



Deliverable D3.1

Measuring Intangible Assets – A Review of the State of the Art

Due date of deliverable: 2019/05/31

Actual submission date: 2019/08/30

Globalinto Identifier:	WP3. Processing data ad indicators
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Work package/task:	WP3 / Task 3.1 Assessment of the IA-related statistical activities undertaken by NSIs at the EU level
Document status:	draft / <u>final</u>
Confidentiality:	confidential / restricted / <u>public</u>

DOCUMENT HISTORY

Version	Date	Reason of change
1	yyyy/mm/dd	
2		
3		
4		



This project has received funding from the *European Union's Horizon 2020* The mechanisms to promote smart, sustainable and inclusive growth under grant agreement No 822259.

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Executive Summary

This deliverable, D3.1, presents an overview of the state of the art in the field surrounding the measurement of 'intangibles'. The purpose of the paper is to inform indicator development, both at the micro and aggregated levels, within the GLOBALINTO project and for intangibles measurement in general. We aim to contribute to the understanding of how the measures of 'intangibles' are operationalized. Since the conceptualization of 'intangibles' happens in various ways and choices regarding measurement issues are plentiful, the eventual constructs used in scientific analyses are also heterogeneous. Our review seeks to capture the development of intangibles measurement, which has explored a variety of directions, both in terms of definition, method and data. In order to both characterize the diversity of the field and its development over time, the review of literature will be guided by four key dimensions.

The scope of this deliverable is somewhat different from the original objective stated in Task 3.1, which was "Assessment of the IA-related statistical activities undertaken by NSIs at the EU level". The scope of D3.1 is broader, seeking to cover all forms of recent analysis and statistical work concerning the measurement of intangible assets. We viewed this broader approach to be more informative to the reader and to be more beneficial in informing project work on intangibles measurement.

D3.1 complements in particular project work on a theoretical framework for intangibles measurement (D1.2) and reviews of the link between intangible assets and productivity (D1.4 and D6.1).

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Introduction and Motivation

A relative shift from physical to intangible means of production has been taking place in the last several decades (e.g. Haskel and Weslake, 2017). Scholars voiced critiques regarding the lack of adequate accounting for these ever more important intangibles (e.g. Lev, 2003). At the same time, the western world has seemingly experienced a slowdown in productivity growth. Subsequently, and following the seminal work by Corrado, Hulten and Sichel (2005), CHS (2005) henceforth, much scientific work has revolved around to which extent investments into intangibles contribute to productivity, and thereby constitute a missing piece in the productivity puzzle. Solow noted early on that “the computer age can be seen everywhere except in the productivity numbers”. The existence of a difference between the real and the measured economy can explain at least partly this paradox. Thus, in order to make analysis fit with economic realities it is of prime importance to have quantitative measures for these ‘intangibles’.

A number of papers have stressed the need for better and more complete measures of investments in intangible assets, along with the many challenges involved in producing reliable measures. For example, Nakamura (2010) builds a formal microeconomic model to make his case of why and how measurement of intangibles can move forward. From the model, he concludes that while perfect competition has been underlying in our measurement of nominal economic activity, private stocks of intangibles have not historically been included in the measures of wealth, and temporary monopoly based on intellectual property was not considered a relevant factor of production. Therefore, if we want to understand the sources of growth better, we must develop economic measurement and theory together. Much work has been done over the last 20 years, and with wide diversity in terms of the conceptualization of intangibles, methods and data used. An overview of past projects that have made efforts to quantify intangibles can be found in appendix A. Much of the literature in this review builds on work within these projects. To further identify relevant literature for review, we conducted a systematic but non-exhaustive search, consisting of a key-word-search in Web of Science (WoS) and google scholar (GS) with additional snowballing of the references therein. This literature search is by no means claimed to be exhaustive, but seeks to be indicative for trends in the field. The full list and description of articles reviewed can be found in the table in appendix B.

The current document gives an overview of the state of the art in ‘intangibles measurement’ and identifies potential routes for future research. We aim to capture the development of intangibles measurement, which has explored a variety of directions, both in terms of definition, method and data. This review is also informed by earlier reviews on intangibles measurement. Bontis (2001) describes several models to measure intangible capital using firm valuation methods. However, one of the shortcoming most of these models (i.e. Skandia, IC index, technology broker, intangible asset monitor) share is that they not well suited for cross firm comparison, as they often rely on in depth knowledge idiosyncratic to the firm.

Further, Kauffman and Schneider (2004) make the point that there is a lack of standard definitions and unclear classification of intangibles. Moreover, they state that the models are often too qualitative in nature to provide

concrete help. We argue that that the emergence of a theoretical base with CHS (2005) is an interesting entry point for a literature review on the topic focusing on quantitative and comparable measurement of intangibles.

In order to both characterize the diversity of the field and its development over time, the review of literature will be guided by four key dimensions: purposes for the measurement of intangibles; methods of measuring intangibles; conceptualizations and types of intangible assets (IA); and the level of aggregation for measures. In the following four sections of this document, we review the thus found academic literature where each section corresponds to one of the identified key dimensions.

First, we distinguish between data and measures for different *purposes*, each raising a number of measurement issues. These include measurement activities to inform firm-specific strategic or managerial analysis, productivity analysis, and national accounts measures. In addition, much data may have initially been collected with a different main purpose in mind.

Second, one can distinguish three *measurement methods*: expenditures based, market based and intellectual property right (IPR) based. *Expenditures based approaches* estimate intangibles by projecting forward the past flow of expenses into a current stock of assets. In other words, they apply a net present value type (NPV) of rule (see e.g. Corrado et al. 2005). Existing studies have captured expenses from accounting data, national statistics, surveys and labor-occupation data. The underlying assumption of the expenditures approach is that firms are willing to invest in intangible assets until the discounted present value of the expected income stream equals the cost of producing the marginal asset. *The market valuation approach* seeks to assess the value of intangibles based on the difference between the book and market value of the firm by calculating Tobin's Q types of measures. The crucial assumptions are that the market value anticipates 'all' future revenue streams whereas the book value does not include intangible assets. *An Intellectual property right (IPR) based approach* relies on the legal rights being awarded and their value in the market.

Third, depending on how intangible assets are conceptualized, one can distinguish between a spectrum of *types of measures* ranging from 'broad intangibles' to 'specific intangibles', where broader intangibles aggregate a larger set of more specific types of intangible assets. Corrado et al. (2005) for example identify three components of intangible assets, economic competencies, innovative property and software and computerized information. Depending on which part of the spectrum is measured, a whole range of measures potentially emerges. Work devoted to organizational assets, as in for example Squicciarini and Mouel (2012) or Eisfeldt and Papanikolaou (2013, 2014), is only one example of efforts concentrating on a particular range of the spectrum.

Fourth, depending on the *level of aggregation*, one can distinguish between micro (firm), meso (industry), and macro (national) level measures of intangibles. Where some studies use firm level information to estimate economic aggregates, or use the aggregates (we will call these macro/meso studies), others conduct analysis where the main interest lies in identifying relations based on the firm level information (we will call these micro level studies). While Corrado et al. (2009) establish macroeconomic data on intangibles, the work of Götzig et

al. (2010) establish a method to estimate micro-level intangibles from register data. Finally, the last section concludes.

1. Purposes of intangibles measurement

In broad terms, there are a number of uses for data on IAs, each with their own separate issues, but at the same time closely interconnected. We discuss here three purposes of intangible measurement: internal and accounting use by businesses, national accounts statistics and productivity and other forms of analysis. Analysis is arguably the most visible use, and this review covers a number of studies that have measured intangibles expressly for this purpose. These papers will also be summarized below. We start here with internal use, which motivates a discussion of the “accounting perspective” (Lev, Cañibano and Marr, 2005) on the capitalization of intangibles.

Internal measurement and the accounting perspective on intangible assets

The treatment of intangible capital in accounting standards is important for measurement as a whole, as it provides guidance on how firms should identify and account for expenditures on intangible capital. This both involves to what extent intangibles expenditures can be recorded as capital formation, and the classification of different types of intangibles expenditures.

