Chapter 4.

Measuring knowledge-based capital

This chapter describes recent advances in the measurement of knowledge-based capital (KBC) and the contribution of the OECD to this work. Important areas of progress relate to the international harmonisation of estimates and methodologies and the publication of comparable figures at the macroeconomic and industry levels. The OECD has also addressed the measurement of assets for which guidelines do not exist, and proposed an experimental task-based methodology to estimate investment in organisational capital (OC). Results suggest that investments in OC are almost twice as large as previously estimated and that many occupations, in addition to managers, contribute to its accumulation. OECD work on research and development (R&D) has focused on aligning the various existing measures of investment and on proposing output-based measures that capture the economic and technological value of inventions through the use of patent data. The results point to the sources of differences in investment estimates and show that the quality of R&D output varies substantially within and across technologies and industries. Finally, the OECD has estimated depreciation rates for R&D and OC and found that these assets remain valuable for longer than previously assumed. Overall, the estimates suggest the growing importance of investments in KBC assets and their relation to productivity growth, although causal links, complementarities and spillover effects remain to be addressed.

Modern economies rely heavily on knowledge and on complex production systems, and economic actors need to know how to navigate these dense and interconnected systems. While certain businesses have quickly understood the importance of knowledge and knowledge-based assets, and have thrived in this challenging environment, others have struggled to embrace new economic models and to keep up. To recover from the crisis and achieve sustained economic growth and job creation all economic actors need to make a smooth transition to knowledge-intensive production systems. At a time of constrained public and private resources, this will require carefully targeted investments, notably in knowledge-based assets.

It has often been said that knowledge is to the economy of the 21st century what coal was to that of the 19th century and oil to that of the 20th century. Yet, defining and measuring a unit of knowledge is not as straightforward as weighing tons of coal or counting barrels of oil. Properly measuring knowledge and the value added that its use and transfer may generate has significant implications for understanding economic activity and for the design of policies aimed at fostering productivity and economic growth. This point was also stressed by Ben Bernanke, chairman of the United States Federal Reserve, at the opening conference of the New Sources of Growth project, held in Washington DC in 2011: "As someone who spends a lot of time monitoring the economy, let me put in a plug for more work on finding better ways to measure innovation, R&D activity, and intangible capital. We will be more likely to promote innovative activity if we are able to measure it more effectively and document its role in economic growth."

In recent years there have been important advances in the measurement of knowledge-based capital (KBC), from the standpoint both of methodology and data availability. These advances have helped shed light on a wide array of policy issues, and have improved understanding of many important issues, including the role of investment in KBC in economic growth. As certain countries start to invest more in KBC than in physical capital, understanding the determinants and effects of such investments becomes a priority for formulating evidence-based policy. Therefore, the OECD has sought to develop metrics that will provide policy makers with sounder estimates of how much is invested in knowledge assets and how these investments shape economic activities, performance and competitiveness.

This chapter first recalls the conceptual and measurement breakthroughs of Corrado et al. (2005, 2009), and then discusses the main questions that their analytical framework left unanswered and how recent advances have addressed them. In particular, it focuses on the international efforts of recent years to improve the international harmonisation of methodologies and estimates, to develop disaggregated estimates at the industry and firm levels, to produce guidelines to measure assets for which guidelines were lacking, and to refine modelling parameters. On each of these fronts, significant advances have helped to paint a much clearer picture of the role of knowledge-based assets in economies worldwide. Concerted international efforts have resulted in the publication of KBC investment estimates that are comparable across countries, at both the macroeconomic and industry levels.

The OECD's work has focused on better measuring assets recognised as central to innovation and economic growth for which no guidelines exist, such as organisational capital (OC). To this end, Corrado et al.'s manager-focused approach has been refined, based on an experimental task-based methodology that identifies OC-related occupations on the basis of tasks performed on the job by employees rather than on their occupational titles. The methodology was applied to data from the United States. The results suggest

that the long-term organisational capability of firms rests on a much wider array of occupational categories than previously thought, and that OC is not exclusively about managers. Once all of these are taken into account, the overall size of investment in OC is almost double previous estimates. Moreover, industry-specific patterns of investment show that services are large investors in OC.

The OECD has also made efforts to reconcile measures of a single asset, research and development (R&D), collected on the basis of different methodologies. Part of this work has focused on reconciling R&D investment estimates made in the framework of the System of National Accounts (SNA) and the survey-based figures collected following the guidelines provided by the OECD *Frascati Manual* OECD, 2002). Expenditures based on the *Frascati Manual* are recorded on the basis of the performers and funders of R&D activities, whereas SNA estimates relate to the producers and owners of R&D assets. The data coverage also varies in terms of time frames and countries for which data are available. Reconciling these figures helps to improve comparability across countries and over time.

In addition, the OECD has investigated the possibility of measuring KBC in terms of outputs as well as inputs to see what investing in KBC assets may lead to. It has proposed a number of metrics for assessing the economic and technological value of patented inventions. They have the advantage of relying on a homogenous body of information contained in patent documents and can therefore be computed for every patent. Results suggest that patent quality and value – and hence the value of the R&D contained in them – varies greatly among technological fields and countries and over time. They provide quantitative evidence about differences in R&D output in terms of economic importance and future technological developments.

Finally, and to obtain a more complete picture of the role of KBC in shaping economic performance, efforts have been made to learn for how long investments in R&D and OC continue to prove useful for economic agents. This work relates to depreciation rates and suggests that both OC and R&D depreciate much more slowly than previously thought and that there are industry-specific patterns. Overall, the main findings emphasise the key role of human capital, and of skilled labour in particular, in the organisational and research capabilities of firms. Moreover, investment in this type of human capital is much longer-lived than previously thought.

Before concluding, this chapter describes the picture of KBC investment that emerges from these measurement efforts. There is little doubt about the growing importance of KBC investments in many OECD economies or about the fact that investments in KBC have increased steadily in most countries, sometimes surpassing investments in physical capital. If KBC investments are included in models of economic growth, they are likely to account for a large share of productivity growth. However, the modelling and analytical frameworks available so far uncover correlations but not causal links. This means that it is not known whether investment in KBC leads to productivity growth or is simply associated with it. The ability to judge whether a causal link exists along with improvements on various measurement and methodological fronts will help provide the evidence that policy makers need.

The framework developed by Corrado, Hulten and Sichel

In their seminal work, Corrado, Hulten and Sichel (Corrado et al., 2005, 2009; henceforth CHS) made a number of ground-breaking contributions that have led to a better understanding of the importance of KBC in OECD economies. First, they proposed to classify expenditures on KBC into three broad categories: computerised information, innovative property and economic competencies. Each of these categories covers a number

of assets of a similar nature. Second, they developed an expenditure-based approach to measuring these assets: quantifying the monetary value of the resources devoted by firms to these assets on a yearly basis. Third, they argued that these annual investments feed into production for a number of years and should thus be capitalised rather than counted as current expenditures that are consumed within a year. They also constructed capital stock series from their investment figures and made explicit assumptions about the proportion of investments that are used from one year to another and about the extent to which they depreciate. Finally, they used these capital figures in a growth accounting framework to assess the contribution of the different factors of production – namely labour, physical capital and knowledge-based capital – to productivity and economic growth.

Box 4.1 presents the main features of the CHS measurement framework. It synthesises and briefly discusses the knowledge-based assets considered, and summarises some of the key aspects of the CHS methodology in a table that lists the different types of assets included in the framework, the data sources used for the investment series, and the measurement assumptions (what these items include) and the depreciation rates used.

Outstanding measurement and modelling issues

The CHS framework was initially conceived for, and experimented on, data for the United States. A number of academics in other OECD countries then endorsed the CHS approach and used it to estimate investments in KBC and their contribution to output and productivity growth. However, use of the methodology in other economies relied on different data sources and measurement parameters, adapted to fit country-specific features, and, more generally, on differences in the way definitions are operationalised. The research community has sought to provide common guidelines in order to harmonise national estimates in recent years. This has led to the publication of international datasets such as the INTAN-Invest dataset, which covers 27 countries of the European Union, plus Norway and the United States.

To obtain fully comparable international figures will require further methodological work aimed at more accurate definitions and measurement of assets for which no guidelines currently exist. This is the case for items like brand equity, which remains very hard to measure, especially in an expenditure-based approach that focuses on the amount of spending required to produce a certain asset, rather than on the value the asset has once it is created. This is also the case of databases related to customers' purchasing behaviour, which are collected as a by-product of retail activities and may have great value (for streamlining supply processes and targeting prospective consumers, for example). The need for definitions and measurement guidelines is even more urgent for assets that play a central role in economic activities. In the case of organisational capital, for example, recent advances have been made by examining how its generation and accumulation relate to various dimensions of human capital.

Another important outstanding issue relates to measuring investment in KBC at the sector and the firm levels. While the CHS framework was developed as a macroeconomic approach, many of the effects of investment in KBC are best observed and understood at more disaggregated levels. This creates the need for robust sectoral and micro-level figures that would be extremely useful for policy-making purposes. Understanding the patterns of industries' and firms' investments in knowledge-based assets could help in the design of more effective policies – especially new industrial policies – and in the identification of the most suitable policy tools. Sectoral estimates have recently been produced for a handful of countries, but measurement of investment in KBC at the firm level remains exploratory.

Box 4.1. Details of the CHS measurement framework

The asset categories of the CHS framework are the following:

- *Computerised information*: Knowledge codified in computer programmes and computerised databases recorded in the official System of National Accounts since 1993. The emergence of "big data" (see Chapter 8) has raised new challenges for the measurement of resources used to create this asset and of the economic value that can be obtained from it.
- *Innovative property:* Knowledge assets that are protected through intellectual property rights (IPR), such as patents, designs, copyrights and to some extent trademarks. These assets result from spending on R&D and mineral exploration, but also from a range of expenditures on creative and inventive activities, artistic originals, architectural designs and new financial products. While most of these expenditures are recorded somewhere in official national accounts, few are explicitly reported as investments in KBC.
- *Economic competencies:* Knowledge embedded in a firm's human and structural resources, such as firm-specific training, organisational capital, and brand equity and measured mainly by using secondary sources of data and a set of provisional assumptions. This asset category represents the biggest challenge in terms of definition, measurement and modelling.

Assumptions and data sources, investments in knowledge-based assets

Asset type	Data sources	Measurement assumptions	Depreciation rate (%)
Computerised information			
Software	Recorded in SNA	Includes own use, purchased and custom made software	33
Databases	Included in SNA estimates of software investment		33
Innovative property			
Science and engineering R&D	R&D surveys, business expenditures on R&D (BERD) estimates	BERD	20
Mineral exploration	Recorded in SNA	R&D in the mining industry	20
Artistic originals, usually leading to copyrights and licences	Recorded in SNA		20
New product development in the financial services industry	Input-output and supply-use tables	20% of intermediate purchases of the financial industry	20
New architectural and engineering designs	Services Annual Survey and supply-use tables	50% of purchases of architectural and consulting engineering services	20
R&D in social sciences and humanities	Included in BERD estimates		20
Economic competencies			
Brand equity	Surveys of advertising expenditures; Services Annual Survey; supply-use tables	*Advertising*: purchases of advertising services *Marketing*: outlays on marketing services Doubled to take into account production costs and own account component	60
Training	Surveys of employer-provided training	Direct costs and wage costs of employee time in training for market-sector industries	40
Organisational capital	Employment and earnings data; Services Annual Survey	*Own account*: 20% of managerial wages *Purchased*: 80% of services purchased from the management consulting industry	40

Source: Based on: Corrado, C., C. Hulten and D. Sichel (2005), "Measuring Capital and Technology: An Expanded Framework", in C. Corrado, J. Haltiwanger and D. Sichel (eds.), *Measuring Capital in a New Economy*, National Bureau of Economic Research and University of Chicago Press, Chicago, IL; Corrado, C., C. Hulten and D. Sichel (2009), "Intangible Capital and US Economic Growth", *Review of Income and Wealth*, Vol. 55(3), pp. 661–685; and Barnes, P. and A. McClure, (2009), "Investments in Intangible Assets and Australia's Productivity Growth", Australia Productivity Commission.

Assessing how investment in knowledge-based assets relates to productivity and economic growth also requires refinement of a number of analytical parameters, in particular asset prices and asset service lives. First, price information is important to capture the quantity of assets purchased. For instance, the general reduction in the price of information and communication technologies (ICT), including software, means that the same amount of money can buy much more and much better ICT goods today than ten years ago. Another example relates to the cost of R&D personnel: in countries and fields where specialised researchers are in short supply, an increase in R&D expenditures may simply reflect the higher salaries that firms may have to pay to retain researchers, rather than an increase in the number of scientists hired. Second, it is important to know how long firms expect to benefit from their investments in different assets. Hence, quantifying the service life of KBC is crucial. This requires determining the mechanisms that lead to discarding an asset that is no longer needed (e.g. a new generation of technologies that makes previous ones obsolete), and those affecting its loss of productivity as it ages. Many assumptions underlying price deflators and depreciation rates are now being developed and tested worldwide. Making significant progress in these areas will nevertheless require sustained efforts over the medium to long term.

Finally, understanding the role of KBC in productivity and economic growth raises some important questions. They relate to the analytical framework generally used and to the type of information it can provide. Growth accounting models have shown that KBC, which was previously omitted from the analysis, relates significantly to productivity growth. However, these models cannot determine the direction of causality in the relationship between KBC and growth, nor can they account for possible complementarities, substitutabilities or spillover effects. Moreover, while specific assets have been the object of tailored modelling strategies, each emphasising a particular causal link or interaction,[1] the lack of a general model for KBC and growth hinders the ability to identify market failures for which government intervention could be warranted, and to design effective policies and avoid possible distortive effects.

