software and databases (and to some extent, R&D) - are available only in value series or at current prices. Hence further data or assumptions need to be made in order to get volume series at the sectoral level.

48. For instance, in the case of R&D expenditures data are typically supplied in current prices and then deflated using GDP price deflators, which is not the most appropriate price index for R&D. In order to accurately compare or add investments made at different points in time in different industries, R&D expenditures need to be deflated using sector-specific R&D price deflators. For example, changes in R&D input costs in the software industry can be very different from the changes in R&D input costs in the petroleum refining industry. With the capitalization of R&D in System of National Accounts (SNA) 2008, national statistical agencies are working towards creating such estimates. Given the early stage of this reform, R&D deflators are not yet readily available, and assumptions have to be made in order to calculate them for our current purpose.

49. For the asset types in the economic competencies category, which are not covered in SNA 2008, the data construction is more indirect. The investment (at current prices) in these intangibles is estimated using a related proxy series. The assumptions used by CHS regarding the choice of such proxy series and the mapping of proxy series to investment expenditures have been used by other researchers as well. For

example, CHS use 20% of managers' earnings to estimate the investment in own-account organizational capital.

50. In addition to making these assumptions, the sectoral dataset also requires finding the industry-shares of estimated investments in intangibles. National I-O tables can provide the basis for calculating those shares. For example, Barnes (2010) uses sector's share of total advertising less expenditures on classifieds and directories as a proxy for investment in advertising by sector. Another research project on creating industry level intangible asset dataset for Korea uses detailed I-O tables to estimate the share of investment in intangibles going to different industries. The industry level national accounts data also provides the price deflators that could be used as proxy for prices of investment in intangibles. For example, implied sector gross value-added deflator for advertising could be used as a proxy for price of brand-building investment.

Table 4: Possible Data Sources for Investments in Intangible Assets by Industry

Asset Type	**Possible Sources**
Computerized information	
Software	OECD National Accounts (Gross Fixed Capital Formation – GFCF- by asset types). EU or World KLEMS database
Databases	Included in software estimates
Innovative property	
R&D	Business Expenditure on R&D.OECD: ANBERD, GERD. BERD
Mineral explorations	National Accounts Sectoral Output. Business Statistics. Surveys.
Copyright and license costs	National Accounts (Sector-wise). Detailed national I-O tables. TV and radio, publishing and music industries.
New product development costs in the financial industry	Occupational data on researchers' earnings.
New architectural and engineering designs	Purchased: Using detailed national I-O tables. Own-account: Using designers' earnings surveys.
Economic competencies	
Brand-building advertisement	Detailed I-O tables. Advertising Industry Surveys. Sectoral Output from Business Statistics (4-digit ISIC/ NACE / NAICS codes).
Market research	Detailed national I-O tables. Sectoral Output from Business Statistics
Firm-specific human capital	Vocational Training Surveys. EuroStat Education and Training Data.
Management consulting	Consulting Firms Revenue. Sectoral National Accounts and Business Statistics (4-digit ISIC/ NACE / NAICS codes).
Own account organizational capital	Employment/Earnings Surveys. Labour Force Surveys (LFS).

51. Table 5 lists some of the existing multi-country databases that may be used to compile sector-specific intangible investment data. It highlights the type of data available, the countries covered, as well as the industries for which data exists, and the time coverage of such datasets. Investment in intangible assets can be derived or indirectly estimated using some of the series listed in Table 5. Having multiple sources of data for the same variables is helpful to validate the accuracy, fill in the missing values and extend the time coverage.