International Accounting Standard (IAS) 38 defines an intangible asset as “An identifiable nonmonetary asset without physical substance. An asset is a resource that is controlled by the enterprise as a result of past events (for example, purchase or self-creation) and from which future economic benefits (inflows of cash or other assets) are expected.” IAS 38 forms a central criteria concerning the capitalization of intangibles assets, stating that a company can only recognize an asset if it is identifiable, controlled, measurable, and if it is probable that future benefits of the asset can be accrued to the company (Lev, Cañibano and Marr, 2005). This restrictive treatment of intangible assets, particularly concerning the required certainty of eventual income generation, has strong implications for rules on the capitalization of intangible expenditures. According to US rules (Generally Accepted Accounting Principles, GAAP), essentially no internally generated intangibles are capitalized, while acquired intangibles can in some cases be capitalized. Rules according to the International Financial Reporting Standards (IFRS) are similar, though allow for capitalization of development costs when strict conditions are met concerning certainty in terms of feasibility and financing for project completion. Baruch Lev and others have been very critical of the treatment of intangibles in accounting rules, arguing that by not recognizing value-creating resources as assets, financial reports fail to state the true value of companies (Lev and Gu 2016, Lev, Cañibano and Marr 2005). Furthermore, they create a bias with greater understatement of the earnings and assets of companies with growth in intangibles investments and overstatement for companies with declining investment.

A further consequence of current accounting practices is in terms of intangibles measurement. Without the standardized requirements to financially report specific intangible assets, companies may decide themselves, based on managerial or strategic considerations, whether to record expenditures on intangibles investments

and in what way. Studies suggest that many knowledge intensive companies do in fact record some intangibles expenditures, but in varying ways. For example, Hunter et al. (2012) survey 614 Australian companies and find that around 40% record expenditures for different types of intangibles, with shares varying greatly according to which types were recorded.

Intangibles in national accounts statistics

A distinction between statistics and analysis is to some degree artificial, but it is still instructive to examine work on intangibles with the intention of greater incorporation of intangibles investments into national accounts. Here it is a question of agreement on standard practices for which expenditures should be capitalized in national accounts and which should be considered as consumption and expensed. As Nakamura (2010) points out, different perspectives on which expenditures constitute investments in intangible assets can greatly influence our view of the dynamics of investment activity in economies. For example, a narrow measurement of intangible assets (that only includes assets that are capitalized according to current standards) shows little growth in investment over time, while there is strong growth in broader forms of intangibles (that are currently expensed) (Nakamura 2010).

The 1993 System of National Accounts¹ treated only a very limited set of intangibles as capital formation (software, mineral exploration rights, subscriptions to databases, patenting, goodwill). Yet, it also discussed the main reasons for the expensing of other intangibles: “Expenditure by enterprises on activities such as staff training or research and development are ... designed to raise productivity or increase the range of production possibilities in the future ... However, expenditures on training and research or development do not lead to the creation of assets that can be easily identified, quantified and valued for balance sheet purposes.” (SNA 1993, para. 51)

Hence, many other intangibles have long been recognized as constituting capital formation in an economic sense, but are not included due to measurement difficulties (many of these issues were carefully reviewed in Moulton (2004)). Further connected to these issues, the lack of available information on intangibles from firm balance sheets (due to current accounting rules for the capitalization of intangibles) greatly limits our knowledge on these technical measurement issues.

The current SNA from 2008 notes that these same challenges are still relevant, though a series of advances have been made (Mortensen 2013):

- ICT equipment included as new category under machinery and equipment
- “intangible fixed assets” renamed to “intellectual property products”, and now include RandD products
- “other intangible fixed assets” renamed to “other intellectual property products”, and now includes RandD, mineral exploration and evaluation, computer software and databases, literary or artistic originals.

¹ Inter-Secretariat Working Group on National Accounts, and Commission of the European Communities. (1993). *System of national accounts 1993* (Vol. 2). INTERNATIONAL MONETARY FUND.

- “mineral exploration” renamed to “mineral exploration and evaluation” to conform with international accounting standards
- Computer software modified to include databases

As noted by Mortensen (2013), satellite accounts potentially provide a way forward from the current situation where we may not be able to fully resolve the many technical challenges in measuring IAs that have been noted, but we at the same time accept that broader intangibles (such as training, design and other organizational assets) play an important role for value creation and growth. Satellite accounts allow greater flexibility in expanding national accounts in selected areas, for example through rearrangement of central classifications, or the use of alternative concepts (such as changing the boundary between consumption and capital formation).

A number of studies have had a dual focus, both seeking to further discussions of the official statistical treatment of intangible as capital formation and *conducting analysis* using these broad measures of IAs (Eg. Corrado et al. 2017, 2016, 2014, 2013, 2006, 2005, Nakamura 2010, Crass et al. 2015, van Ark et al. 2009, Roth and Thum 2013, Niebel et al 2017).

2. Measurement methods

Among the methods to measure intangible assets, the expenditure based approach is the most widely used and draws in particular on the work of Corrado, Hulten and Sichel. However, there are a number of other variants, in particular related to efforts to measure intangibles investments at the firm level. This section first describes the CHS approach and other work that has utilized the CHS approach. Thereafter, we review other methods for measurement, including survey-based approaches and measurement based on firm balance sheet data.

Expenditures based approach

The seminal theoretical and empirical contributions by Corrado, Hulten and Sichel from the mid-2000's (Corrado et al. 2005; 2006) take an expenditures based approach and measure a spectrum of specific intangibles at the macro-economic level. They make the simple, straightforward argument that “any outlay that is intended to increase future rather than current consumption is treated as a capital investment.” (Corrado et al. 2005, p. 13). While not necessarily novel in itself, this argument in combination with a feasible approach has had a significant impact on the measurement of IAs. Bundling together specific intangibles, they arrive at a broad measure of intangibles and use this as an input in a growth accounting exercise, by expanding the conceptual framework of the sources-of-growth with a variant of the standard model of intertemporal choice developed in Hulten (1979) (Corrado et. al. 2005). The empirical test of this new framework (Corrado et al. 2006) uses macroeconomic US data from the period spanning 1950 to 2000 to arrive at some profound conclusions. First, many intangible assets are still unaccounted for in GDP. Second, when capital deepening becomes the dominant source of labor productivity growth, then the role of multi-factor productivity is correspondingly diminished. Third, labor's income share is found to have decreased significantly over the last 50 years.

Corrado, Hulten, and Sichel (2005) identify three main categories of intangible assets: economic competencies, innovative property and computerized information². Economic competencies include spending on strategic planning, worker training, redesigning or reconfiguring existing products in existing markets, investment to retain or gain market share and branding such as investing in brand names. Innovative property refers to innovative activity built on a scientific base of knowledge as well as to innovation and new product/process RandD more broadly defined. Computerized information essentially coincides with computer software and databases.

Corrado et al. (2009: 669-672) construct their estimation of intangible capital types from several sources. For the broad category of *computerized information*, the source is National Income and Product Account (NIPA). The broad category of *innovation property* utilizes National Science Foundation Industrial RandD survey for scientific RandD and Census Bureau's Services Annual Survey (SAS) for non-scientific RandD. *Economic competencies* estimate a wide area from advertisement to strategic development and are covered by Bureau of Labor Statistics (BLS), SAS and employer paid training is captured from American Society for Training and Development (ASTD). Corrado et al. (2009) note that one can expect only 60 % of advertisement expenditures to have effects lasting over a year.

Corrado et al. (2009) construct their capital stocks using specific depreciation rates for each IA type. The depreciation rate for computerized information (33%) is based on expected life cycles of 5 years. Scientific RandD's depreciation rate (20%) is the middle value used in the literature. Corrado et al. (2009) highlight that advertisement efforts last over a year but do depreciate higher than the other types; they assume it to be 60%. An intangible investments price deflator is approximated from the price index of non-farming industries using a three year moving average.

The EU FP7 Innodrive project implements a macro approach that follows the CHS approach in measuring intangibles for all EU27 countries (see Jona-Lasinio et al. 2011³, Roth and Thum 2012).

Survey based measurement of expenditures

A small number of studies have used a survey-based approach to measure investments in intangibles. Innovation surveys have long sought to measure expenditures connected to innovation activities, including RandD, other purchases of IPR, training, design, and other expenses related to the development, testing and implementation of product and process innovations (OECD and Eurostat 2005). The Oslo Manual for collection of data on innovations has also recently been revised (OECD and Eurostat 2019). Innovation expenditures are closely related to investments in intangibles, though are restricted to expenditures that can be directly related to the development of product or process innovations.

² These three categories can be broken down into in all nine types of intangible assets.

Crass and Peters (2014) utilize innovation survey data from the German Mannheim Innovation Panel to create measures of intangibles within three categories: innovative capital, human capital and branding capital. Innovation capital is estimated from RandD, patent stock and design and licenses. Branding capital is proxied from firms' total marketing expenditures: "in-house and purchased advertising expenditure, conceptual design of marketing strategies, market and customer demand research and establishment of new distribution channels" (Crass and Peters, 2014, p. 10). Human capital is approximated from the survey with 1) share of highly educated employees and 2) expenditures on professional development training, both internal and external. The survey does not cover expenditures on computerized information. Organizational capital is covered by dummy variables from the survey for: new business processes, new methods in workplace organization and new types of external relationships.