Recent advances and the work of the OECD

Over the last decade, the research community has worked to advance the KBC measurement agenda by proposing, refining and testing definitions, assumptions, and estimation strategies in order to inform policy making. The four main measurement challenges addressed concern the international harmonisation of methodologies and estimates, the development of estimates at disaggregated levels, the drafting of measurement guidelines for assets that are less well measured, and the refinement of modelling parameters. The OECD has focused on two broad issues: i) the measurement of KBC at the microeconomic and sectoral levels, with implications at the macroeconomic level; and ii) the measurement of two CHS asset categories, innovative property and economic competencies, in terms of investment and depreciation.

The measurement of innovative property has been approached both from an input and an output perspective. Efforts to measure the inputs to the construction of innovative property have focused on reconciling survey-based R&D expenditure measures with the SNA R&D investment series at both the sectoral and the macroeconomic levels. On the output side, OECD work has concentrated on designing and building measures related to the "quality" of the innovative property of firms, intended as the technological and economic value of patented inventions. Patent data have also been used to calculate sector-specific depreciation rates of R&D capital, given evidence showing patents to be highly correlated with R&D expenditures, and patent renewals to be linked to returns to R&D investment.

The OECD work to measure economic competencies has focused on the definition and measurement of organisational capital at the sectoral level (see Squicciarini and Le Mouel, 2012[2]). The experimental methodology proposed relies on information about the tasks performed by employees in different occupations to identify those who contribute to the generation and accumulation of OC. Investment in OC is then estimated on the basis of the earnings of the personnel who – as indicated in task-level information – genuinely contribute to the accumulation of OC.[3] Sector-specific depreciation rates are calculated on the basis of the mobility of these employees, as a firm's organisational capability may be disrupted when such employees leave the firm.

Moving towards internationally harmonised investment series

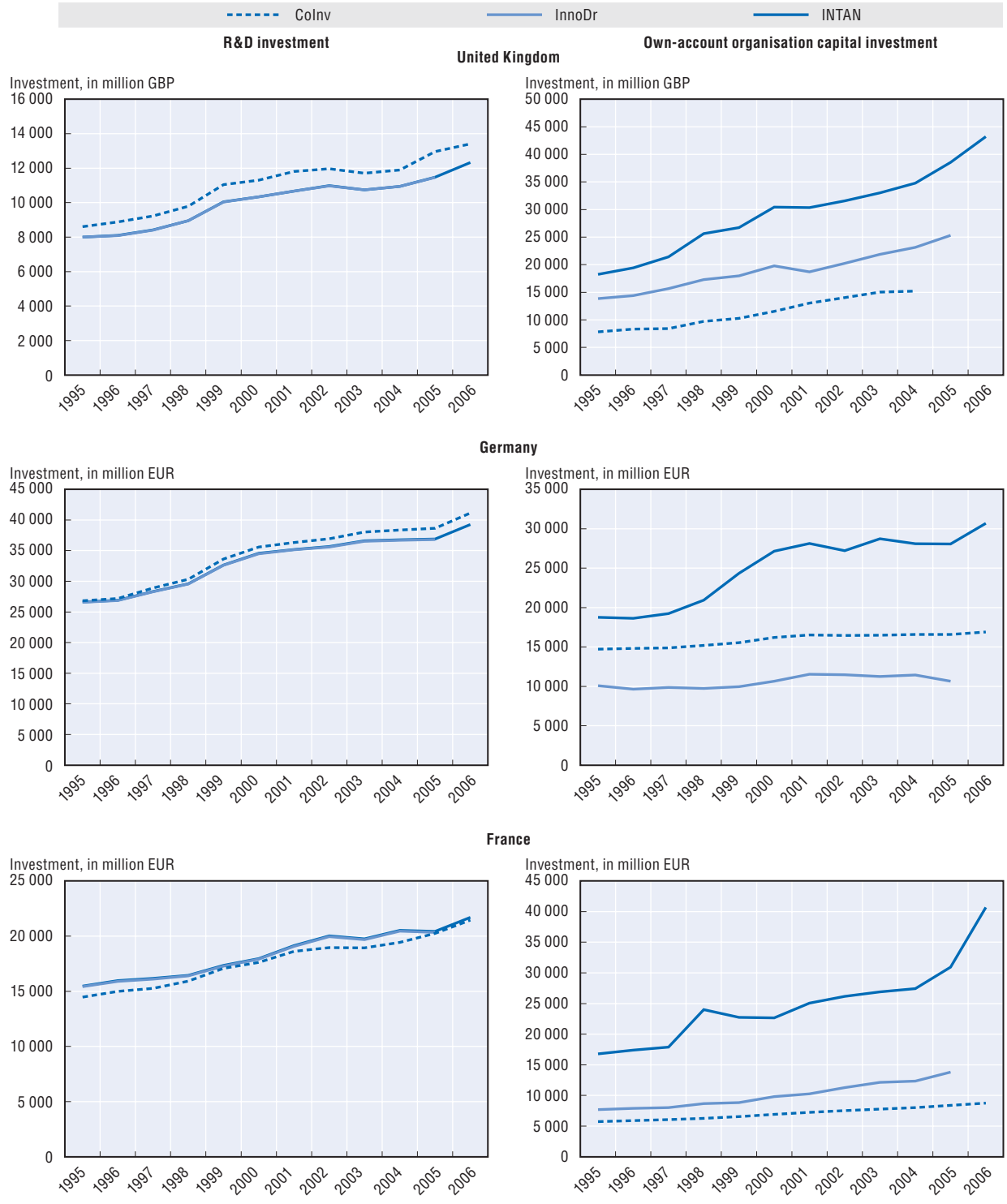
The work of Corrado, Hulten and Sichel has made clear the growing importance of KBC in terms of the magnitude of the investments involved and their contribution to growth. Motivated by these findings, researchers worldwide have compiled comparable estimates of investments in KBC for most OECD countries. Table 4.1 lists the countries for which such estimates are available at the macroeconomic level, along with the sources and the time coverage.

Table 4.1. Investment in KBC – available macroeconomic level estimates

Country	Reference	Coverage
Australia	Australia (2012)	1974-2011
	Barnes and McClure (2009)	1974-2006
Austria	van Ark et al. (2009)	1995-2006
Canada	Baldwin et al. (2012)	1976-2008
	Belhocine (2009)	1998-2005
China	Hulten and Hao (2012)	1995-2008
Czech Republic	van Ark et al. (2009)	1995-2006
Denmark	van Ark et al. (2009)	1995-2006
EU 27	INTAN-Invest (2012)	1995-2010
	Piekkola (2011)	1995-2006
Finland	Jalava et al. (2007)	1975-2005
France	Delbecque and Bounfour (2012)	1980-2008
	Hao et al. (2008)	1991-2004
Germany	Hao et al. (2008)	1991-2004
Greece	van Ark et al. (2009)	1995-2006
Italy	Hao et al. (2008)	1991-2004
Japan	Chun et al.(2012)	1980-2008
	Fukao et al. (2009)	1980-2005
Korea	Chun et al. (2012)	1980-2008
Netherlands	van Rooijen-Horsten et al. (2008)	2001-2004
Norway	INTAN-Invest (2012)	1995-2010
Slovakia	van Ark et al. (2009)	1995-2006
Spain	Hao et al. (2008)	1991-2004
Sweden	Edquist (2011)	1995-2006
United States	INTAN-Invest (2012)	1995-2010
	Corrado et al. (2005, 2009)	1950-2003

Source: Based on national studies, see References for full URLs. Australia (2012), www.innovation.gov.au/; Barnes and McClure (2009), www.pc.gov.au/; van Ark et al. (2009), www.eib.org; Baldwin et al. (2012), www.statcan.gc.ca; Belhocine (2009), www.imf.org; Hulten and Hao (2012), www.nber.org; INTAN-Invest (2012), www.intan-invest.net; Piekkola (2011), www.innodrive.org; Jalava et al (2007), www.etla.fi; Delbecque and Bounfour (2012), www.chairedelimmateriel.u-psud.fr; Chun et al (2012), www.rieti.go.jp; van Rooijen-Horsten et al. (2008), www.cbs.nl; Edquist (2011), www.snee.org/; Corrado et al. (2009), www.conference-board.org/, accessed in February 2013.

Figure 4.1. Investment in R&D and OC: Comparing estimates from INNODRIVE, COINVEST and INTAN-Invest, 1995-2006



Note: INNODRIVE estimates are marked as "InnoDr" in the charts. COINVEST data are shown as "CoInv" and the harmonised estimates of INTAN-Invest are shown as INTAN.

Source: Based on COINVEST and INNODRIVE (www.innodrive.org) databases, October 2011, and the INTAN-Invest database (www.intan-invest.net), accessed in July 2012.

In Europe, two projects financed by the European Commission, INNODRIVE and COINVEST, have been particularly important.[4] Under the INTAN-Invest umbrella, the results of these two projects, along with those of the Conference Board for the United States, have led to the publication of harmonised macroeconomic estimates, covering the 27 European Union (EU) countries, Norway and the United States.[5] Canada and Australia have also built on previous initiatives and recently published KBC-related figures. Finally, remarkable efforts at measurement have been made in Japan[6] and are currently under way in Korea.

Efforts at international harmonisation have proven relatively straightforward for assets such as software and R&D for which measurement guidelines exist,[7] but have proven more difficult for other assets, especially those in the economic competencies category. For example, estimates for investments in training had to be revised to include apprenticeships, which had previously been omitted (see Corrado et al., 2012, for a detailed discussion of the methodology).

Figure 4.1 illustrates the sensitivity of estimates to the use of different data sources or approaches in the same CHS framework. It compares the initial INNODRIVE and COINVEST estimates of investment in R&D and OC for France, Germany and the United Kingdom with the corresponding figures in the more recent INTAN-Invest database. The R&D series appear almost identical, whereas there are differences in the OC-related series, not only in the level of investment but also, and more importantly, in the path of investment over time. Such differences lead to a different interpretation of the importance of the various assets for productivity growth and call for more accurate definition and measurement of assets for which no general guidelines exist.

Measuring KBC at the industry and firm levels

Discovering the role of knowledge-based assets in economic performance and growth requires understanding the investment decisions of individual firms and the way different industries behave. Firm- and sectoral-level data might directly inform the design of industrial policy: they help identify the most suitable policy tools and the contexts in which these are likely to be effective. Sectoral-level data might help show, for example, whether and how employment protection legislation (EPL) and the degree of competition shape the ability of firms to make the best use of investments in KBC. Firm-level data may also be used to identify the profile of firms, young or old, small or large, that are most affected by such framework conditions.

Various initiatives have followed the CHS framework to estimate KBC investment series at the sectoral level. Country-specific sectoral-level investment series have been calculated for the following economies: Australia (Barnes, 2010); France[8] (Delbecque and Bounfour, 2012; Delbecque et al., 2012); Germany (Crass et al., 2010); Japan (Chun et al., 2012); Korea (Chun et al., 2012); the Netherlands (van Rooijen-Horsten et al., 2008); Sweden (Edquist, 2011); and the United Kingdom (Gil and Haskel, 2008; Haskel et al., 2011). In addition, O'Mahony et al. (2012)[9] estimate and compare investment in KBC for 11 sectors in 14 EU countries. They find that in most countries, manufacturing industries account for the largest share of KBC investment[10] and have benefited the most in terms of KBC-induced labour productivity growth. This is in line with the results of Chun et al. (2012) for Japan and Korea, who suggest that the significant and positive effect of KBC investments on total factor productivity (TFP) growth at the economy-wide level has been driven by the manufacturing sector. They further argue that the productivity gap between manufacturing and services, observed in Japan in the early 2000s, was likely due to slow

growth in investment in knowledge-based assets and their possibly ineffective utilisation in the services sector. Table 4.2 lists the countries for which sectoral estimates exist and the relevant sources, as well as the time period covered by the estimates.

Two main approaches have been pursued to collect KBC investment data at the firm level. On the one hand, efforts have been made to improve the disclosure of KBC investments in firms' corporate reporting, i.e. in periodic performance- and finance-related communications to stakeholders. However, these initiatives remain voluntary and have not been systematically implemented. On the other hand, a few initiatives have aimed at collecting KBC investment data through surveys. The first of such surveys, the UK Intangible Assets survey, was carried out by Awano et al. (2010) in 2009, 2010 and 2011. It covers all asset types in the CHS framework and asks firms to provide information about spending on both own-account assets (assets produced in-house) and purchased assets, as well as service lives. Building on this pioneering work, a similar pilot survey was performed in Italy in 2010 as a joint initiative by ISFOL, the Italian Institute for the Development of Vocational Training, and ISTAT, the Italian National Statistics Office. A full survey is to be carried out in 2013.[11] In other countries, attempts have been made to include questions on KBC investments in regular innovation surveys. Finally, in Australia, methodological work has been undertaken to obtain firm-level financial measures of KBC by mapping business accounting records to measures of innovation following definitions of the Frascati and Oslo (OECD, 2002, 2005; manuals Talbot et al., 2012).