Table 5: Datasets with industry-level Input- Output or intangible investment series

	EU WIOD[7] project	OECD STAN family	EU-KLEMS and World-KLEMS[8] projects	Eurostat
Data	Output and Labour files. Time Series Supply-Use Tables. Harmonized National IO tables. Inter-country IO tables in current and constant prices	Output and total labour and capital input Harmonized Input-Output Tables. R&D Expenditure in Industry (ANBERD) Bilateral trade by industry and end-use	Capital Input Files (ICT and non-ICT) Labour Input Files. Intermediate input files (EMS – energy, materials, services)	Output and total labour and capital input Time Series Supply-Use Tables. Input-Output Tables. R&D Expenditures.
Countries Covered	27 EU countries and 13 other countries in the world	31 OECD Countries. 6 Other Major Economies.	Australia, Austria, Canada, Czech Republic, Denmark, Finland, Germany, Italy, Japan, Korea, Netherlands, Portugal, Slovenia, Sweden, UK, US.	EU-27, Norway, Turkey.
Industries/ Sectors	More than 30 industries and at least 60 products	2-Digit Industry Code and Aggregates.	Up to 70 industries	60 Industries.
Time Periods	1995 to 2006 (up to 1980 for some countries)	1987-2009 (from 1970-2009 for STAN industry)	1970 to 2005	1995-2008

Computerised Information

52. Data on investment in software (which includes database management software) is directly available from the System of National Accounts (SNA) Gross Fixed Capital Formation (GFCF) series for few countries, mainly EU countries and US. For selected countries it can also be obtained from EU-KLEMS Capital Input files. Once data is released under the World-KLEMS project, series on software investment by industry may also become available for additional countries.

53. For the latest years, data contained in the World Information Technology and Services Alliance (WITSA) Digital Planet Reports could also help quantifying investment in computerised information. WITSA publishes the estimated spending on software for 75 largest ICT buying nations and regions. The latest 2010 report breaks down the data by market segments. Such data can be adjusted using Jorgenson and Vu's "Kuznets" database (Jorgenson and Vu, 2005) to estimate the spending on software by businesses since WITSA data includes ICT spending by consumers. In addition, as WITSA data are reported in current prices, price deflators for software investment have to be obtained from national accounts data.

7. Access to the WIOD database is restricted at present.

8. The data from other World-KLEMS projects like Asia-KLEMS, Latin America-KLEMS is not yet available.

Innovative Property (Research & Development)

54. OECD ANBERD provides data on industrial R&D broken down by 60 industries for OECD member countries and a few other economies. These numbers are internationally comparable (available in Purchasing Power Parities, PPPs). However, GDP deflators are used as proxies for R&D prices. Eurostat also publishes data related to business expenditures on R&D for various countries. Having two series for the same set of variables can help identify possible misalignments and calculate missing values.

55. As for mineral explorations and copyright and licensing costs, these could be directly derived using industry breakdowns of national accounts and I-O tables. For copyright and licensing costs in particular, the industry classifications “Publishing, printing and reproduction of recorded media” and “Recreational, cultural and sporting services” may be relevant. However, these series would only proxy for artistic originals and not include the patent licensing costs. Investments in new product development in the financial industry could conversely be estimated using data about the financial service activity sector. Evidently assumptions would have to be made in order to obtain such estimates, as only a proportion of the output of these sectors may qualify as an investment.

56. The OECD handbook on deriving capital measures for intellectual property products (OECD, 2010) presents recommendations for national statistical agencies on how to correctly measure these investments in software and databases, R&D and artistic originals. It suggests implementation strategies for taking into account price and quality changes and obtaining the information on service lives of these assets. Architectural and engineering design is treated as a separate type of intangible assets in many studies including the CoInvest and InnoDrive data projects. The OECD handbook (OECD, 2010) suggests that technical and architectural designs and models do not satisfy the criteria for primary artistic intent and therefore should not be considered originals. One justification for this conventional approach can be that these designs are usually developed as part of the production process of the building or structure. It is very likely that the costs of developing these designs are already included in measures of investment relating to buildings and structures, since SNA 2008 specifies that “fees paid to architects” as well as the “costs of site preparation” should be considered as GFCF (Gross Fixed Capital Formation).

Economic Competencies (Brand Equity, Training)

57. Data about economic competencies, intended as both brand equity and training are not easy to obtain. Even at the aggregate level, this is derived using various assumptions, many of which may be subject to criticism. Estimates for workers’ training can be obtained from the Eurostat database on Education and Training, which contains a survey series on Continuing Vocational Training (CVT) in enterprises for the years 1999 and 2005. It also contains data on training and non-training enterprises, grouped following the NACE classification.