The Investments in Intangible Assets (IIA) survey is directly targeted at the measurement of investments in intangibles (Awano et al. 2010). The survey measures in all six categories of intangibles (both in-house activities and purchases): employee training, software development, reputation and branding, RandD, design and business process improvements. The IIA survey also seeks to measure depreciation rates for different intangibles by collecting data on expected benefit lives for the six asset categories.

Measurement based on firm balance sheet data

A number of studies have used data from firm balance sheets to measure intangible assets, where both data on activities that have been capitalized and those that have been expensed have been considered. The availability of data on intangibles from firm balance sheets varies across countries and is also influenced by the accounting standards used in each country. As discussed above, there are two key issues that influence the quality and scope of measures of intangible assets based on balance sheet data. First, rules are very conservative on what types of activities may be capitalized (the accounting perspective on intangibles is much more restrictive than the economic perspective), so financially reported measures of intangible assets are typically very narrow. Second, due to this practice, there is a lack of standard practice for how firms financially record different intangibles related activities.

Peters and Taylor (2017) also rely on balance sheet data, drawing on Compustat data for US companies. They include both financially reported intangible assets (which are subject to very strict rules on what can be capitalized according to US standards, see below), RandD expenditures as a measure of Knowledge Capital and Selling, General and Administrative (SGandA) expenses as a measure of organizational capital. SGandA is essentially a mix of expenditures that are viewed to contribute to intangible asset accumulation (such as advertising and marketing), but also a number of purely administrative expenses. Peters and Taylor assume that 30% of SGandA expenses contribute to intangible asset accumulation.

Similarly, Marrocu et al (2012) use the variable "intangible fixed assets" from the BVD Amadeus company database, for firms in six European countries. Hence, the measure relies on intangible assets that firms have chosen to (and were allowed to) capitalize.

Bontempi and Mairesse (2015) argue that Italian accounting standards allow for broader measurement of intangibles based on balance sheets than in other countries. They construct measures of two types of intangible assets (Intellectual Capital and Customer Capital) based both on reported assets and on expensed costs. Intellectual Capital consists of RandD, advertising costs essential to the start up phase of new products, purchases of patents, IPR and software, and licensing costs. Customer Capital consists of trademarks and similar rights, and additional advertising costs. Bontempi and Mairesse (2015) excluded start-up and expansion costs and goodwill as these types require further analysis.

Occupation or task based approach

The final expenditures based approach can be characterized as an occupation or task based approach. This approach seeks to quantify intangibles investments based on the resources used in generating intangibles, forming estimates of both own-account and purchased investments. The approach is based on three assumptions. First, the generation of new knowledge and knowhow is assumed to be undertaken by employees within knowledge intensive occupations that are related to the specific type of intangible. The second is that a share of these knowledge intensive workers' time is devoted to the development of intangible capital (while the remaining share is devoted to day-to-day operations). The final assumption concerns an estimate of purchased intangible capital that is connected to the own-account activities. As part of the Innodrive project, Görzig et al. (2010) established a new micro-level method where intangibles are approximated from intangibles producing employees, using Linked Employer-Employee Data (LEED) on occupations, education level and employee salaries. These employees are persons with relevant higher education and occupations that are viewed to produce intangible assets. Three types of intangible assets are identified: organizational, ICT and broadly measured research and development.

Labor shares and intermediate factor shares are approximated based on the EU KLEMS database, yielding a *combined multiplier* for both the investment share of labor and the factor multiplier. Table 1 summarizes these numbers together with depreciation rates. The combined multiplier is used to approximate intangible investments from salary expenses. Capital stocks are calculated using the perpetual inventory method.

Table 1. Görzig et al. (2010: p. 14) methodology in numbers.

Intangible capital type	Investment share of labor input	Factor multiplier	Combined multiplier	Depreciation rate
ICT ¹	0.5	1.48	0.7	0.33
RD ²	0.7	1.55	1.1	0.2
OC ³	0.2	1.76	0.35	0.25

¹ information communication technology, ² research and development, ³ organizational capital

Squicciarini and Le Mouel (2012) utilizes a related approach to measure organizational capital in US companies. Instead of classifying according to the type of occupation, they identify relevant, intangibles generating occupations based on the individual tasks for each occupation (thereby seeking to capture managerial activities undertaken by non-managerial staff). Intangibles investments are assumed to comprise 20% of these workers' time, and purchased organizational capital is estimated at an aggregate level to correspond to 80% of the turnover of the management consulting services industry. In contrast to the Innodrive method, Squicciarini and Le Mouel (2012)'s approach creates measures at the sectoral and macro level. Instead of using LEED data, their method uses occupation data combined with estimates of average earning for individual occupations from the US Current Population Survey.

IPR based measures

Investments into innovative property are inputs into an innovation production function where intellectual property rights (IPRs) are part of the output. Formal IPR counts, i.e. number of patents, trademarks and designs can thus be seen as a crude measure of the volume of protected intangible capital within a firm. When an intangible asset is protected by formal intellectual property rights, a low correlation between the investment series and the corresponding IPR counts would indicate that the investment series is inadequate. Accordingly, de Rassenfosse (2017) test whether expenditures based measures of brand equity and architectural and engineering designs are adequate. The data is unbalanced data from 1980 to 2010 and covers 32 countries. de Rassenfosse (2017) finds that brand equity predicts trademarked applications but that design activity does not correlate with design rights. Thus, the article suggests that brand equity captures what it is supposed to but design activity needs more development. Apart from specific use cases, e.g. industries that heavily rely on IPRs for their innovation, the use of IPR based measures might seem fairly limited. These cases do however provide the opportunity to cross check expenditure type measures for their adequateness.

Market valuation approach

Some valuation methods can be viewed as a "residual approach", based on the argument that differences between the market valuation of companies and their book value (which may include intangible assets if they are financially reported) reflects the value of intangible assets, where the ratio of equity market to book value corresponds to the standard estimation of Tobin's Q.

Forte et al (2017) examine the determinants of Tobin's Q for a sample of Italian companies listed on the Milan stock exchange, where they use a measure of intangible assets taken from balance sheets (it is not fully clear what this reported measure includes). Data is a sample of 140 Italian firms from Milan Stock exchange over the period 2009-2013.

An additional example is the Value-Added Intellectual Capital Coefficient method, which seeks to measure the extent to which a company produces added value based on intellectual (capital) efficiency or intellectual resources. The method defines two types of intellectual capital, where human capital is measured as labor expenses and structural capital as the difference between value added and human capital. While being

straightforward to construct based on generally available data, the method can only be considered as indirect in its measurement of intangible assets, leading to questions of its validity (see eg. Stähle et al. 2011).

3. Types of Intangibles

Given that intangibles investments include any activities or purchases that have a positive expected value for future growth, there may in principle be a large number of different types of intangibles. While there are some studies that mainly concerned with estimation and analysis of a single overall measure of intangibles, a number of studies either focus on a single specific type or construct a typology of different types. Many of these types have already been mentioned above. While there may be differences in definition and distinction among types, or in the level of detail, there appears to be a common general conceptualization of intangibles. We review here the main categorizations of types of intangibles investments.

A fairly early attempt to develop a measurement framework is an OECD study (Young 1998), which covers the core components of intangibles investments. Young proposes six categories:

- Computer-related (software, large databases, other computer services)
- Production and technology (RandD, Design and engineering, new quality control systems, patents and licenses, knowhow)
- Human resources (organized training, learning by doing, activities to improve workforce well-being, remuneration for innovative ideas)
- Organization of the firm (new organizational methods, networks, new working methods)
- External: marketing and sales (market research, advertising, brands, customer lists, quality certificates, goodwill)
- Industry specific

The purpose of this classification is similar to that of guidelines concerning the classification of RandD expenditures (OECD 2015) or innovation (OECD and Eurostat 2018), to promote standardized reporting across companies, either in financial reporting or in survey-based data collection. With the exceptions of RandD, innovation, and the treatment of some intangible assets in national accounts, this has not yet been successful on a broader scale.

This fairly detailed list of types corresponds well with the categories in CHS that are listed above and also the more detailed list of intangibles used in the IIA survey, which also builds on CHS⁴. Computerised information and innovative property coincide well with the first two types in Young (1998) while economic competencies encompasses the next three types. The six types in the IIA survey (Software, RandD, Training, Business process improvement, reputation and branding, design) are quite similar to Young (1998), though where design is given a separate, and arguably more prominent, position as a type of intangibles investment.