Table 4.2. Investment in KBC at the sectoral level – available estimates

Country	Reference	Coverage
Australia	Barnes (2010)	1993-2006
Austria	O'Mahony et al. (2012)	1995-2007
Belgium	O'Mahony et al. (2012)	1995-2007
Czech Republic	O'Mahony et al. (2012)	1995-2007
Denmark	O'Mahony et al. (2012)	1995-2007
Finland	O'Mahony et al. (2012)	1995-2007
France	O'Mahony et al. (2012)	1995-2007
	Delbecque and Bounfour (2012)	1980-2008
Germany	O'Mahony et al. (2012)	1995-2007
	Crass et al. (2010)	1995-2006
Hungary	O'Mahony et al. (2012)	1995-2007
Ireland	O'Mahony et al. (2012))	1995-2007
Italy	O'Mahony et al. (2012)	1995-2007
Japan	Chun et al. (2012)	1980-2008
Korea	Chun et al. (2012)	1980-2008
Netherlands	O'Mahony et al. (2012)	1995-2007
	Van Rooijen-Horsten et al. (2008)	2001-2004
Spain	O'Mahony et al. (2012)	1995-2007
Sweden	O'Mahony et al. (2012)	1995-2007
	Edquist (2011)	1995-2006
United Kingdom	O'Mahony et al. (2012)	1995-2007
	Haskel et al. (2011)	1997-2007
	Gil and Haskel (2008)	1997-2004

Source: Based on national studies, see References for full URLs. Barnes (2010), www.pc.gov.au; O'Mahony et al. (2012), http://indicser.com; Delbecque and Bounfour (2012), www.chairedelimmateriel.u-psud.fr; Crass et al. (2010), www.coinvest.org.uk; Chun et al (2012), www.rieti.go.jp; van Rooijen-Horsten et al. (2008), www.cbs.nl; Edquist (2011), www.snee.org; Haskel et al. (2011), www.nesta.org.uk, accessed in February 2013.

Potential scaling up of firm-level surveys will require co-ordination on the design of questionnaires and the harmonisation of definitions. The OECD has been operating as a clearinghouse for proposals and pilot experiences on questions about a wider range of expenditures on knowledge-based assets and is working towards the development of international measurement guidelines in this area.[12] The OECD has also been collaborating with Eurostat's Community Innovation Survey Task Force to identify the potential for convergence of measures of innovation expenditures and of KBC-related expenditures. An initial round of tests aimed at assessing how survey respondents understand the questions has provided satisfactory results, and further work is planned. As work at the sectoral and firm levels would greatly benefit from the harmonisation of methodologies and estimates, the OECD has been actively engaged in fostering co-operation with a view to enhancing international comparability.

Developing guidelines for hard-to-measure assets

Many assets included in the CHS framework have not been a focus of definitional and measurement work, and no official methodological approach or agreed guidelines exist in relation to their measurement. These types of KBC – in particular some assets in the categories of economic competencies and innovative property – are not included in official statistics such as national accounts, and researchers have been devising methods to estimate such investments using other data sources. By contrast, R&D has received much attention in recent decades and measurement has progressed steadily. However, while a number of official data collections for this asset now exist, they take different measurement approaches and result in figures that are diverse in terms of the elements of the asset captured and hence in the amount of R&D investment measured. In particular, the R&D figures that statistical offices collect following the guidelines and definitions set out in the OECD *Frascati Manual* (2002) differ from the official R&D investment figures currently provided in so-called "satellite" national accounts.

The OECD has tried to address some of the problems arising from the absence of asset-specific measurement guidelines and to bridge methodological differences when existing estimates vary. In both cases, it has focused on R&D and organisational capital, two assets widely recognised as central to firms' innovation activities and broader performance. For R&D, the work has sought to measure R&D as an input into innovation and to assess the output of R&D activities in terms of patenting and the quality of inventions protected through Intellectual Property Rights (IPR). For organisational capital, the OECD has proposed a new approach to measuring investment in this type of human capital-related asset. It relies on information about the tasks employees accomplish in their job and the extent to which they contribute to the long-term organisation and functioning of the firm.

In addition, in the category of innovative property, the OECD and other institutions have tried to better understand the role of design. Their efforts should lead to the publication of international guidelines for the definition and measurement of this asset. In the category of economic competencies, the INDICSER project has proposed estimates of investment in firm-specific training at the industry level for a number of EU countries. Under the INTAN-Invest umbrella, estimates of training-related spending that include apprenticeship expenditures have been proposed.

Investing in innovative property: Measuring R&D expenditures

In 2008, the System of National Accounts agreed that from 2013 R&D expenditures would no longer be treated as current expenditures but as investments that accumulate over time. Efforts have been made to bridge these new R&D investment estimates with existing

survey-based figures (collected over a number of decades on the basis of the OECD *Frascati Manual* guidelines). The need for reconciliation is due to the fact that under the *Frascati Manual* guidelines, R&D expenditures are recorded according to the performer and the funder of the R&D activity, whereas the SNA estimates record the producers and owners of the R&D assets. To give one example, publicly funded R&D activities carried out by private firms represent a case in which assigning ownership may be non-trivial. The United States and Australia, for instance, have for some time maintained satellite accounts for R&D to complement official national income and production accounts. Australia has now incorporated R&D in its accounts and the inclusion of R&D as a capital asset has raised Australian gross domestic product (GDP) by between 1% and 1.25% in recent years.

Box 4.2 highlights some of the main conceptual differences between the R&D figures based on the *Frascati Manual* and on the SNA and shows how SNA investments may be derived from *Frascati Manual*-based expenditures. It summarises the OECD's recent work to help identify the possible sources of cross-country variation and to facilitate international harmonisation.

Box 4.2. Bridging *Frascati Manual* (FM) and System of National Accounts (SNA) R&D figures

The *OECD Handbook on Deriving Capital Measures of Intellectual Property Products* (2010) provides guidelines on how to bridge FM-based R&D expenditure figures with SNA R&D investment series. The Handbook also highlights some of the main challenges. In particular, moving from FM to SNA-consistent numbers requires addressing the following issues:

- Mapping FM-based R&D expenditures related to performers and funders to SNA measures of R&D output reflecting ownership. This is necessary as the FM is not always clear about whether the funder is also the ultimate owner of the asset produced. Assumptions have to be made, for instance, when allocating the R&D performed or funded by the higher education sector to one of the SNA sectors, which include corporations, non-financial corporations, government and non-profit institutions serving households.
- Determining which R&D expenditures qualify as R&D gross fixed capital formation (GFCF), to avoid double counting. Most countries – with the exception of the United States – include all capital costs in FM-based R&D expenditure figures. However, the SNA definition of R&D output and R&D GFCF requires the sole inclusion of capital services provided by non-R&D capital. An example is the adjustment needed for expenditures on software used to produce R&D, as these expenditures may have already been capitalised under a separate category.
- Accounting for exports and imports of R&D in GFCF estimates. This requires additional information about the industrial and institutional sectors involved, and can usually be obtained from supply-use tables detailing the flow of goods and services between producing and using sectors.
- Constructing R&D capital stock series, i.e. capitalising the R&D investment series obtained following the steps above. This has to be done for both market and non-market producers of R&D. A key challenge is to disentangle changes in quantities (i.e. volumes) from changes in prices (due for instance to inflation). This is challenging for many knowledge-based assets, partly because products may be unique and partly because prices are often not observed. In the absence of such data, price indexes have traditionally been estimated using input-cost price indexes and adjusted for labour productivity.
- Obtaining sector-specific figures further requires paying attention to the unit of analysis on which the initial numbers rely. FM-based figures are typically reported at the enterprise level, while SNA estimates are often based on establishment-level data, which may lead to an incorrect attribution to particular industries.

Valuing innovative property output: The economic and technological value of patents

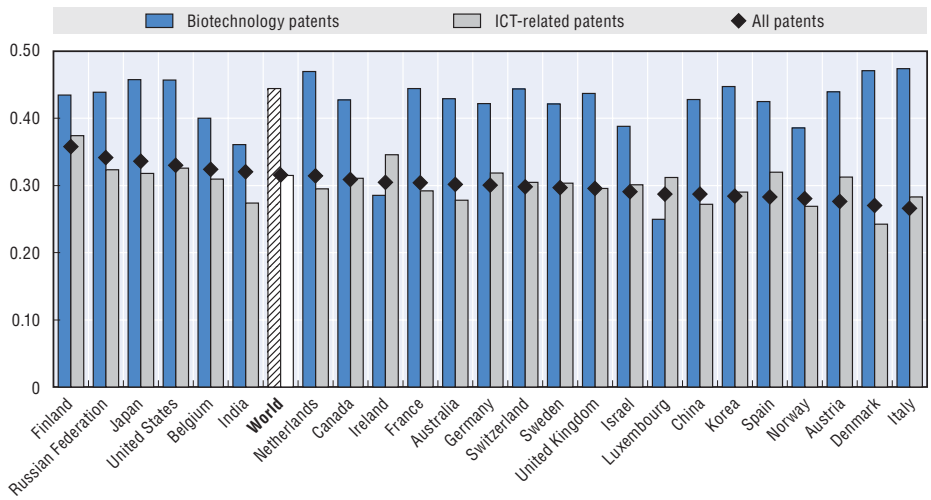
An often-cited caveat to the input-based approach to measuring knowledge-based assets is that it gives little indication of the value of the resulting assets produced. Some light has been shed on this issue through the analysis of R&D outputs, such as patents. The work is based on evidence that patents are highly correlated with R&D expenditures,

and that changes in R&D expenditures are typically paralleled by changes in patenting behaviour (Griliches, 1998). Moreover, R&D appears to be contemporaneous to patenting and possible lag effects are small and not well estimated (Hall et al., 1986).

However, measuring R&D output on the basis of simple patent counts does not suffice, as patents differ substantially in their economic and technological value. Only a small number are very valuable, and most bring little value to their owners. Recent work by the OECD's Working Party on Industry Analysis has aimed to address this issue through better definition and measurement of "patent quality", i.e. the technological and economic value of patented inventions (for instance in terms of their potential impact on subsequent innovations). Information contained in patent documents has been used to construct indicators that rely extensively on recent literature and on earlier OECD work. Such measures can be constructed for all patents and have the advantage of relying on a homogeneous set of information. This makes them generally comparable across countries and over time, and therefore suitable for cross-country analysis.

Among the many indicators of quality proposed are patent family size, patent generality and whether the patent represents a breakthrough invention. In the case of patent families, the value of an invention is held to be associated with the geographical scope of patent protection, that is, with the number of patent offices at which it is protected, as this gives an indication of the markets it targets. Patent generality instead refers to the range of later inventions that benefit from a patent, i.e. the range of technology fields and consequently industries that cite that patent. Finally, breakthrough inventions are defined as high-impact innovations that serve as a basis for future technological developments. Breakthrough inventions are strongly associated with entrepreneurial strategies and with further technological development.

Figure 4.2. Generality of patents: Average index, by country of applicant, patents filed at the European Patent Office, 2000-04



Note: Only OECD and BRIICS countries (Brazil, Russian Federation, India, Indonesia, People's Republic of China, South Africa) with at least 200 patent applications filed in 2000-04 are reported.
Source: OECD, Patent Statistics (database), DOI: http://dx.doi.org/10.1787/patent-data-en, accessed in February 2013.

Figure 4.2 shows the country-specific level of patent generality. Biotechnology patents typically have a relatively higher generality than patents in ICT and in other fields. This may be due to the fact that biotechnology inventions tend to spur developments in a wide array of areas.

Research undertaken at the Catholic University of Leuven (KUL) and at the Ecole des Hautes Etudes Commerciales (HEC) in Paris has drawn on information in patent applications to identify radical patents. The tools developed use citation relationships between patents to identify inventions that differ substantially from existing technologies and that heavily influence subsequent innovation patterns.

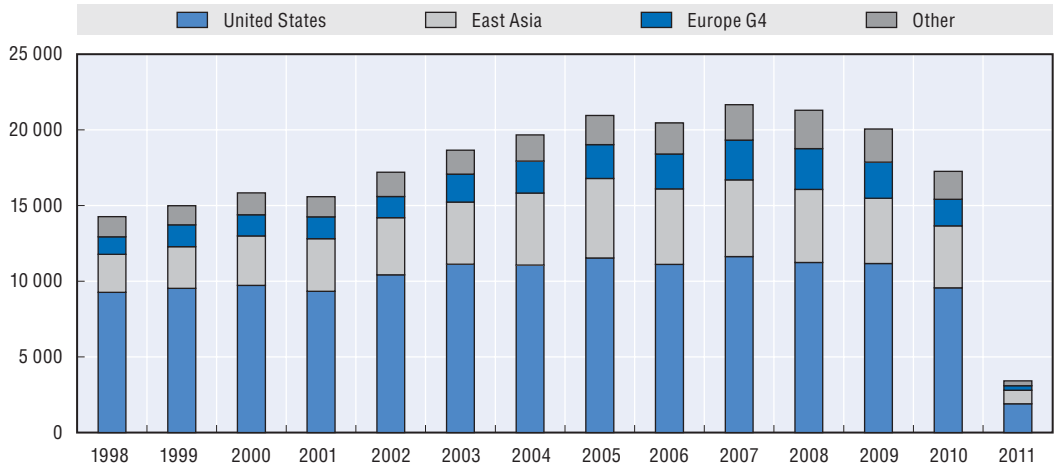
The OECD's work on patent quality seeks to develop harmonised metrics able to capture the economic value of R&D output and go beyond simple patent counts. The ultimate aim is to construct measures that capture the long-term value of the innovative property of firms and to inform policy making in areas such as taxation, innovation support policies and the worldwide mobility of key knowledge-based assets.

Defining and measuring design to capture creativity

Design is perceived as an important driver of business competitiveness. The need to define and measure design accurately has recently attracted considerable policy attention, given that no existing metrics reflect the broad range of activities and outputs associated with design. Design-related assets may be created through R&D and technology-based forms of innovation as well as non-technological, creative and experience-focused activities, and may be appropriated in different ways, including via several types of IPR protection. For example, design patents granted by the United States Patent and Trademark Office (USPTO) aim to protect the distinctive look of a product and to avoid confusion with a similar-looking product. The recent conflict between Apple and Samsung has showcased the importance of design assets. Damages were awarded to Apple for the violation of its utility and design patents; for the design patents alone for three products the damages amounted to USD 154.6 million.[13]

Figure 4.3 illustrates the growing importance of design patents in the United States from 1998 to 2011 (figures for the most recent years may be incomplete owing to delays in disclosure of administrative data). The figure also shows the increasing share of design patents belonging to non-resident applicants, especially East Asian countries.