58. As for brand equity, some countries have data in I-O tables at a detailed industrial classification level which can be used to get the investments in brand equity. For example, NACE Rev. 2 73.1 class “Advertising” and 73.2 “Market research and public opinion polling” could be used to estimate the relevant series.

59. The intangible assets in this category are excluded from SNA 2008 GFCF calculations. Regarding the human capital, SNA 2008 recognizes its importance by mentioning that “the main aggregates as shown in the central framework” may change due to “increase in fixed capital formation if human capital is considered an economic asset”. For brand equity SNA mentions that “Goodwill and marketing assets are only recognized as assets in the SNA when they are evidenced by a sale”.

Industry characteristics

60. The data for many relevant sector-specific characteristics is available in industry level National Accounts. Examples are capital intensity and size of the industry in terms of capital and labour. Other sources like OECD STAN (including I-O tables), Eurostat, EU-KLEMS and WIOD can provide additional source of data on variables such as the share of workers by skill levels, the share of input that is imported or the share of output that is exported.

61. Using these controls would increase the robustness of the estimated coefficients and would allow testing for some possible relationships, *e.g*., whether the effect of R&D on industrial productivity is higher in industries with a larger share of highly skilled workers; or whether export oriented industries have a larger impact from developing engineering designs.

Institutional features

62. Investing in intangible assets and the possible impact of intangible assets over productivity or output may be shaped by (economy-wide) framework conditions. It may be reasonable to suppose, for instance, that the benefits from investing in software capital may be higher if the workforce is (more) educated. In some industries advertising spending might be higher just to create entry barriers or match competitors' spending, while in others it might help building brand equity and increase output. Taxes and subsidies affect the effective prices faced by the firms and thus the actual amount of investment in intangible assets. Finally, the cost of finance for innovation may depend on the level of development of venture capital markets.

63. Capital market indicators are available from the IMF International Financial Statistics database and tariffs data can be obtained from WTO. Other socio-economic and policy indicators are available from the OECD and Eurostat (*e.g*. Information Society Statistics), the World Bank, and other institutions.

6. Conclusions and Roadmap for Further Research

64. This paper discusses the role of intangible assets in output and productivity growth at sector and industrial level. The literature is rich on both macro and firm level analysis of this relationship. Despite the difficulties involved in creating a dataset for sector level analysis, studying the role of intangible assets on sectoral growth has the potential to offer many useful insights and policy implications. The paper outlines an empirical approach that could be taken to do such an analysis depending on the data availability. Various possible data sources and methods to create such a dataset are also discussed.

65. Delegates are invited to:

- comment on the methodological issues raised, and suggest possible solutions and analytical strategies;
- mention relevant ongoing work and data collections that could be used in the analysis;
- express their interest in joining the OECD Secretariat on this work.

REFERENCES

Aghion, P., P. Howitt, and C. García-Peñalosa. 1998. *Endogenous growth theory*. MIT Press.

Arnold, J., B. Javorcik, and A. Mattoo. 2011. "Does Services Liberalization Benefit Manufacturing Firms? Evidence from the Czech Republic" *Journal of International Economics* 85(2011) 136-146.

Athey, S, and S. Stern, S.1998. "An Empirical Framework for Testing Theories about Complementarities in Organizational Design," *NBER Working Paper No. 6600*.

Barnes, P. 2010. "Investments in Intangible Assets and Australia's Productivity Growth: Sectoral Estimates". *Productivity Commission*.

Barnes, P., and A. McClure. 2009. "Investments in Intangible Assets and Australia's Productivity Growth." *Productivity Commission*.

Belhocine, N. 2009. "Treating intangible inputs as investment goods: the impact on Canadian GDP." *International Monetary Fund*, Western Hemisphere Dept.