The Innodrive approach (Görzig et al. 2010) also includes three categories: organizational capital, which relates to marketing and management, and research and development, relating to RandD work and to technical and

⁴ Though it should also be noted here that the CHS categorization includes a more detailed list of nine types of intangibles.

engineering work in general, and information and communication technologies. As general concepts, these types correspond fairly closely with those of CHS and the other typologies, though with the exception of types of investments that are primarily based on purchases of intermediate inputs (such as worker training). A later version of this method, developed in Innodrive project, is based on estimations of own-account investments combined with a multiplier to account for intermediate inputs.

While there appears to be much common ground in terms of the conceptualization of different types of intangibles investments, each measurement approach draws on in some cases very different types of data, and at different levels of aggregation. An important question is how these different approaches compare in their estimation of amounts of intangible assets. We will return to this question below.

4. Level of measuring intangible assets

With a macroeconomic research purpose in mind, the seminal work by Corrado et al. (2005) sets up a framework to measure intangible assets. It builds a set of estimated aggregate series of investments into an array of intangibles for the US economy in the 90's. Early empirical tests of the framework (Corrado et al. 2006; 2009) use macroeconomic US aggregate data to conduct a national growth accounting exercise. Corrado et al. (2013) makes an international comparison (including EU, UK and US) of growth accounting results. Corrado et al. (2014, 2017) takes the analysis to the industry level and investigates if and how intangibles affect sectoral growth. Empirical work using an expenditures based approach to measurement has been mainly grounded in the theoretical framework set up by CHS. (Marrano 2009, van Ark 2009, Squicciarini and Mouel, 2012, Roth and Thum 2013, Crass et al. 2015, Crass and Peters 2014).

Work by Hannu Piekkola on the other hand has investigated measures of intangibles from another angle. In terms of theorizing, he starts at a more disaggregated firm, assuming intangibles are created by firms expensing labor effort. The data used stems mainly from micro sources, i.e. linked employer-employee data, where available. Piekkola and Ilmakunnas (2013) measures the returns to three types of labor that create intangible capital by accounting for differences in their productivity compared with other labor inputs. Piekkola (2016) analyzes how well market equity measures of value capture intangible assets of Finnish firms for the period 1997-2011. Piekkola (2018) uses industry level data to find out to which extent intangibles have contributed to growth in the post financial crisis period 2008-2013 in a set of European Countries. Further, closely related work by Roth and Thum (2013) investigated the relation between labor productivity and intangibles, where their decomposition of intangibles follows CHS.

As pointed out earlier, a wide array of data sources have been used to construct measures for intangibles; national and sectoral accounts data, balance sheet and other accounting data (Bontempi and Mairesse, 2015; Cucculelli and Bettinelli 2015; Forte et al., 2017), recurrent data capture such as the Community Innovation Survey (e.g. Crass and Peters, 2014), dedicated surveys such as the 'Investment in Intangible Asset (IIA)

Survey' (e.g. Awani 2010) and linked employer-employee data (Piekkola, 2016, 2018; Ilmakunnas, and Piekkola, 2014).

The level of aggregation places constraints on the data sources that are available and thereby can potentially have influence on the definitions and measures of intangibles. On one hand, meso/macro studies can use data that is not available at the micro level and there is also no requirement for micro-linking of different data sources, which makes decomposing the measures easier. In empirical macro studies, the contribution of intangibles to growth (e.g. van Ark et al. 2009, Nakamura 2010, Corrado et al. 2013, Corrado et al. 2014, Niebel et al. 2017) has been extensively discussed. Meso/Macro studies have also addressed an array of other topics relevant to regional dynamics: the composition of intangible investment and its effect on market sector value added and labor productivity (Marrano et al. 2009), knowledge spillovers (Corrado et al. 2017), and complementarities between intangibles (Chen et al. 2016, Corrado et al. 2017).

Marrano, Haskel, and Wallis (2009) use the CHS definition of intangible capital to compare UK and US data and show what the difference is when intangibles are treated as capital instead of consumption. Niebel et al. (2017) and Chen et al. (2016) follow CHS in the types of intangibles used utilizing the INTAN-invest data source.

Micro studies on the other hand face additional data challenges. When the individual firm is the unit of observation and data from different sources are being used, micro-linking the data becomes a necessity in order to, for example, make the decomposition ala CHS possible. Potentially this perhaps tends towards the use of more narrow conceptualizations of intangibles for many micro studies. With (linked) micro data constructed however, finer-grained questions can be addressed. Cucculelli and Bettinelli (2015) find that a firm's chosen business model is one important factor in how intangibles impact firm performance. Forte et al. (2017) more broadly investigate the drivers of IC value at the firm level and find, amongst other things, that knowledge management is important for all firms, also outside the KIBS (Knowledge intensive business services) sector. In line with this, Crass and Peters (2015) find strong positive productivity effects of intangible assets in a representative cross section of the economy. In addition, Ilmakunnas, and Piekkola (2014) find evidence for this positive relation in Finish register data. Other studies find evidence of complementarities between certain specific types of intangibles (Brynjolfsson et al. 2007, Crass and Peters 2014), further underscoring the importance of firm level analysis.

5. Conclusion

This article sets out to review the literature on intangibles from the perspective of measurement. A number of studies have helped to further work on the measurement of intangible assets, both at the macro and micro level. This also includes both technical types of intangibles (such as R&D and software) and broader forms of intangible such as organizational competences. However, there is a large gap between the broad measurement of intangible assets in many studies, such as Corrado et al. (2009) and Görzig et al. (2010), and the more

limited set of intangibles that are treated as capital formation in accounting practices or national accounts. In addition, a broad range of different data sources have been used to measure intangible assets, complicating comparison across studies.

In order to bridge this gap, further work is needed, both concerning the estimation of 'technical' aspects such as depreciation rates and deflators, and in the continued testing and comparison of different measurement efforts. Many opportunities exist to aggregate across or cross-validate between the measures that are currently being used, enhancing our understanding of the properties of these measures. And, while it faces greater challenges in terms of data availability, micro-based work will be important for the estimation of depreciation rates and in better understanding (and thereby better measuring) of broader forms of intangibles, which can thereafter inform measurement at more aggregated levels.

6. References

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7. Appendix A. Intangible Projects

Here we present an overview of the methods used in past projects. Additional information on these project is found in the table below. The table also includes basic information on three new H2020 projects that consider intangibles, measurement, and the role of intangibles in solving the productivity puzzle. These three projects are: Globalinto, Microprod and Growinpro.

The INNODRIVE project established a new micro-level method where intangibles are calculated based on intangible producing employees. The method, which utilizes LEED (linked employer employee data, including employee data on occupations, education and salary), is described above in Görzig et al. (2010). The Innodrive project divides intangibles into three subgroups. Information communication technology (ICT), organizational capital and broad research and development (RD) capital.

INTAN-invest is a research collaboration between C. Corrado, J. Haskel, C. Jona-Lasinio , M. Iommi and provides open data for intangible capital in 14 EU countries from 1995 to 2010. The data is aggregated at sector level with a harmonized calculation for each of the countries. The methodology of INTAN-invest differs from INNODRIVE. INTAN-invest provides investment expenditures of design, advertising and market research, organizational capital and training. Data for RandD and organizational capital stems from Eurostat. National Accounts provide “software, mineral exploration and spending on the production of artistic originals”. The “Continuing Vocational Training Survey” and “Labor Cost Survey” are used as the sources for training expenditure.

CO-INVEST, *Competitiveness, Innovation and Intangible Investments in Europe*, is a sister project to INNODRIVE that has three types of intangibles: computerized information, innovative property, and economic competencies following Intan-invest. Co-invest compared intangible investments at the macro level between several European countries and developed micro measurements of intangible capital. CO-invest also

studied accounting data to explain book value puzzle in German and US firms and performed a survey in UK to better understand the costs associated in intangible capital expense.

Furthermore, Co-invest discussed the capitalization of design (Galindo-Rueda, Haskel, and Pesole, 2011). They calculate own account design from employees classified in design related occupations.

The **SPINTAN** project developed public sector intangibles to measure the innovativeness within the public sector and non-profit institutions⁵. The project complements the INTAN-invest project by developing intangibles measures for “non-market” industries⁶. *Cultural assets* are a novel inclusion.

The **IAREG** project looks at how intangible assets support regional economic growth and productivity, innovation process and knowledge accumulation. The project divided intangible assets into knowledge, human, social and entrepreneurship capital and measured them with indicators.

SERVICE-GAP focused on the services and their role to the European economic performance. They found that the service sector was less affected by the financial crises than other sectors and the reason seems to be weaker exposure to international trade. Service-Gap researched productivity puzzle with intangible investments and links between manufacturing and services.

INDICSER is a sister project to Service-gap aiming to understand the impact of services into European economic growth. INDICSER builds on CO-INVEST, INNODRIVE and IAREG.