Figure 4.3. Number of USPTO design patents granted, by application year and origin of applicant, 1998-2011



Note: East Asia includes Japan, Korea, China (mainland and Hong Kong) and Chinese Taipei. Europe G4 includes France, Germany, Italy and the United Kingdom.

Source: OECD compilation based on USPTO data, online USPTO Design Patent Report, www.uspto.gov/web/offices/ac/ido/oeip/taf/design.htm, accessed in February 2013.

The definition and measurement of design has recently been the object of significant research, especially in the United Kingdom. Following the encouraging results of a design-focused survey conducted in 2008 by the UK Art and Humanities Research Council and the Engineering and Physical Sciences Research Council, the design component of the UK Innovation Survey was greatly improved. The survey now better captures the somewhat ambiguous position of design as an asset between R&D and marketing. Experimental expenditure figures for the United Kingdom suggest that design spending amounts to GBP 1.7 billion, around 5% of total innovation expenditures. This is similar to the sum spent for the acquisition of external knowledge. It gives an indication of the importance of design activities, and highlights the need for better understanding creativity and how it can be harnessed.

The OECD has recently investigated the possibility of producing guidelines for the measurement of investment in design. Based on experience in asking questions about design in innovation surveys, *ad hoc* intangibles surveys and other sources, the project aims to co-ordinate the formulation and testing of a set of concepts and questions targeted at incorporating design in existing measurement frameworks for R&D and innovation.[14] The "Value creation by design" project led by the Barcelona Design Centre has also recently committed to producing guidelines for the compilation of design-related data by 2014.

Firms' economic competencies and the importance of organisational capital

Organisational capital is one of the assets in the category of economic competencies that has proven hardest to measure. While its importance is widely acknowledged – especially as an enabling asset that complements other innovation-related investments – there is no consensus regarding its definition and measurement. Some initiatives have taken a managerial perspective and have proposed to approach OC as a set of work practices, such as decentralisation of decisions or autonomous performance of tasks on the job. Others have tried to use information on investment in a specific type of human capital, managerial occupations, to estimate the organisational capability of firms.

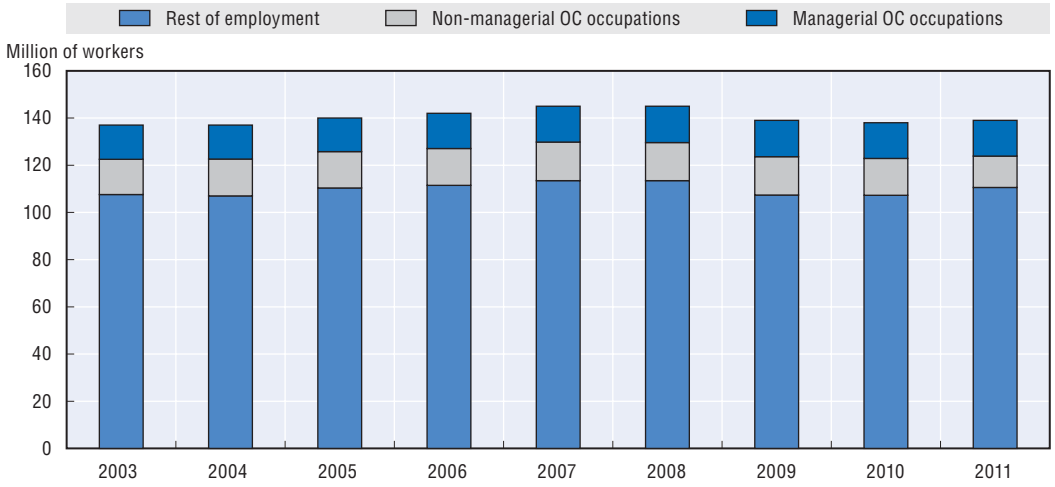
This is the approach followed by the OECD, which focuses on improving the methodology based on labour costs of the CHS framework by identifying the full spectrum of human capital involved in the generation and accumulation of firms' organisational capital. The CHS approach assumes that organisational capital is solely the result of managerial activities, and considers 20% of managers' wages to represent investment in organisational capital. The OECD work relies on recent studies suggesting that organisational capital is created by and embedded in several categories of employees, including but not limited to, managers. It can be defined in terms of the tasks that contribute to the long-term functioning of the firm and are performed by employees, irrespective of their occupational title. These tasks relate to: developing objectives and strategies; organising, planning and prioritising work; building teams, matching employees to tasks and providing training; supervising and co-ordinating activities; and communicating across and within groups.

The experimental approach proposed by the OECD relies on data from the Occupational Information Network (O*NET) of the United States Department of Labor. It identifies OC-relevant occupations based on the tasks performed by employees on the job. Results confirm that managerial activity is an important part of organisational capital, but also underline the necessity to broaden the array of occupations considered OC-relevant. Among these are business support staff, scientists and engineers, health and

education occupations, which do not have a "manager" component in their definition but help to ensure the long-term functioning of firms (see Squicciarini and Le Mouel, 2012). On this basis, investment in OC over time at both the macroeconomic and sectoral levels has been calculated using employment and earnings data from the Current Population Survey of the United States' Bureau of Labor Statistics.

Figure 4.4 shows the overall employment in the United States during 2003-11 and the number of OC-related persons employed in both managerial and non-managerial occupations. The figures indicate that non-managers who contribute to OC outnumber managers. However, in monetary terms, managers contribute more than non-managers, as shown in Figure 4.5. These patterns may reflect salary differences in the different occupations as well as the number of workers in each occupational category.

Figure 4.4. Managerial OC employment, non-managerial OC employment, and other employment in the United States, 2003-2011

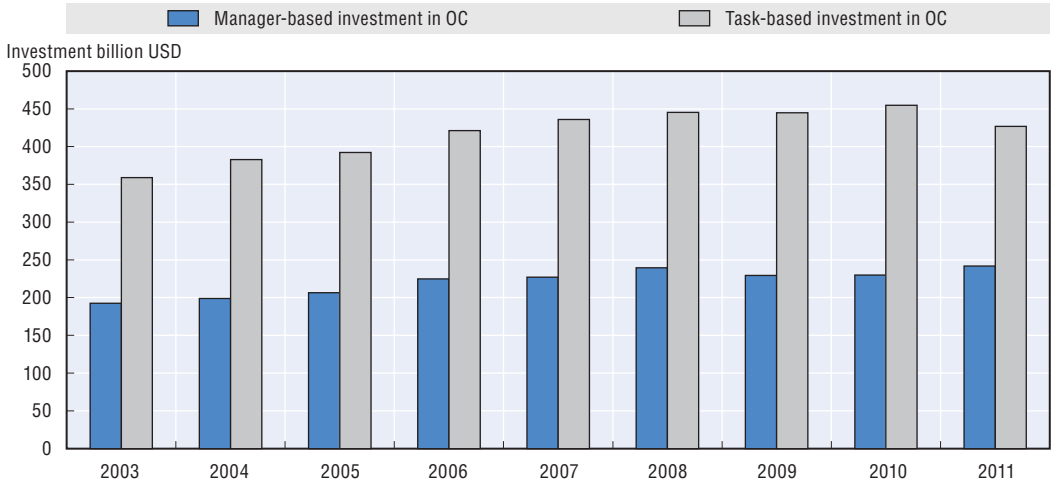


Source: OECD calculations based on employee and earnings data from the Annual Social and Economic (ASEC) supplement of the Current Population Survey (CPS), US Bureau of Labor Statistics, 2003-11, www.bls.gov/cps/ , accessed in February 2013.

Figure 4.5 compares the size of measured investment in organisational capital based on managers only with estimates based on the experimental task-based methodology proposed by the OECD. It clearly indicates that overlooking non-managerial occupations omits about half of the overall investment in organisational capital. At the aggregate level, overall investment in OC appears to have increased steadily over the whole period 2003 to 2011, with a slowdown in 2009 and a fall in investment in 2011.

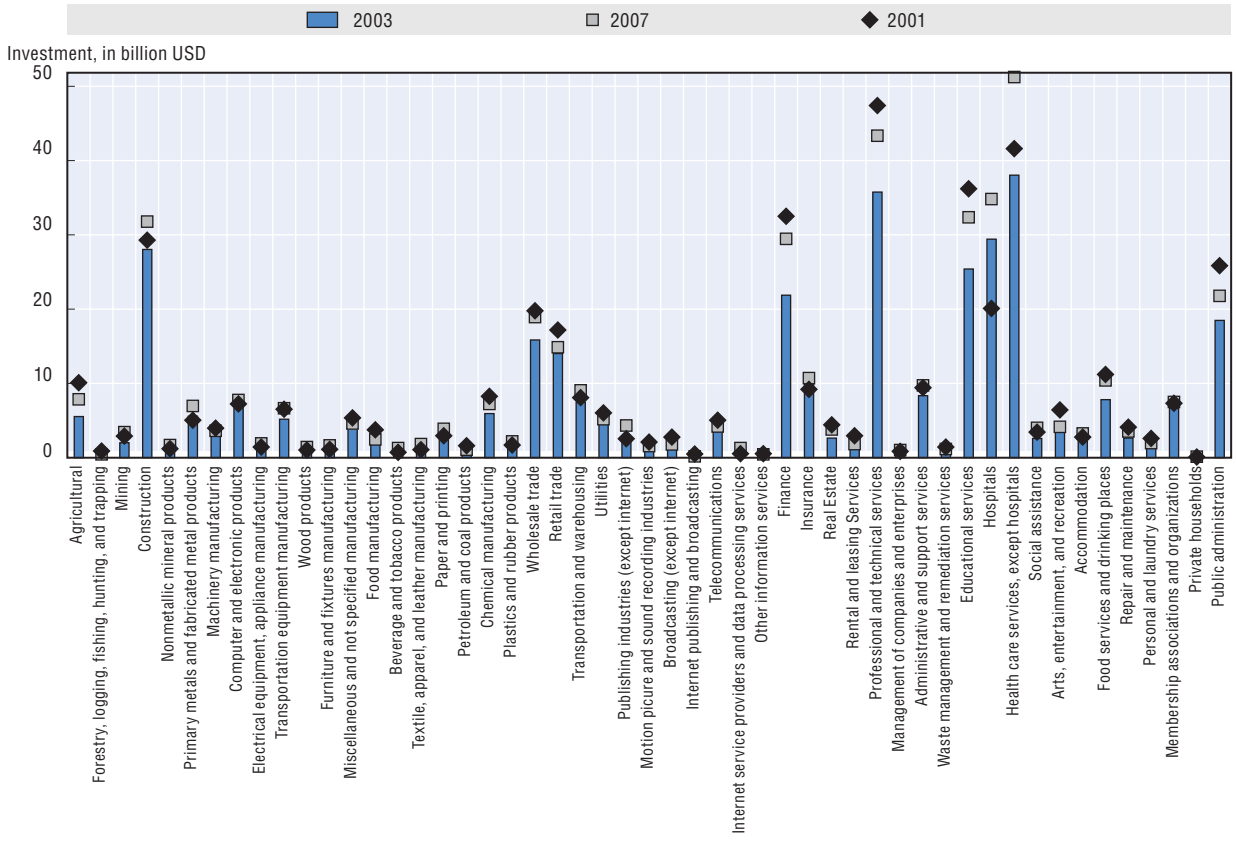
At the sectoral level, large differences emerge, with services – especially health, professional and technical services, educational services and finance – clearly large investors in organisational capital. Differences also appear in the sectoral responses to the crisis, as shown in Figure 4.6, which compares investment in OC in 2003, 2007 and 2011. On the one hand, forestry, food manufacturing, petroleum and coal product manufacturing, broadcasting services, rental and leasing services and arts and entertainment services saw increases in investment in OC of over 40% between 2007 and 2011. On the other hand, textile manufacturing, beverages and tobacco manufacturing, publishing, internet services and data processing services and hospitals saw a more than 40% drop in investment in OC over the same period.

Figure 4.5. Investment in organisational capital, United States, 2003-11



Source: OECD calculations based on the earnings data by occupation and industry from the Annual Social and Economic (ASEC) Supplement of the Current Population Survey (CPS), US Bureau of Labor Statistics, 2003-11, www.bls.gov/cps/ , accessed in February 2013.