Black, S. and L. Lynch. 1996. "Human-Capital Investments and Productivity". *The American Economic Review* Vol. 86, No. 2, pp. 263-267

Bourlès, R., G. Cette, J. Lopez, J. Mairesse, and G. Nicoletti. 2010. "Do Product Market Regulations in Upstream Sectors Curb Productivity Growth?: Panel Data Evidence for OECD Countries", *OECD Economics Department Working Papers*, No. 791, OECD Publishing.

Bresnahan, T., E. Brynjolfsson, and L. Hitt. 2002. "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence." *Quarterly Journal of Economics* 117(1): 339–376.

Caroli, E., and J. van Reenen, .2001. "Skill-Biased Organizational Change? Evidence From A Panel Of British And French Establishments," *The Quarterly Journal of Economics*, MIT Press, vol. 116(4), pages 1449-1492, November.

Che, N.X. 2009. "Sectoral Structural Change in a Knowledge Economy." *MPRA Paper*.

Chun, H, H Pyo, and K. Rhee. Forthcoming. "Intangible Investment and Productivity Growth in Korea"

Coe, D. And E. Helpman. 1995. "International R&D spillovers". *European Economic Review*, Volume 39, Issue 5, pp. 859-887

Corrado, C., C. Hulten, and D. Sichel. 2009. "Intangible capital and US economic growth." *Review of Income and Wealth* 55(3): 661–685.

Corrado, C., C. Hulten, and D. Sichel. 2005. "Measuring capital and technology: an expanded framework." *University of Chicago Press*.

Corrado, C., P. Goodridge, and J. Haskel. 2010. "Constructing a Price Deflator for R&D: Calculating the Price of Knowledge Investment as a Residual." Paper presented at the CRIW workshop.

Crepon, B., E. Duguet, and J. Mairesse. 1998. "Research, Innovation And Productivicty: An Econometric Analysis At The Firm Level." *Economics of Innovation and New technology* 7(2): 115–158.

Dahl, C., H. Kongsted, and A. Sorensen. 2010. "ICT and Productivity Growth in the 1990's." EUKLEMS Project.

Dearden, L., H. Reed, and J. Van Reenen. (2006), "The Impact of Training on Productivity and Wages: Evidence from British Panel Data." *Oxford Bulletin of Economics and Statistics*, 68: 397–421.

Edquist, H. 2011. "Can Investment in Intangibles Explain the Swedish Productivity Boom in the 1990s?" *Review of Income and Wealth*, doi: 10.1111/j.1475-4991.2010.00436.x.

Fukao, K., T. Miyagawa, K. Mukai, Y. Shinoda, K. Tonogi. 2009. "Intangible investment in Japan: Measurement and contribution to economic growth." *Review of Income and Wealth* 55(3): 717–736.

Gil, V., and J. Haskel. 2008. "Industry-level Expenditure on Intangible Assets in the UK." Coinvest Publication.

Griliches, Z. 1979. "Issues in Assessing the Contribution of Research and Development to Productivity Growth" *Bell Journal of Economics,* The RAND Corporation, vol. 10(1), pages 92-116, Spring.

Griliches, Z. 1991. "The search for R&D Spillovers" *NBER Working Papers*, 3768, National Bureau of Economic Research, Inc.

Griliches, Z. 1998. "R&D and Productivity Growth at the Industry Level: Is There Still a Relationship?" in R&D and Productivity: The Econometric Evidence." *NBER Books*, National Bureau of Economic Research, Inc.

Hao, J., V. Manole, and B. van Ark. 2008. "Intangible Capital and Growth – an International Comparison." *Economics Program Working Paper Series*, EPWP: 08–14.

Huang, N., and E. Diewert. 2011. "Estimation of R&D depreciation rates: a suggested methodology and preliminary application." *Canadian Journal of Economics/Revue canadienne d'économie* 44(2): 387–412.