CRE8TV inspected the relation of creativity to innovation and European growth. The project mapped creative industries, defined different models of creativity and innovation. Further, CRE8TV explored entrepreneurship in creative industries and property rights in creative industries. CRE8TV suggest identifying creative industries with a creative intensities approach that uses the intensity of creative workers. They call for wider understanding of innovation inputs than RandD and give design as an example. The project also notes that the size of creative industry firms can be larger than the number of directly employed personnel due to freelancers and network.

E-FRAME measured well-being, societal progress, and sustainability, social and human capital⁷. The project follows the Intan-invest project to go beyond the GDP.

⁵ Exclusions include: religious organizations and membership organizations serving business (SPINTAN manual p. 7)

⁶ Research and development, Public administration and defense; compulsory social security; Education; Human health activities; Residential care and social work activities; Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; Gambling and betting activities; sports activities and amusement and recreation activities. Source: SPINTAN manual, p.5 and 88

⁷ <http://www.eframeproject.eu/index.php?id=20>

Table A. Intangible Projects

Project name	Brief Description	Participants	Time period	Intangibles	Link/reference
Growinpro	The project will investigate the causes of the economic slowdown in Europe and propose an integrated policy package for sustainable and inclusive growth.	Multinational, coordinated by Scuola Superiore Di Studi Universitari e di Perfezionamento Sant'Anna	Jan 2019- Dec 2021	- measurement of intangible assets: index and surveys - level: micro - Data sources: Digital Use Index; Digital Tasks Index and Digital Skills Index (Cirillo, Evangelista, Guarascio, and Sostero, 2019)	https://cordis.europa.eu/project/rcn/218765/factsheet/en http://www.growinpro.eu/
Microprod	The project aims to provide explanations to recent productivity puzzle, improving our understanding of productivity, its drivers and the way that we measure productivity.	Multinational, coordinated by Leibniz-Institut Für Wirtschaftsforschung	Jan 2019- Dec 2021	Intangibles mentioned in the abstract -measurement of intangible assets: -level: micro -Data sources: LEED, RandD, IPR, firm-to-firm transactions	https://cordis.europa.eu/project/rcn/218761/factsheet/en http://www.microprod.eu/
Globalinto	The project aims to provide new measures of intangible assets at the firm level, and to analyse the various potential explanations of the productivity puzzle, both at	Multinational, coordinated by University of Vaasa, Finland	Feb 2019- Jan 2022	Measurement of intangibles at both micro and macro level. Data sources: LEED,R&D, Innovation, R&D, ICT,	https://cordis.europa.eu/project/rcn/218762/factsheet/en www.globalinto.eu



This project has received funding from the *European Union's Horizon 2020 The mechanisms to promote smart, sustainable and inclusive growth* under grant agreement No 822259.

	micro and macro levels. The project will bring further the earlier work by the EU FP7 Innodrive project.			Input-output data, new survey data	
Spintan	The project aimed to explain economic growth with intangibles. The measurement of intangibles was developed to include public sector. Hence, the project aimed to inform innovation policy and show the big role the intangibles of public sector play in the economic growth.	Multinational, coordinated by Instituto Valenciano De Investigaciones Economicas	Dec 2013- Nov 2016	- measurement of intangible assets: follows Corrado, Hulten, and Sichel (2005a) but expands it to public sector - level: meso - data sources: Intangibles for non-market sector: National and EU Labor Force Surveys - Earnings only for UK and US, EU Structure of Earnings Survey (SES), EU SILC - Individual survey, Enrolment statistics from Eurostat and US National Center for Education Statistics, Life Tables (Corrado, Jäger, and Jona-Lasinio, 2016, p. 5:5).	https://cordis.europa.eu/project/rcn/111389/brief/en

<p>Innodrive</p>	<p>Innodrive aimed to improve our understanding of the economy with new data on intangible capital and showing how intangible capital supports economic growth. Innodrive provided a new measure of intellectual capital assets (e.g. human capital, RandD, patents, software and organizational structures).</p> <p>Innodrive used linked employer-employee datasets, where available, at the micro-level to estimate intangible capital. At the macro-level, Innodrive provided new estimates of intangible capital at the national level and an evaluation of the contribution of intangible capital to the growth process.</p>	<p>Multinational, coordinated by prof Piekkola, University of Vaasa</p>	<p>March 2008-Feb 2011</p>	<p>- measurement of intangible assets: develops a new intangible capital approximation with three sub groups: (broad) RandD, ICT and organizational capital.</p> <p>- level: micro</p> <p>- data sources: national registers: linked employer employee data sets. (Görzig et al., 2010)</p>	<p>https://cordis.europa.eu/project/rcn/88898/brief/en</p> <p>http://www.innodrive.org/</p>
<p>Coinvest</p>	<p>The project aims to understand the contribution of intangible investments to innovation, competitiveness, growth and</p>	<p>Multinational, coordinated by prof Haskel, College London</p>	<p>May 2008-Sept 2010</p>	<p>- measurement of intangible assets: baseline framework is Corrado et al. (2005a): computerized</p>	<p>http://www.coinvest.org.uk/bin/view/CoInvest</p>

	<p>productivity in Europe. This aims to help EU policy formation and to deepen understanding of some of the most crucial questions facing EU economic policy. The reason is simple. Currently, (almost all) intangible investments are either not measured, or are treated as an intermediate input into production so they are assumed to produce no durable assets for firms or economies.</p>			<p>information, innovation property and economic competency. Additionally, Co-invest develops capitalization of design (Galindo-Rueda, Haskel, and Pesole, 2011)</p> <ul style="list-style-type: none"> - level: sector - data sources: Input-output tables, CIS, Business Enterprise RandD data (BERD) 	<p>http://www.coinvest.org.uk/pub/CoInvest/CoinvestProjects/D6_coinvest_217512.pdf</p> <p>COINVEST. (2010). Final report. Retrieved from http://www.coinvest.org.uk/pub/CoInvest/CoinvestProjects/COINVEST_217512_D21.pdf</p>
IAREG	<p>IAREG (Intangible Assets and Regional Economic Growth) aims to analyze the role of intangible assets in the development of innovation, competitiveness, economic growth and regional productivity. IAREG emphasizes the geographical space in their analyses.</p>	<p>Multinational, coordinated by Universitat de Barcelona</p>	<p>Feb 2008 – July 2010</p>	<ul style="list-style-type: none"> - measurement of intangible assets: indicators for the following: knowledge capital, human capital, social capital and entrepreneurship capital, - level: micro - data sources: <ul style="list-style-type: none"> 1) qualitative case study approach with interviews 	<p>https://cordis.europa.eu/project/rcn/88565/factsheet/en</p> <p>final report: https://cordis.europa.eu/docs/results/216/216813/118296721-6_en.pdf</p>

			<p>of senior manager and technical staff in Germany and UK (Kramer, Diez, Marinelli, and Iammarino, 2009).</p> <p>2) The final report mentions the following data sources</p> <p>UK Regionalised Community Innovation Survey 2002-2004, Work Research Center (Tampere) Finnish Organizational Innovation Survey, RUW Stratified Survey of Academics in top 201 European Research Universities (2009), French National Association for Research and Technology) database on RandD collaborations in Telecommunication and Microelectronics, The University of Pécs (UP) Library and the Science</p>	
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				Direct and EBSCOhost publication databases, OECD REGPAT database	
Service-gap	The primary objective was to produce a comprehensive study on the impact of market services on aggregate economic growth in the EU and compare it to competitor regions, especially the US. The research is divided into three areas: 1) productivity and its drivers in service industries; 2) firm strategies in the knowledge-based economy and 3) internationalization of service markets and growth.	Multinational, coordinated by The University of Birmingham	March 2010 – Feb 2013	- measurement of intangible assets: uses intangibles developed at INDICSER project (as stated in https://cordis.europa.eu/project/rcn/92995/reporting/en). - level: sectoral - data sources: CIS, some country specific surveys	https://cordis.europa.eu/project/rcn/92995/factsheet/en http://www.case-research.eu/en/servicegap-the-impact-of-service-sector-innovation-and-internationalisation-on-growth-and
CRE8TV	The project investigated the role of creativity for innovation and growth in Europe. The Cre8tv project identified the creative industries and models of creativity, design and innovation. The project also discussed entrepreneurship in creative industries and digital ecosystems and platforms.	Multinational, coordinated by the University of Manchester	Feb 2013 – Apr 2016	- measurement of intangible assets: creativity - level: micro - data sources: CIS, creative industries and creative occupations (LEED), Community Trademarks, intellectual property rights (patents,	https://cordis.europa.eu/project/rcn/106719/factsheet/en Final report: https://cordis.europa.eu/docs/results/320/320203/final1-cre8tv-final-report-16-september-2016.pdf