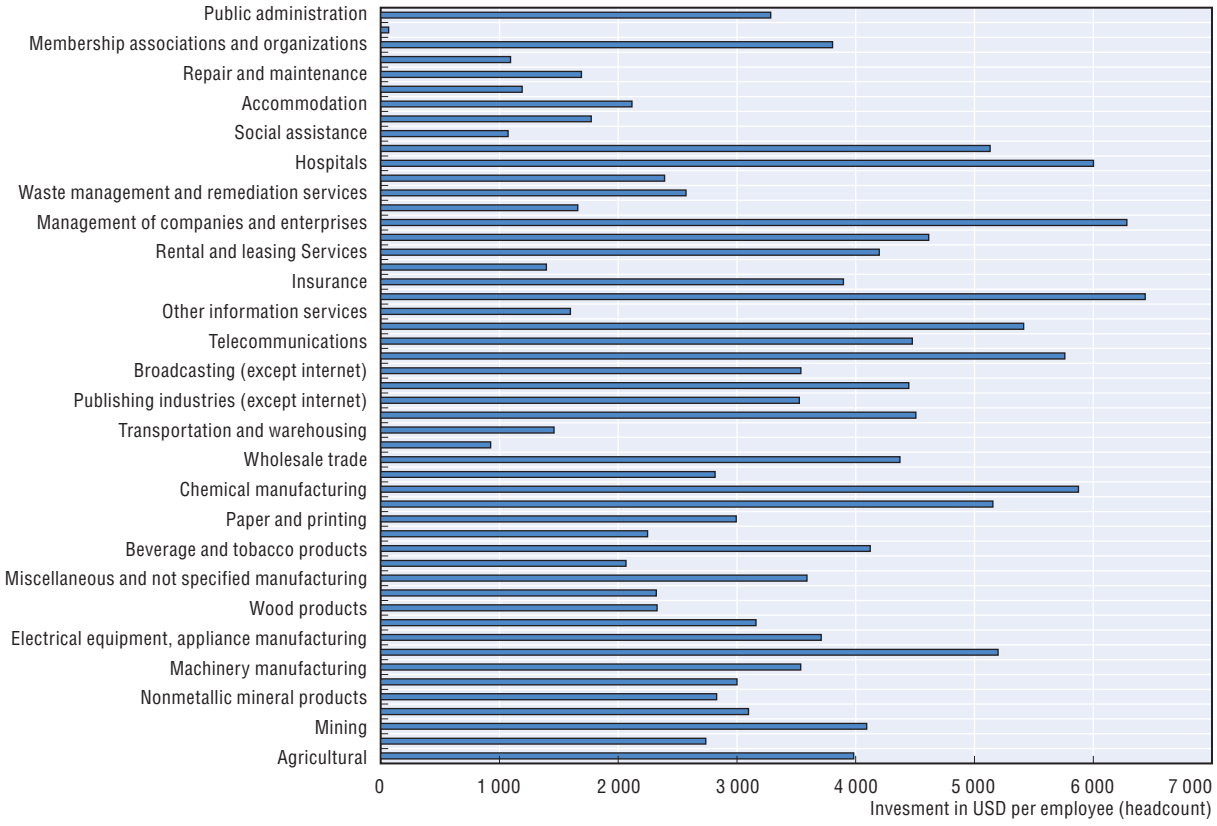
Figure 4.6. Investment in organisational capital at the sectoral level, United States, 2003, 2007 and 2011



Source: OECD calculations based on the earnings data by occupation and industry from the Annual Social and Economic (ASEC) Supplement of the Current Population Survey (CPS), US Bureau of Labor Statistics, 2003-11, www.bls.gov/cps/ , accessed in February 2013.

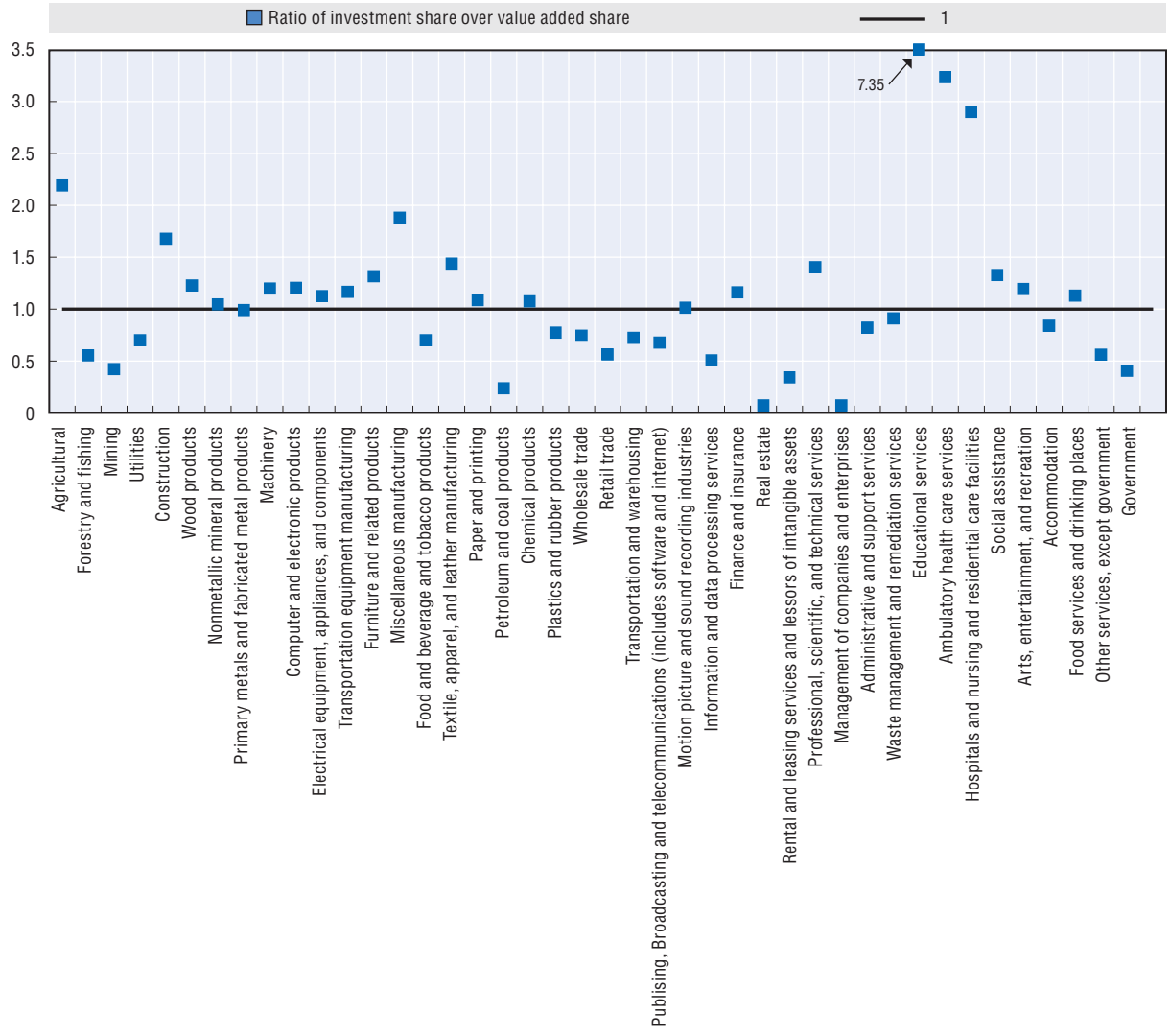
Figure 4.7 shows investment in organisational capital per person employed at the industry level in the United States. Figure 4.8 depicts the ratio of each sector's share of total investment in OC over the sector's share of value added, or its investment intensity in OC. On a per-person basis, the sectors that invest most heavily in OC appear to be finance, hospitals, chemical products manufacturing, Internet publishing, petrol and coal products manufacturing, and computer and electronic products manufacturing. In terms of OC investment intensity, most manufacturing industries invest more in OC than would be expected on the basis of their share of value added. Conversely, most services sectors – with the notable exception of the education and health sectors – invest proportionally less than their share in value added. These estimates align relatively well with the industry-level figures proposed in studies of France, Japan and Korea, where manufacturing industries appear to be more intensive investors in KBC than services.

Figure 4.7. Organisational capital investment per person employed (headcounts), United States, yearly average by industry, 2003-11



Source: OECD calculations based on the earnings data by occupation and industry from the Annual Social and Economic (ASEC) Supplement of the Current Population Survey (CPS), US Bureau of Labor Statistics, 2003-2011, www.bls.gov/cps /, accessed in February 2013.

Figure 4.8. Sectoral OC investment compared to value added, United States, yearly average, 2003-11



Note: The squares represent the ratio of the industry's share of investment in OC to the industry's share in value added. Industries with a ratio above one (line) invest relatively more in OC than their share in value added would imply.

Source: OECD calculations based on the earnings data by occupation and industry from the Annual Social and Economic (ASEC) Supplement of the Current Population Survey (CPS), US Bureau of Labor Statistics, 2003-11, www.bls.gov/cps/ , accessed in February 2013, and GDP-by-Industry data from the US Bureau of Economic Analysis, www.bea.gov/industry/index.htm#annual, accessed in February 2013.

The OC-related experimental methodology proposed by OECD has so far only been applied to US data. Extended to other countries, it would help to shed light on the role of human capital, in particular skilled employees, in the organisation and long-term functioning of firms, as well as their performance. This would facilitate the design of policies to improve industry performance based on human capital. It is also important to understand the role played by training in (re)skilling human resources and in optimising the long-term organisational capacity of firms and their productivity. Efforts have recently been made to measure investment in training more carefully, and to include apprenticeships, to account for the characteristics of employees that benefit from training (see O'Mahony, 2012), and more generally, to assess how training relates to aggregate economic performance.

Refining capitalisation parameters

Fully appreciating the role of KBC for economic growth requires learning about the share of investment that remains in production from one year to the next and is capitalised and about the length of time during which specific KBC continues to be economically useful. Moreover, comparing investments across countries and over time requires translating monetary values into real values and accounting for changes in prices that may have occurred. Many hypotheses about depreciation rates and price indices are being developed and tested worldwide, and recent OECD work has contributed by estimating the depreciation of organisational capital and R&D at the industry level.

The depreciation of organisational capital

The CHS framework considers that the accumulation of organisational capital over time is shaped by two complementary dynamics. On the one hand, as a result of learning by doing, organisational capital is codified in the structure of firms and depreciates in a fashion similar to R&D capital. On the other hand, organisational "forgetting" may lead to rapid OC depreciation, similar to what happens for advertising activities. This leads to a depreciation rate for organisational capital of 40% a year. However, recent survey-based estimates for the United Kingdom (Awano et al., 2010) and preliminary results from the Italian ISTAT-Isfol Survey (Perani and Guerrazzi, 2012) suggest that the average life of business process improvements is much longer than that implied by Corrado et al. (2009). According to these survey results, the average estimated life of business-related firm-specific resources, including organisational capital, is between 4 and 5.4 years. This would mean linear depreciation rates of 18% to 25%.

Building on these findings, exploratory work by the OECD proposes to calculate industry-specific depreciation rates for organisational capital based on labour mobility and job tenure data. The former reflects the extent to which workers move between jobs, occupations and geographical areas, whereas the latter refer to the time employees spend in a particular office or position. Many studies suggest that labour mobility, and in particular job separations in the form of voluntary departures, may have a disruptive effect on the accumulation of human capital, including organisational capital. Job tenure and employee turnover data for 2004-10 from the US Bureau of Labor Statistics were used to calculate industry-specific depreciation rates for OC in the United States (see Squicciarini and Le Mouel [2012], for details).

Table 4.3 presents the estimated life and associated linear depreciation rates for OC for different industries. These range between 10% and 20% and suggest that OC generally depreciates more slowly than previously assumed. In addition, OC seems to depreciate more slowly in manufacturing than in services. Exceptions to the 10-20% range are found in the agriculture and utilities industries, with linear depreciation rates of 5% and 7%, respectively, and in the arts and entertainment, food services and drinking places, motion picture and sound recording industries, and rental and leasing services, which show above 20% linear depreciation rates. The Internet publishing and broadcasting industry stands out with a particularly low median tenure of three years, and thus a linear depreciation rate of 33%. Taken together, these results appear significantly lower than those assumed by Corrado et al. (2009), but in line with those suggested by survey results, although somewhat lower in some cases.

Table 4.3. Estimated sectoral service lives and linear depreciation rates for organisational capital

Median tenure of OC occupations	Linear depreciation rate	Industry
11 - 20	5% - 9%	Agriculture; Forestry and logging; Utilities; Public administration
7- 10	10% - 15%	Manufacturing Machinery; Computer and electronic products; Chemicals; Electrical equipment and appliances; and ten other manufacturing industries Construction; Mining; Transportation and Warehousing; Wholesale trade Services Telecommunications; Insurance; and four other services industries
5 - 6	16% - 20%	Manufacturing Petroleum and coal products Services Finance; Retail trade; Professional and technical services; and ten other services industries
4	25%	Services Arts, entertainment and recreation; and three other services industries
3	33%	Internet publishing and broadcasting
2.5	40%	CHS assumption

Source: OECD calculations based on tenure data by occupation and industry from the January supplement of the Current Population Survey for the years 2004, 2006, 2008, 2010, Bureau of Labor Statistics, www.bls.gov/cps/lfcharacteristics.htm#tenure, accessed in July 2012.

The depreciation of R&D capital

Obtaining consistent industry-level depreciation rates for R&D investments is also a challenge. There is no agreement among the many studies that have calculated sector-specific depreciation rates for this knowledge-based asset. The figures proposed range between 12% and 29% for the overall business sector, and between -11% and 52% for industry-specific R&D depreciation rates (see Mead, 2007, for a survey). In most studies, however, the depreciation rate of R&D at the economy-wide level has been assumed to be 15% to 20% a year.

The wide variation in estimates, especially at the industry level, coupled with the importance of R&D as a knowledge-based asset, has motivated the OECD to investigate this question. It has taken what is technically called a "revealed preference approach", whereby the length of time for which R&D investment remains useful can be inferred by looking at the period of continued enforcement of the relevant IPR. The renewal of a patent can be interpreted as a signal that the R&D output described in the patent document is still useful for the firm, as no rational agent is willing to pay for an asset that is no longer needed. By the same token, the withdrawal of a granted patent can be considered an explicit signal that the R&D output contained in the patent document is no longer useful to the firm.

This idea has been the basis of patent renewal models, which use information on patent renewals to estimate the returns to R&D investment that firms can expect (e.g. Pakes and Schankerman, 1984). Such models rely on evidence showing that patents are highly correlated with R&D expenditures and that changes in R&D expenditures are typically paralleled by changes in patenting behaviour (Griliches, 1998).