Jaffe, A. 1986. "Technological Opportunity and Spillovers of R & D: Evidence from Firms' Patents, Profits, and Market Value." *The American Economic Review* Vol. 76, No. 5 (Dec., 1986) (pp. 984-1001)

Jalava, J., P. Aulin-Ahmavaara, and A. Alanen. 2007. "Intangible capital in the Finnish Business sector, 1975-2005." *Pellervo Economic Research Institute Discussion Papers* 1103.

Javorcik, Beata (2004). "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages," *American Economic Review* 94(3), 605-627

Javorcik, B., and M Spatareanu. 2011. "Does it matter where you come from? Vertical spillovers from foreign direct investment and the origin of investors." *Journal of Development Economics* 96(2011) 126-138

Jones, C. 2005. "Growth and Ideas." *The Handbook of Economic Growth*, Elsevier.

Jorgenson, D.W., and K. Vu. 2005. "Information Technology and the World Economy." *Scandinavian Journal of Economics* 107(4): 631–650.

Marrano, M., J. Haskel, and G. Wallis. 2009. "What happened to the knowledge economy? ICT, intangible investment, and Britain's productivity record revisited." *Review of Income and Wealth* 55(3): 686–716.

Mead, C. 2007. "R&D depreciation rates in the 2007 R&D Satellite Account." *Bureau of Economic Analysis/National Science Foundation*.

Milgrom, P, J, Roberts, 1990, "The Economics of Modern Manufacturing: Technology, Strategy and Organisation" *The American Economic Review* 80, no 3: 511-528.

Milgrom, P, J, Roberts, 1995, "Complementarities and Fit: Strategy, Structure, and Organisational Change in Manufacturing" *Journal of Accounting and Economics* 19, no 2-3: 179-208.

Miller, R, and P Blair. 2009. *Input-Output Analysis: Foundations and Extensions*. 2nd ed. Cambridge Univesrity Press.

OECD. 2009. *Innovation in Firms: A Microeconomic perspective*. OECD Publishing, Paris.

OECD. 2010. *Handbook on Deriving Capital Measures of Intellectual Property Products*. OECD Publishing, Paris.

Oliner, S., D. Sichel, and K. Stiroh. 2007. "Explaining a productive decade." *Brookings Papers on Economic Activity* 2007(1): 81–137.

Ornaghi, C. 2006. "Spillovers in product and process innovation: Evidence from manufacturing firms." *International Journal of Industrial Organization* 24(2): 349–380.

Oulton, N. 2010. "Long term implications of the ICT revolution: applying the lessons of growth theory and growth accounting." *CEP Discussion Papers*.

Rajan, R.G and L. Zingales. 1998. "Financial Dependence and Growth". *The American Economic Review,*1998, Vol. 88: 559-586.

Romer, P. 1986. "Increasing returns and long-run growth." *The Journal of Political Economy*: 1002–1037.

Romer, P. 1994. "The origins of endogenous growth." *The Journal of Economic Perspectives* 8(1): 3–22.

van Rooijen-Horsten, M., D. van den Bergen, and M. Tanriseven. 2008. "Intangible capital in the Netherlands: A benchmark" *Statistics Netherlands*, Discussionpaper (08001)

Solow, R. 1987. "We'd better watch out", *New York Times Book Review*, July 12 1987, page 36.

Spiezia, Vincenzo. 2008. "The contribution of the ICT sector to economic growth in OECD countries: Backward and Forward linkages." OECD, Paris.

Tybout, James R. 2003. "Plant- and Firm-level Evidence on the 'New' Trade Theories". in E. Kwan Choi and James Harrigan, ed., *Handbook of International Trade*, Oxford: Basil-Blackwell, 2003.

Wolff, E. 2011. "Spillovers, Linkages, and Productivity Growth in the US Economy, 1958 to 2007". *National Bureau of Economic Research*.

Wolff, E. 1997. "Spillovers, linkages, and technical change". *CV Starr Center for Applied Economics*, New York University. Faculty of Arts and Science. Department of Economics.

Wolff, E., and M. Nadiri. 1993. "Spillover effects, linkage structure, and research and development." *Structural Change and Economic Dynamics* 4(2): 315–331.