				<p>trademarks, registered designs)</p> <ul style="list-style-type: none"> - They call for new methods to study creative industries and design. 	
e-Frame	<p>Now, even to policy level recognizes the need to go beyond GDP for well-being measure and societal progress.</p> <p>e-Frame developed well-being measures and analysis for policy.</p>	<p>Multinational, coordinated by Istat, Donatella Fazio</p>	<p>Jan 2012 – June 2014</p>	<ul style="list-style-type: none"> - measurement of intangible assets: indicators of wellbeing and INTAN-invest - level: macro - data sources: such as: the Capability Index (CI) – measure of quality of life , happy planet index 	<p>http://www.eframeproject.eu/</p> <p>Map on policy use of progress indicators, p 36-38</p> <p>http://www.eframeproject.eu/fileadmin/Deliverables/Deliverable11.1.pdf</p>
Indicser	<p>The project aimed to fill the gap in the information about the performance of service sectors. The project developed indicators for evaluating service sector performance.</p> <p>Indicser estimated intangible investments and capital with novel estimates for firm specific</p>	<p>Multinational, coordinated by The University of Birmingham</p>	<p>Jan 2010 – Dec 2012</p>	<ul style="list-style-type: none"> - measurement of intangible assets: indicators - level: micro - data sources: BERD, CIS <p>http://www.indicser.com/images/RP1_Saam_etal.pdf</p>	<p>https://cordis.europa.eu/project/rcn/93023/factsheet/en</p> <p>http://www.indicser.com/index.php</p>

	human capital and firms' own account organizational capital. It developed composite indicators for innovation and ICT use and new measures for labor market regulation and the market environment.				
Neujobs	Overall, the project aimed to analyze future possible developments of the European labor market(s) under the main assumption that European societies are in the process of facing main transitions, which will concern specific sectors of the economy and certain groups of the labor force.	Multinational, coordinated by Center for European Policy Studies (Belgium)	Feb 2011 – Jan 2015	- measurement of intangible assets: human capital, education - level: micro - data sources: Household data: micro data from the ECHP and EU-SILC surveys.	https://cordis.europa.eu/project/rcn/99646/factsheet/en
Inno-europe	Intangibles in Finland and Europe as source of future growth	University of Vaasa, Hannu Piekkola	2013-2014	Innodrive	
Innomitta II	The project analyzes the time series of intangible capital in Denmark and Finland.	PTT, VTT, University of Vaasa, Tilastokeskus, Aarhus University	Jan 2015 – Dec 2016	Innodrive	http://www.ptt.fi/julkaisu-ja-hankkeet/kaikki-hankkeet/innomitta-ii-critical-competences-for-value-creation-in-the-

					danish-and-finnish-manufacturing.html https://www.vtt.fi/inf/pdf/technology/2017/T302.pdf
Intan-invest	<p>Research collaboration dedicated at improving the measurement and analysis of intangible assets.</p> <p>INTAN-Invest disseminates harmonized cross-county data on intangible investment by industry covering 15 EU countries and the United States from 1995 on.</p>	Corrado, Haskel, Jonas Lasinio, Iommi	-2016	<p>- measurement of intangible assets: Computerized information, Innovation property, Economic competencies</p> <p>- level: macro</p> <p>- data sources: National accounts, Eurostat (BERD), the Structure of Earning survey or the Labor Force survey, Use Tables (Corrado, Haskel, Jonas Lasinio, and Iommi, 2018)</p>	http://www.intaninvest.net https://www.eib.org/attachments/efs/investment_and_investment_finance_in_europe_2016_en.pdf

8. Appendix B. Literature Review Table

Table B. Literature Review

Reference and Title	MAIN PURPOSE OF THE PAPER <i>Quote from the paper that summarizes setup and/or motivation of the paper.</i>	DATA Indicates the data used in quantitative work. (Measurement aspects are highlighted in bold .)	METHOD Brief description of the paper's method. (Measurement aspects are highlighted in bold .)	RESULTS Summarized or <i>quoted</i> results.
<u>Awano 2010</u> Measuring investment in intangible assets in the UK: Results from a new survey.	<i>"This article presents results of the Investment in Intangible Asset (IIA) Survey launched by ONS in October 2009. It is a new and unique survey of firms in the UK, drawn from the business register to represent the market sector of the economy."</i>	Data collected with Investment in Intangible Asset (IIA) Survey , launched by ONS in October 2009.	The IIA survey Measures investment of firms in six categories of intangible assets , these are: employer funded training, software, research and development (RandD), reputation and branding, design, and business process improvement. Additionally the IIA survey sets out to measure the life lengths of investments in each asset.	Considerable overall IA spending in the UK is detected. The incidence, expenditure levels and life lengths of these IA are explored.
<u>Bontempi and Mairesse 2015</u> Intangible capital and productivity at the firm level: a panel data assessment.	<i>"The econometric literature on measuring returns on intangible capital is vast, but we still know little about the effects on productivity of different types of intellectual capital (RandD and patents) and customer capital (trademarks and advertising)."</i>	Firm level data on both: <ol style="list-style-type: none"> intangibles measured from expenditures intangible assets reported by companies in their balance sheets (a measure which is available in the Italian context, for example, but less common in the literature) 	Marginal productivity estimates for different types of intangibles. Production function estimates applied on a large panel of Italian firms. Analysis are ran for <u>both</u> types of intangible measurement.	The analysis confirms that having accounting information on intangible assets (as reported in companies' balance sheets) is useful for our understanding of the relation between intangibles and productivity .
<u>Bontis 2001</u> Assessing knowledge assets: A review of the models used to measure intellectual capital.	<i>"Since knowledge assets are at the crux of sustainable competitive advantage, the burgeoning field of intellectual capital is an exciting area for both researchers and practitioners. Unfortunately, the measurement of such intangible assets is difficult. A variety of models have surfaced in an attempt to measure IC and this paper aims to highlight their strengths, weaknesses and operationalization"</i>	Literature Review stemming from 2001.	Review of existing IC measurement models: Each section reviews the assumptions of a measurement model and describes its main conceptualizations as well as its strengths and weaknesses.	Pursuing (inter)national accounting standards for IC disclosure might be harmful given the nascent stage of research development. Voluntary disclosure is the only short-term solution for companies wanting to appease their audience.

<p><u>Brynjolfsson et al. 2007</u> Intangible Assets: Computers and Organizational Capital.</p>	<p><i>“Whereas early applications of computers were primarily directed at factor substitution (particularly of low-skill clerical workers), modern uses of computers have both enabled and necessitated substantial organizational redesign and changes in the skill mix of employees. Collectively, this research argues for a complementarity between computer investment and organizational investment, ...This paper analytically explores the hypothesis that new, intangible organizational assets complement IT capital...”</i> <i>We study how the financial markets can be used to help identify such assets.</i></p>	<p>Panel of computer capital (= Computer Intelligence Infocorp (CII) installation database) and stock market valuation data (= compustat) for 1,216 firms over the 1987-97 period, matched to a cross-sectional survey of organizational practices conducted in 1995 and 1996.</p>	<p>Market value approach. Production function framework.</p>	<p><i>“The financial markets treat the organizational assets associated with IT much like other assets that increase long-term output and profits.”</i> Results provide evidence for complementarity in terms of value creation between computers and organizational assets.</p>
<p><u>Chen et al. 2016</u> Are intangibles more productive in ICT-intensive industries? Evidence from EU countries.</p>	<p><i>“There is much firm-level evidence that maximising productivity benefits from investments in information and communication technologies (ICT) requires complementary investments in organizational structures, employee training, and other intangible assets. Yet convincing macro-level analysis to quantify the importance of this effect was not possible until industry-level data on investment in intangibles were developed.”</i></p>	<p>The data set used in this paper is a breakdown of the INTAN-Invest database by industry as developed by the INDICSER project, i.e. cost approach.</p>	<p>Production function estimates... distinguishing between NICT ICT and intangible capital components ...further augmented with interaction terms to gauge complementarity.</p>	<p><i>“The research shows that the output elasticity of intangible capital is stronger in more ICT-intensive industries. This suggests that intangible capital and ICT capital are complements in production.”</i></p>
<p><u>Corrado et al. 2018</u> Intangible investment in the EU and US before and since the Great Recession and its contribution to productivity growth.</p>	<p>Growth accounting in the light of the Great Recession.</p>	<p>Revised and updated INTAN-Invest dataset (i.e. cost approach)</p>	<p>Cross-country cross-industry growth accounting.</p>	<p>Tangible investment fell massively during the Great Recession. The slowdown in labor productivity since the Great Recession, growth was mainly driven by TFP growth slowing, tangible and intangible capital played minor role.</p>