R&D depreciation rates at the industry level are calculated using information on patent renewal data obtained from the European Patent Office (EPO) linked to commercial firm-level data. This is necessary to assign patents to industrial sectors, as patent documents do not provide such information. Sector-specific average and median patent lives are presented in Figures 4.9a and 4.9b, which show depreciation rates in the manufacturing and services sectors, respectively. The results indicate that patent lives vary widely and that in all sectors at least 1% of patents are renewed for the full 20-year period. The figures further suggest that average and median renewal figures differ across industries. Robustness tests to assess the sensitivity of depreciation rates to the inclusion or exclusion of big firms in the sample suggest that renewal behaviour is much more volatile when only small and medium enterprises (SMEs) are considered. Finally, the resulting average renewal period of 12.7 years for all sectors leads to a linear annual depreciation rate of around 8% rather than the 15% generally adopted in most studies and suggests that R&D depreciates at a much slower pace than previously thought.

Figure 4.9a. Duration of EPO patents granted in manufacturing industries, for applications filed in 1978-91

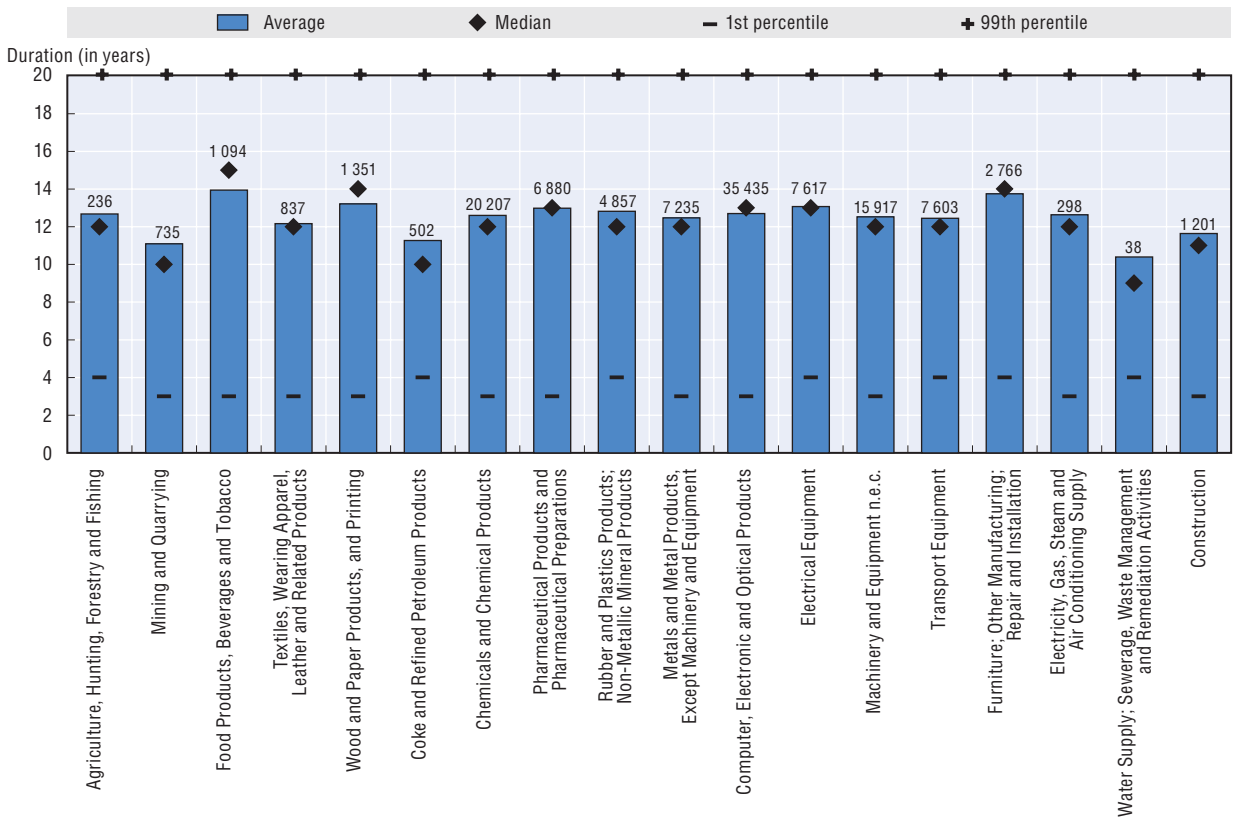
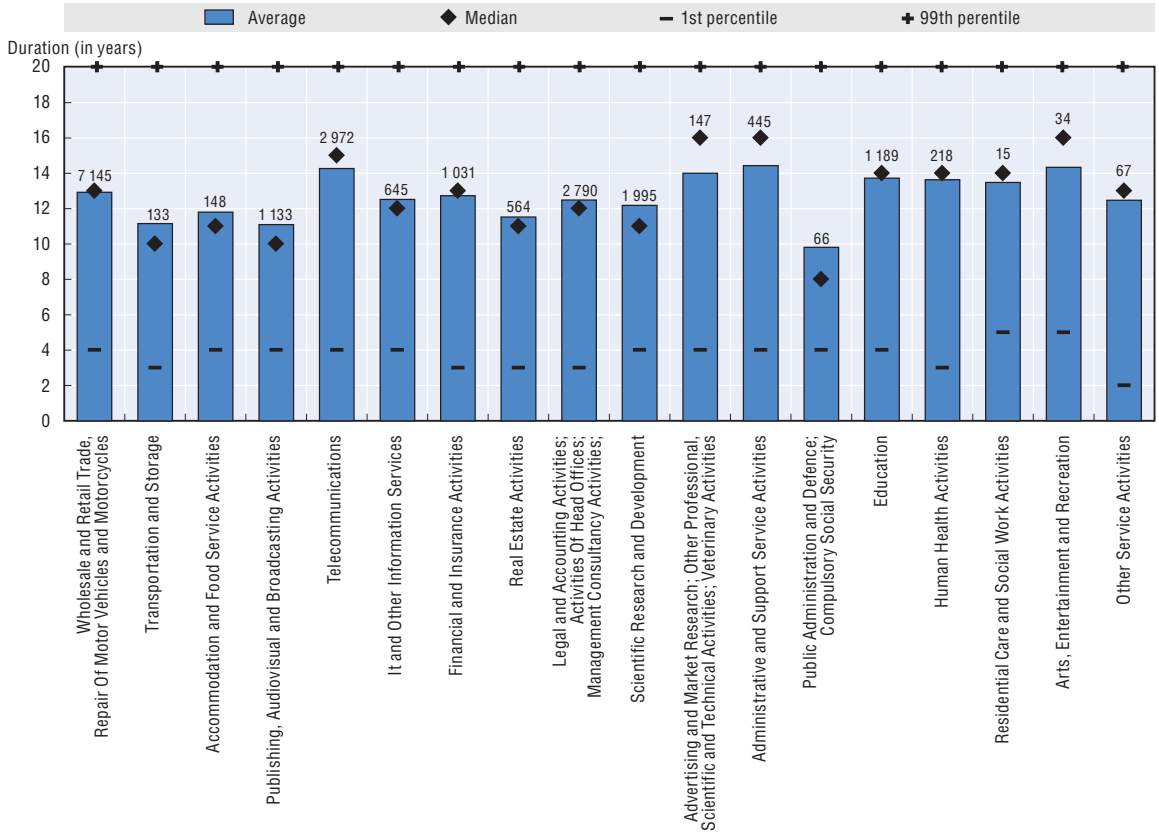


Figure 4.9b. Duration of EPO patent granted in services industries, for applications filed in 1978-91



Note: Number of patents considered by sector displayed on top of each bar. Sectors defined according to NACE Rev. 2. Calculations based on firms of 20 employees or more.

Source: OECD calculations based on the Worldwide Patent Statistical Database (PATSTAT) and Worldwide Legal Status Database (INPADOC), EPO, April 2012; and ORBIS© Database, Bureau van Dijk Electronic Publishing, June 2011; matched using algorithms in the Imalinker system developed for the OECD by IDENER, Seville, 2011.

Deflating investments in R&D

Building internationally comparable estimates of stocks and service flows of KBC requires adopting harmonised price deflators in order to capture and compare the true quantity of assets purchased. While quality-adjusted price indexes for computer hardware and software have been calculated for some time, this issue has only recently been raised for R&D, motivated by the SNA recommendation to capitalise R&D in national accounts. In a joint initiative of the Conference Board, members of the COINVEST project and researchers from UK National Endowment for Science, Technology and the Arts (NESTA), Corrado et al. (2011) developed a model for the production and use of knowledge. They argue that the price of R&D should be calculated, not from input prices as is currently done, but from final output prices, factor costs and TFP. This is necessary to reflect the presence of monopoly rents and productivity gains in the knowledge-producing sector. Empirical results for the United Kingdom suggest that the price of R&D has fallen from 1985 to 2005 and that R&D investment has been significantly underestimated.

Understanding the extent to which investment in KBC may have been over- or under-estimated will require calculating price deflators for all the assets concerned, including R&D. Making significant progress in this area will require a sustained effort over the medium to long term to address the important role played by prices in shaping investment dynamics.

Investments in knowledge-based assets are important and growing

Following a number of recent national and international initiatives, a picture that places knowledge-based assets at the centre of economic activity has begun to emerge. The resources devoted to investments in KBC appear to have increased steadily for some decades in all countries for which information is available and now correspond to a significant proportion of GDP, sometimes equalling or even surpassing the size of investments in physical capital. Evidence further suggests that investment in KBC has increased not only in absolute size but also in terms of annual growth rates.

The figures presented in this section were calculated following the CHS approach and would differ if other approaches, such as the OECD experimental methodology for measuring organisational capital, were used. They nevertheless represent a useful basis for comparing investments across countries and over time and appear to mirror structural differences that may exist.

In Australia, investment in KBC increased steadily between 1980 and 2000 to reach around 9% of adjusted value added,[15] and has since remained at around this level. The levelling off during the 2000s seems due to a decline in investment in software and in economic competencies starting in the late 1990s, which has not been compensated by equivalent increases in investments in innovative property.

In France, KBC investments more than doubled as a share of adjusted value added from 5% to 12% from 1980 to 2008, with a sharp acceleration between 1995 and 2000, driven by investments in software (Delbecque et al., 2012).

In Japan, KBC investment increased from 5.9% of adjusted value added in 1985 to 9.6% in 2008, with two periods of stagnating or declining investment, from 1992 to 1995 and from 2001 to 2006. The stagnation of KBC investment during the latter period seems to have been driven by the steady decline in investments in economic competencies during the 2000s, which Chun et al. (2012) argue is the result of deep restructuring following the financial crisis of 1997.

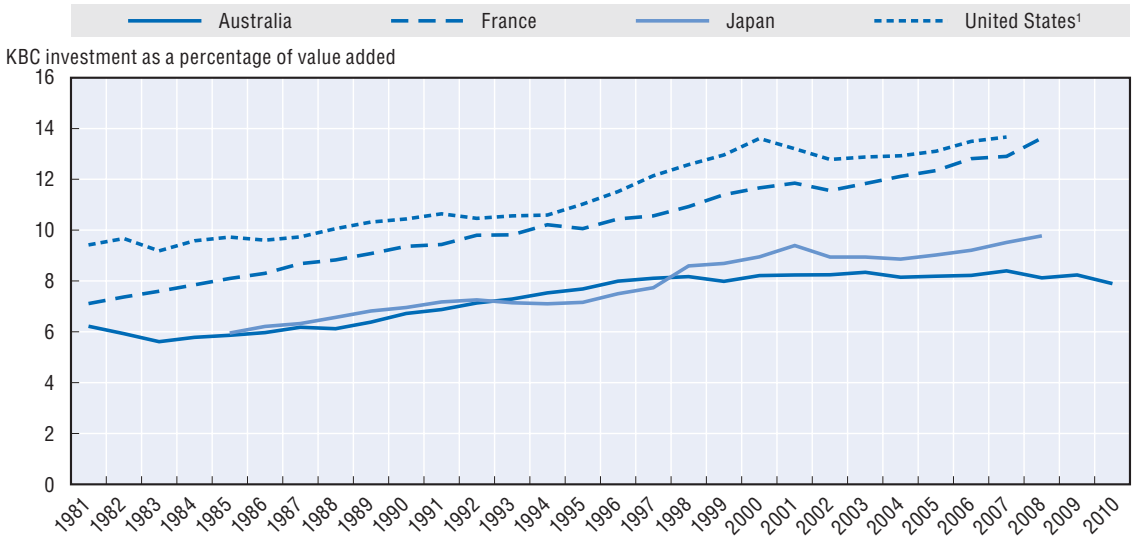
In the United States, investment in KBC has been increasing steadily since the 1950s and reached around 13.7% of adjusted value added by 2007. In the 1990s the rate of investment in KBC picked up significantly, led by investment in software, and surpassed investments in tangible capital (Corrado et al., 2009).

These long-term patterns are shown in Figure 4.10, which shows the evolution of total KBC investment as a share of adjusted value added for Australia, France, Japan and the United States for 1981-2010.

In Canada, a similar secular increase in investment in KBC has been reported and the share of investment in KBC reached 12% of adjusted value added in 2008. While investment in KBC rose faster than investment in tangible assets from 1974 to 2008, it did not surpass it and in 2008 stood at 66% of tangible investment (Baldwin et al., 2012).

In the United Kingdom, investment in KBC increased throughout the 1990s but declined slightly during the 2000s to 12% of adjusted value added. In contrast, tangible investment fell very sharply over this period and by 2009 investment in KBC was 34% higher than tangible investment (Goodridge et al., 2012). Figure 4.11 compares investment in tangibles and in KBC for 2010 for a number of OECD countries.

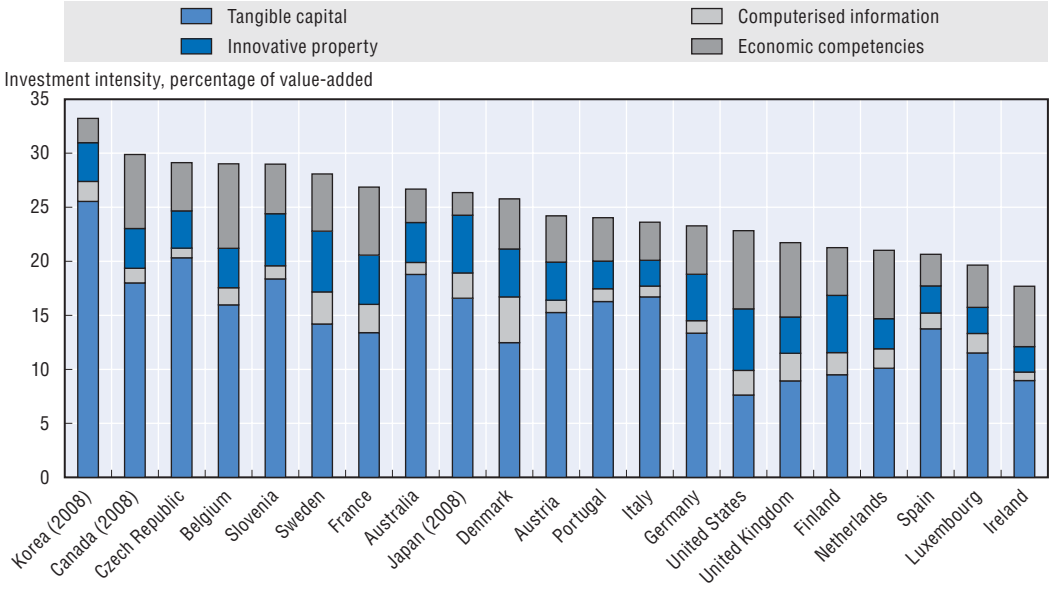
Figure 4.10. KBC investment as share of market-sector adjusted value added, 1981-2010



Note: Values for the United States refer to the non-farm market sector; for the other countries, agriculture is included.

Source: KBC investment data for Australia are from Australia (2012), for France from Delbecque et al. (2012), for Japan from the Japanese Industrial Productivity (JIP) Database, and for the United States from van Ark et al. (2009). Market-sector adjusted value added is based on OECD calculations from the Main Science and Technology Indicators (January 2013 release), Bureau of Economic Analysis (November 2012 release) and JIP Database.

Figure 4.11. Investment intensity in KBC and tangible capital, as percentage of adjusted value added, 2010



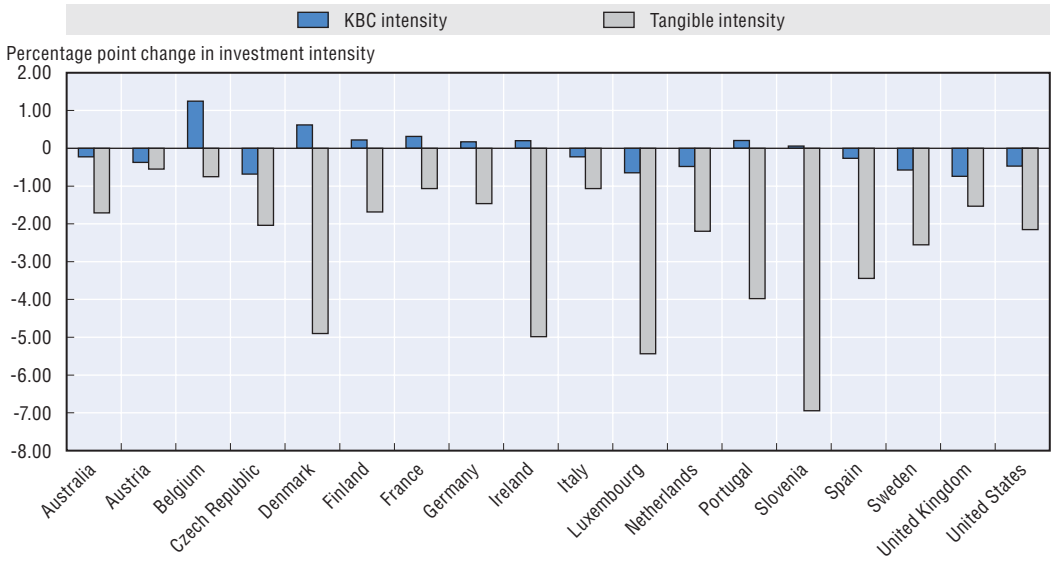
Note: Figures refer to the market economy, which excludes real estate, public administration, health and education, with the exception of Korea, where figures refer to the whole economy.

Source: Based on INTAN-Invest (www.intan-invest.net, KBC investment for EU27 and United States), OECD Main Science and Technology Indicators (www.stastats.oecd.org, Korea, Luxembourg and Portugal market-sector value added and Korea tangible investment), National Accounts from Eurostat (http://ec.europa.eu/eurostat, Austria, Denmark, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Spain and Sweden tangible investment), Australian Innovation System Report (2012, KBC investment), National Accounts from the Australian Bureau of Statistics (www.abs.gov.au, value added and tangible investment), the Japanese Industrial Productivity (JIP) Database (www.rieti.go.jp/en/database/JIP2011/, all data for Japan), Chun et al. (2012) (Korea KBC investment), and Baldwin et al. (2012, all data for Canada), accessed in June 2013.

A higher level of investment in KBC appears to be associated with better economic performance, both in the short run and over the long term. In particular, investment in knowledge-based assets seems to be positively related to labour productivity growth and to the level of GDP per capita. In addition, estimates suggest that, during the recent crisis, investment in KBC proved more resilient to the downturn in GDP than investment in physical capital. This is suggested in Figure 4.12, which shows the change in the intensity of business investment in both KBC and tangible capital during 2008-10.

Growth accounting analyses bring out the fact that the main source of growth has shifted from TFP to knowledge-capital deepening (the intensity of knowledge capital per worker). Moreover, investments in KBC have led to significant changes in the nature of work: more knowledge-intensive economies have labour markets very different from those of more traditional economies, in particular in terms of employment possibilities and earnings of different skill groups. Inequalities among workers have increased: both high-skilled and low-skilled employees have seen their earnings increase – although to a different extent – whereas medium-skilled employees carrying out routine tasks have not.

Figure 4.12. Change in business investment from 2008 to 2010, in percentage points



Source: Based on INTAN-Invest (www.intan-invest.net, KBC investment for EU27 and United States), OECD Main Science and Technology Indicators (www.stastats.oecd.org, Korea, Luxembourg and Portugal market-sector value added and Korea tangible investment), National Accounts from Eurostat (http://ec.europa.eu/eurostat, Austria, Denmark, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Spain and Sweden tangible investment), Australian Innovation System Report (2012, KBC investment), and National Accounts from the Australian Bureau of Statistics (www.abs.gov.au, value added and tangible investment), accessed in June 2013.

Most studies concerned with the measurement of knowledge-based capital and with the effect of KBC on productivity and economic growth remain at the level of correlations and are unable to show the extent and direction of causality. This has important consequences for policy making: it may be, for instance, that investment in KBC and productivity growth are determined by specific framework conditions.

Building on recent work to advance the KBC measurement agenda

Knowledge and knowledge-based capital are essential for competing in the economy of the 21st century, yet measuring these assets remains a challenge. Properly assessing the value of the knowledge that is created, used and transferred within and across economies has significant implications for a better understanding of the sources of employment, productivity and economic growth, and for the design of evidence-based policies.

In recent years, a number of initiatives worldwide have estimated investment in knowledge-based assets, mainly following a measurement framework conceived for and tested on data for the United States. This has inevitably resulted in differences in the sources of information used and in the way definitions have been applied. Researchers in different countries have relied on alternative sources of data and have used a wide range of measurement parameters. Efforts to harmonise these national-level estimates have mobilised the research community and have led to the publication of comparable macro-level data for a number of countries.

Discovering the role of knowledge-based assets in the economic performance and growth of countries nevertheless requires deeper understanding of the investment decisions of individual firms and of the behaviour of different industries. Firm- and sectoral-level data might feed directly into the design of industrial policy by helping to identify the most suitable policy tools and by determining the framework conditions under which they are likely to be effective. Recent work has tried to adapt the KBC macroeconomic framework to obtain industry-level estimates for 17 countries. Although this constitutes a major advance in understanding industry-specific patterns of investment in KBC, differences remain in the number of industries and assets covered and therefore in the international comparability of these figures. At the firm level, the main recent development has been the integration of questions on KBC in surveys on the innovative activities of firms. These initiatives have provided a wealth of policy-relevant information; their scale-up would allow for more targeted firm- and industry-specific policies and cross-country comparisons.

In the past, certain KBC-related assets were overlooked in definitional and measurement work, and there is neither an official methodological approach nor agreed guidelines for measuring them. These assets, particularly some in the categories of economic competencies and innovative property, are not included in official statistics such as national accounts. Researchers have therefore devised methods to estimate investment in these assets by using other data sources. The measurement of firm-specific training, for example, remains hotly debated. Recent evidence for the European Union suggests that taking appropriate account of the qualifications of employees receiving training can lead to estimates of investment in continuous training amounting to around 2% of GDP, which is equivalent to 35% of total expenditures on general education. Design – which has recently attracted considerable policy attention – is another asset for which measurement guidelines are lacking.

The OECD has addressed some shortcomings related to the absence of asset-specific measurement guidelines and the lack of cross-country harmonisation of measurement methodologies. In both cases, it has given priority to R&D and organisational capital, which are widely recognised as central to firms' innovation activities and broader performance.

Organisational capital is recognised as a central and enabling asset for firm performance. The experimental methodology proposed by the OECD defines it as the set of tasks performed by a firm's employees that contribute to the long-term functioning of a

business. The occupations that contribute to the generation and accumulation of organisational capital are identified by using information about the tasks performed by employees in different occupations. Building on these results, investment in organisational capital is estimated as a fraction of the earnings of these employees. Results suggest that such investments are almost twice as large as when assuming organisational capital to correspond to managerial activities alone. Industry-level estimates point to large differences in the intensity of investment in organisational capital across industries. It appears to be an important asset in many manufacturing industries as well as in finance, education and health.

The importance of organisational capital for production depends not only on yearly investments but also on the number of years firms can expect to reap its benefits. Previous estimates of the life of this asset have relied on hypothetical assumptions about its speed of depreciation. The OECD, using labour mobility data related to resignations, has found that organisational capital is much longer lived than previously thought. Firms expect such investments to last on average four to six years in services industries and seven to ten years in manufacturing.

Assets such as R&D have received much attention in recent decades and their measurement has progressed steadily. This has however led to a number of official data collections and to a variety of methodologies. The resulting figures differ in terms of the part of the asset captured and therefore in the amounts. In particular, the two main sets of guidelines focus, on the one hand, on performers and funders of R&D activities, and, on the other hand, on the producers and owners of R&D assets. Reconciling these figures requires careful assignment of ownership; this in non-trivial, for example, for publicly funded R&D activities carried out by private firms. Recent OECD work has provided guidelines to help countries identify possible sources of cross-country variation and to facilitate international harmonisation and benchmarking, in particular to inform R&D and innovation policies.

An often-cited caveat of the input-based approach to measuring knowledge-based assets is that it gives little indication of the value of the assets produced. The OECD has therefore used information contained in patent documents to design and construct measures of the "quality" of firms' innovative property (i.e. the technological and economic value of their patented inventions). Such indicators are generally comparable across countries and over time, and therefore suitable for cross-country analysis.

Annual investment series are insufficient to understand the use that firms make of their different knowledge assets. It is also necessary to understand and measure the life of these assets. However, obtaining consistent industry-level depreciation rates for R&D investments has proven difficult, and there is no commonly agreed methodology. The OECD has used patent renewal data to estimate the length of time during which firms value their R&D output. In general, R&D appears to be much more long-lived than previously thought, with an aggregate 8% annual linear depreciation figure rather than the 15% figure that is usually used. There are also industry-specific differences, as R&D in manufacturing seems longer-lived than in services.

The growth accounting framework, the main analytical framework currently used, provides extremely valuable information about the role of KBC in productivity and economic growth. However, it only accounts for correlations and is unable to identify causal links. Therefore, in addition to improving measurement of the different assets at all levels – firm, industry, the whole economy – a more comprehensive understanding of the role of KBC would require an analytical framework able to reveal causal links and to account for interactions and spillovers between different knowledge-based assets, and

between investment in KBC and other types of investment. For example, the complementarities between organisational capital and ICT infrastructure and between R&D and human capital investments are well documented. This suggests that the effectiveness of certain policies in support of R&D or ICT investment might be diminished by framework conditions that hinder investments in complementary assets.

Achieving consistent investment estimates for all the assets included in the CHS framework will require sustained effort over the medium to long term. Monitoring and co-ordinating the efforts of research groups and national statistical offices worldwide, in particular by facilitating knowledge sharing, enabling peer review activities, and avoiding duplication of work, will help to reach this goal more quickly.

In addition, appreciation of the importance and role of knowledge-based assets for output and productivity growth is contingent upon improving the theoretical and modelling frameworks that guide empirical analysis. Measurement strategies should be anchored in theory and the insights afforded by theoretical work. The lack of a general model impinges upon the ability to identify market failures and the root causes of such failures and hence to design more effective policies.

Notes

1. For instance, the role of the ICT sector and its linkages with other sectors are addressed by Oliner et al. (2008); Oulton (2010); and Dahl et al. (2011); its complementarities with the organisational structure of firms are addressed by Bresnahan et al. (2002). Spillovers of R&D investments across sectors are analysed by Wolff and Nadiri (1993) and Wolff (1997, 2011), and spillovers of investment in organisational capital between upstream and downstream firms are studied by Javorcik (2004).