<p><u>Corrado et al. 2017</u> Knowledge Spillovers, ICT and Productivity Growth.</p>	<p><i>"In light of previous evidence on spillovers from private RandD (e.g., Griliches, 1992; Griffith, Redding and Van Reenen, 2004), it is perhaps unsurprising to find a correlation between intangible capital deepening and TFP growth consistent with spillovers to intangible capital. But private RandD stocks are estimated to be only one-third of the total private stock of intangible assets, suggesting a more thorough investigation of the relationship between non-RandD intangible capital and productivity growth is warranted."</i></p>	<p>a new data set on intangible investment (INTAN-Invest) in conjunction with EUKLEMS productivity estimates for 10 EU member states from 1998 to 2007.</p>	<p>econometric analysis</p>	<p><i>Output elasticity of intangible capital depends upon ICT intensity, consistent with complementarities between ICT and intangible capital.</i> <i>Non-RandD intangible capital has a higher estimated output elasticity than its factor share, as does an index of labour composition (consistent with growth spillovers from investments in knowledge-based/intangible capital and skills).</i></p>
<p><u>Corrado et al. 2014</u> Intangibles and industry productivity growth : Evidence from the EU.</p>	<p><i>"As overall business intangible investment is large and growing in advanced countries (Corrado et al 2013) the development of harmonized methods and measures of intangible capital at a higher level of industry detail is essential for a deeper understanding of the sources of growth and for the design of macroeconomic policies aimed at stimulating sustained growth, competitiveness and sustainable development. "</i></p>	<p>We set out intangible investment data by industry for 14 EU countries in 1995-2010 (newly produced INTAN-Invest industry measures)</p>	<p>Industry growth accounting incorporating these data for 8 countries</p>	<p><i>Intangible investment has grown in manufacturing and services, but most strongly in services. The contribution of intangibles to labour productivity growth is similar in both manufacturing and services and in the high growth economies (Austria, Germany, Finland, France, Netherlands, UK) exceeds the contribution of labour quality</i> <i>The very large size of the service sector means that countries with good manufacturing but poor service productivity growth (Germany and France) have done relatively badly overall and those with good service sector growth (UK, Netherlands) have performed well</i> <i>Spain and Italy have very low labour productivity growth due to very low TFP growth.</i></p>

<p><u>Corrado et al. 2013</u> Innovation and intangible investment in Europe, Japan, and the United States</p>	<p><i>"Everyone seems to think Europe needs some innovation. Innovation to improve a broken financial system, innovation to shore up the Eurozone, innovation to boost economic growth. So we have a profusion of agencies, indices and think tanks competing to offer ideas. The UK produces an innovation index.1 The EU an innovation scoreboard. The OECD an innovation strategy. But what exactly is innovation? How is it measured? What policy works and what should be discarded? Among this melee of activity, there seems surprisingly little agreement."</i></p>	<p>Country/region level (INTAN invest) <i>harmonized time series of intangible investment for the EU27 member countries and Norway and the US in 1995–2005, and for the EU15 economies, the US plus the Czech Republic and Slovenia, we add the years 2006–9.</i></p>	<p>International comparison of growth accounting results</p>	<p><i>The UK, like the US now has more intangible investment than tangible investment, and other EU countries are following. That is to say, future investment will look much more intangible than tangible. Second, this investment is important for growth. In the US, capital deepening is 65% of growth and intangible investment is now 50% of capital deepening. EU countries will be catching up to this level.</i></p> <p><i>This paper suggests there are possible spillover indications that are wider than just RandD.</i></p>
<p><u>Corrado et al. 2006 (and 2009 WP)</u> Intangible Capital and US Economic Growth</p>	<p><i>"Published macroeconomic data traditionally exclude most intangible investment from measured GDP. This situation is beginning to change, but our estimates suggest that as much as \$800 billion is still excluded from U.S. published data (as of 2003), and that this leads to the exclusion of more than \$3 trillion of business intangible capital stock."</i></p>	<p>Macroeconomic (US): '50 s to '00 s</p>	<p>Estimation of (past) GDP by adding intangibles as capital in a SOG framework.</p> <p>Conceptualisation of Intangibles = CHS (2005)</p>	<p><i>A lot of intangible assets are still unaccounted for in GDP. Capital deepening becomes dominant source of labour productivity growth, role of MFP is correspondingly diminished. Labor's income share is found to have decreased significantly over the last 50 years.</i></p>
<p><u>Corrado et al. 2005</u> Measuring Capital and Technology: An Expanded Framework In Measuring Capital in the New Economy.</p>	<p><i>"... great progress has been made in applying the sources-of-growth framework to the analysis of economic growth, doubts have nevertheless been raised about our ability to understand and measure fully the fundamental sources of growth. For example, despite several decades of rapid technological advance in information technology, one of the originators of the sources-of-growth model, Solow (1987) remarked..."</i></p>	<p>Statistical agencies have addressed several data concerns concerning SOG in the new economy, however conceptual work has yet to follow... <i>goal of this paper is to expand the conceptual framework of the sources-of-growth model by linking it to a variant of the standard model of intertemporal choice developed in Hulten (1979)</i></p>	<p>Theoretical conceptualization:</p> <p>Components of IA = EC, IP, ICT EC= Economic Competencies IP= Innovative Property ICT = Information and Communication Technology</p> <p><i>In the expanded framework any outlay that is intended to increase future rather than current consumption is treated as a capital investment.</i></p>	<p><i>There is no basis from the consumers' point of view for treating investments in intangible capital differently from investments in plant and equipment, or tangible capital.</i></p>

<p><u>Crass et al. 2015</u> Intangible assets and investments at the sector level: Empirical evidence for Germany.</p>	<p><i>"In Europe, policy has acknowledged that nowadays knowledge has become a key factor for firms to survive and grow in the increasingly globalised economy. This had already found expression in the last decade in the Lisbon agenda that aimed to make the EU "the most competitive and dynamic knowledge-driven economy by 2010" and also in the current EU2020 strategy that emphasizes that growth should be smart, sustainable, and inclusive. Smart growth means developing economies based on knowledge and innovations. Thus strengthening the efficiency and competitiveness of firms in the knowledge driven economy is a major challenge that the EU economies are currently confronted with. A key characteristic of knowledge is its intangible nature which makes it hard to measure its amount, quality or effects. "</i></p>	<p>German Sectorial data: EU KLEMS November 2009 German turnover tax statistics Analytical Business Enterprise Research and Development database (ANBERD). Community Innovation Survey gross advertising expenditure published by the Central Association of the German Advertising Industry (ZAW) ...</p>	<p>Decomposition of Growth in Real Gross Output at the Industry Level alla CHS.</p> <p>Comparison between Germany and UK.</p>	<p><i>German firms have boosted investments in intangible capital from 1995 to 2006 by 30%. In nearly all sectors investments in design and computerized information are larger in the UK. In contrast, German firms invest a higher proportion of gross output in RandD in all sectors, and advertising is also more common except for the sector trade and transport. Intangible assets have stimulated labour productivity growth in all sectors.</i></p>
<p><u>Crass and Peters 2015</u> Intangible Assets and Firm-Level Productivity.</p>	<p><i>"Firms invest huge amounts into intangible assets. This paper explores to which extent different kinds of intangible assets are conducive to firm-level productivity. Our study contributes to the literature by simultaneously comparing productivity effects of innovative capital, human capital, branding capital and organizational capital and testing whether complementarity or substitutability exists between different intangible assets."</i></p>	<p>Using panel data for the period 2006-2010, following to a large extent the conceptual framework of Corrado et al. (2009) Mannheim Innovation Panel (MIP).</p>	<p>Our results are robust to various parametric (OLS, FE) and non-parametric (Olley and Pakes, Levinsohn and Petrin) productivity estimation methods.</p>	<p><i>Even when controlling for a comprehensive set of intangible assets, we find strong positive productivity effects for RandD, brand capital and firm-specific human capital. We also find positive long-term productivity effects for firms investing in innovative capital and branding capital. We find RandD and patent stocks to be complementary. Furthermore, the results show innovative capital and human capital on the one hand and innovative capital and branding capital on the other hand to be complements with respect to productivity.</i></p>