2. The paper is available at www.oecd-ilibrary.org/science-and-technology/defining-and-measuring-investment-in-organisational-capital_5k92n2t3045b-en.

3. CHS assumes that organisational capital is the product of managerial activity only, and count 20% of managerial wages as investment in this asset.

4. INNODRIVE and COINVEST were funded under the 7th Framework Programme to measure intangible assets for a number of EU countries. COINVEST (2008-10) covered eight European countries, whereas INNODRIVE (2008-11) covered the EU27 and Norway.

5. INTAN-Invest estimates are the authors' own elaboration of work previously conducted under three projects: INNODRIVE, COINVEST and on-going work by the Conference Board. Data are available at www.intan-invest.net/, accessed in May 2013.

6. Estimates of investments in KBC for Japan have been calculated as part of the Japanese Industrial Productivity Database and are published at www.rieti.go.jp/en/database/JIP2011/index.html, accessed in July 2012.

7. Software has been capitalised in the SNA since 1993, and R&D will be capitalised in the SNA from 2013.

8. Sectoral investment series for France are available online in the annex to the Centre de Recherche en Economie et Statistique (CREST) Working Paper 2012-26 by Delbecque et al. (2012), www.crest.fr/content/blogcategory/21/54/.

9. These estimates are part of the deliverables of the INDICSER project, financed by the European Commission under the 7th Framework Programme. For more information see indicser.com.

10. The United Kingdom is a notable exception, as KBC investment is highest in the business services and financial intermediation sectors.

11. See Perani and Guerrazzi (2012). More information about the pilot phase can be obtained at www.isfol.it/temi/Formazione_apprendimento/indagini-e-ricerche/intangible-assets-survey-sintesi-dei-risultati-della-rilevazione-pilota-1 (in Italian).

12. This work is led by the OECD National Experts on Science and Technology Indicators (NESTI) Working Party.

13. Damage award numbers from *Apple Inc. v. Samsung Electronics Ltd. Inc*., No. 11-1846, U.S. District Court for the Northern District of California. See the amended jury verdict of 24 August 2012
http://cand.uscourts.gov/filelibrary/1079/Amended%20Jury%20Verdict.pdf

    Further documentation on the proceeding is available at
http://cand.uscourts.gov/applevsamsung/casedocs.

14. The project, carried out by the OECD NESTI Working Party is partly sponsored by a voluntary contribution from the European Commission (DG Enterprise) and will run until the end of 2013.

15. All the KBC investment series are calculated for the market economy, excluding the public and real estate sectors. As such, nominal investment series are compared to total value added of the market economy rather than the market economy. As spending on KBC is now considered investment rather than current expenditure, it is part of value added and has to be summed with official figures of value added.

References

Ark, B. van, J. Hao, C. Corrado and C. Hulten, (2009), "Measuring intangible capital and its contribution to economic growth in Europe" *European Investment Bank Papers*, Vol. 14, No. 1, www.eib.org/attachments/efs/eibpapers/eibpapers_2009_v14_n01_en.pdf.

Australia, (2012), "Australian Innovation System Report – 2012", Department of Industry, Innovation, Science, Research and Tertiary Education, Commonwealth of Australia, www.innovation.gov.au/innovation/policy/australianinnovationsystemreport/aisreport2012.pdf.

Awano, G., M. Franklin, J. Haskel and Z. Kastrinaki, (2010), "Investing in Innovation: Findings from the UK Investment in Intangible Assets Survey", *National Endowment for Science, Technology and the Arts (NESTA)* report, July.

Baldwin, J., W. Gu and R. Macdonald (2012), "Intangible capital and productivity growth in Canada", in *The Canadian Productivity Review Research Papers*, Statistics Canada, Ottawa, www.statcan.gc.ca/pub/15-206-x/15-206-x2012029-eng.htm.

Barnes, P. (2010), "Investments in Intangible Assets and Australia's Productivity Growth: Sectoral Estimates", Australia Productivity Commission, www.pc.gov.au/__data/assets/pdf_file/0007/99907/intangible-investment-sectoral-estimates.pdf.

Barnes, P. and A. McClure, (2009), "Investments in Intangible Assets and Australia's Productivity Growth", Australia Productivity Commission, www.pc.gov.au/__data/assets/pdf_file/0006/86496/intangible-investment.pdf.

Belhocine N. (2009), "Treating Intangible Inputs as Investment Goods: the Impact on Canadian GDP", *IMF Working Papers* 09/240, International Monetary Fund, www.imf.org/external/pubs/ft/wp/2009/wp09240.pdf.

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

Chun, H., K. Fukao, S. Hisa and T. Miyagawa (2012), "Measurement of Intangible Investments by Industry and Its Role in Productivity Improvement Utilizing Comparative Studies between Japan and Korea", *RIETI Discussion Paper Series* 12-E-037, www.rieti.go.jp/jp/publications/dp/12e037.pdf.

Corrado, C., P. Goodridge and J. Haskel, (2011), "Constructing a Price Deflator for R&D: Calculating the Price of Knowledge Investments as a Residual", August 2011, available at SSRN: http://ssrn.com/abstract=2117802.

Corrado, C., J. Haskel, C. Jona-Lasinio and M. Iommi (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results", Working Paper, June 2012, available at www.intan-invest.net.

Corrado, C., C. Hulten and D. Sichel (2005), "Measuring Capital and Technology: An Expanded Framework", in C. Corrado, J. Haltiwanger and D. Sichel (eds.), *Measuring Capital in a New Economy*, National Bureau of Economic Research and University of Chicago Press, Chicago, IL.

Corrado, C., C. Hulten and D. Sichel (2009), "Intangible Capital and US Economic Growth", *Review of Income and Wealth*, Vol. 55(3), pp. 661–685, www.conference-board.org/pdf_free/IntangibleCapital_USEconomy.pdf.

Crass, D., G. Licht and B. Peters (2010), "Intangible Assets and Investments at the Sectoral Level – Empirical Evidence for Germany" CoInvest Project Report, Deliverable D 10, pp. 133-206, www.coinvest.org.uk/pub/CoInvest/CoinvestProjects/COINVEST_217512_D10.pdf.

Dahl, C. M., Kongsted H. C., and A. Sørensen (2011). "ICT and Productivity Growth in the 1990s: Panel Data Evidence on Europe." *Empirical Economics*, Vol. 40(1), pp. 141-164.

Delbecque, V. and A. Bounfour (2012), "Intangible capital and value creation: A comparative industry analysis" The European Chair on Intellectual Capital Management, *Working Paper Series*, No. 2012-1A, January, www.chairedelimmateriel.u-psud.fr.

Delbecque, V., S. Le Laidier, J. Mairesse and L. Nayman (2012), "L'évaluation des investissements incorporels en France : méthodes et premiers résultats", Centre de Recherche en Economie et Statistique (CREST) *Working Paper Series*, No. 2012-26.

Edquist, H. (2011), "Intangible Investment and the Swedish Manufacturing and Service Sector Paradox" *Research Institute of Industrial Economics (IFN) Working Paper* No. 863, www.snee.org/filer/papers/627.pdf.

Fukao, K., T. Miyagawa, K. Mukai, Y. Shinoda and K. Tonogi (2009), "Intangible Investment in Japan: Measurement and Contribution to Economic Growth", *Review of Income and Wealth*, Series 55, No. 3, September.

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

Goodridge, P., Haskel, J. and G. Wallis (2012), "UK Innovation Index: Productivity and Growth in UK Industries". *CEPR Discussion Paper* No. DP9063, July.

Griliches, Z. (1998), "Patent Statistics as Economic Indicators: A Survey" in Z. Griliches (ed.), *R&D and Productivity: The Econometric Evidence*, University of Chicago Press, Chicago, IL.

Hall, B. H., Z. Griliches and J. A. Hausman (1986), "Patents and R&D: Is There A Lag?", *International Economic Review*, Vol. 27(2), pp. 265-284.

Hao, J. X., V. Manole and B. van Ark (2009), *Intangible Capital and Growth – an International Comparison*, CoInvest Publications, Deliverable D 3.6.

Haskel, J., Goodridge, P., Pesole, A., Awano, G., Franklin, M., and Z. Kastrinaki. (2011). Driving Economic Growth. Innovation, Knowledge Spending and Productivity Growth in the UK, *NESTA Index Report*, available at www.nesta.org.uk/library/documents/Driving_Ecc_Growth_Web_v4.pdf.

Hulten C. and J. Hao (2012), "The Role of iIntangible Capital in the Transformation and Growth of the Chinese Economy", *NBER Working Paper* No. 18405, September, www.nber.org/papers/w18405.

INTAN-Invest (2012), www.intan-invest.net.

Jalava, J., P. Aulin-Ahmavaara and A. Alanen (2007), "Intangible Capital in the Finnish Business Sector – 1975-2005", *Elinkeinoelämän tutkimuslaitos (ETLA) Discussion Papers* No. 1103, www.etla.fi/wp-content/uploads/2012/09/dp1103.pdf.

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

Mead, C. I., (2007). "R&D Depreciation Rates in the 2007 R&D Satellite Account". Bureau of Economic Analysis/National Science Foundation R&D Satellite Account Background Paper. Available at: www.bea.gov/papers/pdf/Mead_RD_Paper_wp.pdf .

O'Mahony M. (2012), "Human Capital Formation and Continuous Training: Evidence for EU Countries", *Review of Income and Wealth*, Vol. 58(3), pp. 531-549.

O'Mahony, M., T. Niebel, and M. Saam (2012), "Intangible Investment at the Industry Level: Growth Accounting", INDICSER Project Deliverables, D 2.3, December, http://indicser.com/images/dp33_omahony_et_al.pdf .

OECD (2002), *Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development*, The Measurement of Scientific and Technological Activities, OECD Publishing. doi: http://dx.doi.org/10.1787/9789264199040-en.

OECD/Statistical Office of the European Communities, Luxembourg (2005),*Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition*, The Measurement of Scientific and Technological Activities, OECD Publishing. doi: http://dx.doi.org/10.1787/9789264013100-en.

OECD (2010), *Handbook on deriving capital measures of intellectual property products*, OECD publishing, Paris. doi: http://dx.doi.org/10.1787/9789264079205-en.

Oliner, S. D., Sichel D. E., and K. J. Stiroh (2008). "Explaining a Productive Decade". *Journal of Policy Modeling*, Vol. 30(4), pp. 633–673.

Oulton, N. (2010). "Long Term Implications of the ICT Revolution: Applying the Lessons of Growth Theory and Growth Accounting". *CEP Discussion Paper* No. 1027, November.

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

Perani, G. and M. Guerrazzi (2012), "The Statistical Measurement of Intangible Assets. Methodological Implications of the Results of the ISFOL 2011 Pilot Survey", mimeo (available upon request from the authors).

Piekkola, H. (2011), "Intangible Capital – Driver of Growth in Europe", *Proceedings of the University of Vaasa.* Reports, 167, Vaasan yliopisto, June, www.innodrive.org/attachments/File/Intangible_Capital_Driver_of_Growth_in_Europe_Piekkola(ed).pdf.

Rooijen-Horsten, M. van, D. van den Bergen and M. Tanriseven (2008), "Intangible capital in the Netherlands: A benchmark", *Statistics Netherlands Discussion Paper* No. 08001, www.cbs.nl/NR/rdonlyres/DE0167DE-BFB8-4EA1-A55C-FF0A5AFCBA32/0/200801x10pub.pdf.

Squicciarini, M, and M. Le Mouel, (2012), "Defining and Measuring Investment in Organisational Capital: Using US Microdata to Develop a Task-based Approach", *OECD Science, Technology and Industry Working Papers*, No. 2012/05, OECD, doi: http://dx.doi.org/10.1787/5k92n2t3045b-en.

Talbot, L, H. Toh, E. Kalenjuk, A. Lal and J Seol (2012), "Firm-level Financial Measures of Innovation: An Exploratory Project to Derive Financial Measures of Innovation Activity from the Accounting Records of Model Australian Firms", Australian Department of Industry, Innovation, Sciences, Research and Tertiary Education, Innovation Division, February.

United States Patent and Trademark Office (2013), *Design Patent Report,* www.uspto.gov/web/offices/ac/ido/oeip/taf/design.htm.

Wolff, E. N., and M. I. Nadiri (1993). "Spillover Effects, Linkage Structure, and Research and Development". *Structural Change and Economic Dynamics*, Vol. 4(2), pp. 315-331.

Wolff, E. N. (1997). "Spillovers, Linkages and Technical Change." *Economic Systems Research*, Vol 9(1), pp. 9-23.

Wolff, E. N. (2011). "Spillovers, Linkages, and Productivity Growth in the US Economy, 1958 to 2007". *NBER Working Paper* No. 16864, March.

From:

Supporting Investment in Knowledge Capital, Growth and Innovation

Access the complete publication at:
https://doi.org/10.1787/9789264193307-en

Please cite this chapter as:

OECD (2013), "Measuring knowledge-based capital", in *Supporting Investment in Knowledge Capital, Growth and Innovation*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/9789264193307-8-en

This work is published under the responsibility of the Secretary-General of the OECD. The opinions expressed and arguments employed herein do not necessarily reflect the official views of OECD member countries.

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

You can copy, download or print OECD content for your own use, and you can include excerpts from OECD publications, databases and multimedia products in your own documents, presentations, blogs, websites and teaching materials, provided that suitable acknowledgment of OECD as source and copyright owner is given. All requests for public or commercial use and translation rights should be submitted to rights@oecd.org. Requests for permission to photocopy portions of this material for public or commercial use shall be addressed directly to the Copyright Clearance Center (CCC) at info@copyright.com or the Centre français d'exploitation du droit de copie (CFC) at contact@cfcopies.com.