<p><u>Cirillo et al. 2019</u> Digitalization, routineness and employment: An exploration on Italian task-based data.</p>	<p><i>“The digital revolution is widely expected to change economic and social paradigms, in the same way that previous technological revolutions have shaped long-term cycles of economic growth and structural change (Freeman and Louçã, 2001; Brynjolfsson and McAfee, 2014). There is however less agreement regarding the effects of digitalization on employment”</i></p>	<p>INAPP-ISTAT - data from a unique profession-level survey on skill, task and work contents Survey on Italian Occupations (ICP) O*NET-type dataset.</p>	<p>Development of three novel digitalization indices. Descriptive and analytical exploration of the extent of “routine-biased technological change”, specifically associated with digital technologies and identifying occupations at risk of automation.</p>	<p><i>Results show the multifaceted nature of both digitalization and routineness, phenomena characterized by strong sectoral specificities and by being strongly associated with the skill content of labour professions. Professions characterized by higher digital skills are those growing faster compared to the others (although this holds only in manufacturing sector). Both the descriptive and econometric evidences show a negative employment dynamics among professions combining high level of digitalization and routineness.</i></p>
<p><u>Cucculelli and Bettinelli 2015</u> Business models, intangibles and firm performance: evidence on corporate entrepreneurship from Italian manufacturing SMEs.</p>	<p><i>Despite the acknowledged importance of this CE element, BM innovation studies are generally limited to the context of large, leading firms, usually in the high-tech and service sectors (Schneider and Spieth 2013). This has left BM innovation in small and medium enterprises (SMEs) largely unexplored, particularly in manufacturing sectors, despite their acknowledged worldwide economic relevance (Ayyagari et al. 2007).</i></p>	<p>Longitudinal data set of Italian SMEs in the clothing sector which combined company financial information (i.e. BvD) with survey data (i.e. interviews) on firms’ BM and intangibles over the period 2000–2010.</p>	<p>transactional event study</p>	<p><i>Modification of the BM had a positive effect on the ability of the firm to perform well. Intangibles also showed a positive impact on performance .The evidence of complementarity was confirmed: companies that linked a modification of their BM to an investment in intangible assets were found to be better performers than those that did not. The more innovative the BM change, the greater the effects on performance and the more robust the positive moderation role of intangibles.</i></p>

<p><u>de Rassenfosse 2017</u> An assessment of how well we account for intangibles.</p>	<p><i>“Estimates of intangible capital stock are of prime importance for accurate measurement of productivity growth. Aggregate intangible capital stock is usually estimated using the so-called Corrado-Hulten-Sichel (CHS) new growth accounting framework. Yet this framework has not received much academic scrutiny to-date. This article proposes a validity test of two intangible investment series in the CHS framework, namely “brand equity” and “architectural and engineering designs.”</i></p>	<p>Comparison of investment series alla CHS to intangible output indicators, nl. trademarks/industrial designs. Data from 1980-2010, but with gaps, i.e. unbalanced</p>	<p>Time series regresions.</p>	<p><i>The results suggest that brand equity investment is a powerful predictor of trademark applications. However, investment in design activity is not correlated with the count of design rights, which I take as evidence that current methodologies do not account well for design activities.</i></p>
<p><u>Eisfeldt and Papanikolaou 2014</u> The value and ownership of intangible capital.</p>	<p><i>“Intangible capital which relies on essential human inputs, or “organization capital,” presents a unique challenge for measurement. Organization capital cannot be fully owned by firms’ financiers, because it is partly embodied in key labor inputs. Instead, cash flows must be shared with key talent and thus neither book nor market values will fully capture its value. Measurement of organization capital requires a model featuring these unique property rights. ”</i></p>	<p>All variables are from Compustat (measures constructed following Eisfeldt and Papanikolaou 2013)</p>	<p>Theoretical model development Tested on the data.</p>	<p>The authors find evidence for the claim that <i>when measuring intangible capital, key talent’s claim to that capital in the form of compensation is a quantitatively important consideration.</i></p>
<p><u>Eisfeldt and Papanikolaou 2013</u> Organization capital and the cross-section of expected returns.</p>	<p><i>“Organization capital is a production factor that is embodied in the firm’s key talent and has an efficiency that is firm specific. Hence, both shareholders and key talent have a claim to its cash flows. We develop a model in which the outside option of the key talent determines the share of firm cash flows that accrue to shareholders. This outside option varies systematically and renders firms with high organization capital riskier from shareholders’ perspective.”</i></p>	<p>All variables are from Compustat.</p>	<p>Theoretical model development and calibration. Tested on the data.</p>	<p><i>We find that firms with more organization capital have average returns that are 4.6% higher than firms with less organization capital.</i></p>
<p><u>Forte et al. 2017</u> Measuring the intellectual capital of Italian listed companies</p>	<p><i>“This paper contributes to the IC literature as it is the first study which applies the market capitalization approach to analyze IC value determinants in the Italian context.”</i></p>	<p>Accounting, financial market and corporate governance data are collected from the AIDA and ORCID databases. Sample of 140 Italian corporations over the period 2009-2013. ROE is used as a firm profitability indicator from the perspective of an equity investor.</p>	<p>A holistic market-based approach relationship between IC value and selected determinants from the extant literature is tested using a pooled OLS regression model, controlling for time.</p>	<p><i>The results show that IA [recognized on the balance sheet], profitability, leverage, industry type, auditor type, and family ownership positively affect IC value, whereas SIZE and AGE negatively affect IC value. Moreover, the findings of the robustness tests suggest that all firms, and not just knowledge-intensive business service industry firms, manage knowledge.</i></p>

<p><u>Galindo-Rueda et al. 2008</u> How much does the UK employ, spend and invest in design?</p>	<p>"Our starting point is that (a) innovation arises from increasing knowledge in the economy and (b) design spending is but one part of the investment in that knowledge stock. The extent to which such spending translates into increased output is an important ultimate aim of this stream of work, but our focus here is on better measurement of expenditure and investment in the design sector."</p>	<p>UK input-output supply-use tables</p>	<p>Estimation of aggregates based on the data.</p>	<p><i>Our main results are (a) in 2004 private sector spending on purchased design services was around £17bn, (b) spending on own-account design services about £27bn; (c) investment in design is around half these total and (d) manufacturing accounts for about 50% of total design spending.</i></p>
<p><u>Görzig et al. 2010</u> Production of Own Account Intangible Investment: Methodology in Innodrive Project.</p>	<p><i>"Purchased intangibles that are incorrectly classified as intermediate consumption underestimate the first item. If expenditures for labor, intermediates, and capital usage combine to create intangible capital goods, then we have own account production. If this is neglected, the last item is underestimated. In both cases value added is underestimated. Depending on the depreciation of intangible capital, operating surplus may also be underestimated"</i></p>	<p>linked employer-employee data for 6 countries</p>	<p>Developing a methodology to estimate production of intangible investment at the national level Comparison of an expenditures-based and performance based approach.</p>	<p><i>In the analysis conducted by INNODRIVE in Finland, Norway, the UK, Germany, Czech Republic and Slovenia, the total shares of intangible capital type workers do not differ much from one country to another, and are typically around 18% of all workers</i> ...</p>
<p><u>Hunter et al. 2012</u> Accounting for the Expenditure on Intangibles</p>	<p><i>"In search of a unifying measurement feature on which to base a more systematic and potentially comprehensive analysis of intangibles, this paper first analyses the economic and accounting properties of intangibles, and second, empirically evaluates managerial practices for measuring and analysing expenditure on intangibles."</i></p>	<p>Dedicated survey of 614 large Australian firms (drawn from the IBISWorld database of the largest firms in Australia)</p>	<p>Literature analysis linked to survey descriptive statistics.</p>	<p><i>Our evidence suggests GAAP has a role to provide guidance that helps firms identify and classify their expenditure on intangibles in ways that elucidate the strategic implications of the different types of intangibles for future output.</i></p>
<p><u>Ilmakunnas, and Piekkola 2014</u> Intangible investment in people and productivity.</p>	<p><i>"According to the World Bank, intangible capital (i.e., human capital, trust, and the value of institutions) constitutes the largest share of wealth in virtually all countries. ... In this study, we examine how intangible capital is created at the firm level and how it contributes to value added."</i></p>	<p>Finnish firm-level, Linked employer-employee, data from 1998 to 2008. Rather than measuring intangible capital directly, we adopt the view that intangible capital is linked to employees who are engaged in long-term planning, which refers to organizational capital (OC), RandD, and information and communicational technology (ICT) work.</p>	<p><i>The method involves the inclusion of employee group shares in a production function to measure the relative productivities of the groups. Specific attention is given to the use of the Olley-Pakes/Levinsohn-Petrin approach to account for the possibility that a firm's decisions are correlated with productivity shocks. We use the novel idea that hiring can serve as a proxy for productivity shocks.</i></p>	<p><i>Tough the service sector is heterogeneous, we find that organizational work has the highest positive overall effect on productivity in this sector. organizational work also clearly improves the profitability of high-productivity firms, which is explained by savings in labor costs.</i></p>

<p><u>Jona-Lasinio et al. 2011</u> National Measures of Intangible Capital in the EU-27 and Norway</p>	<p><i>This article provides an overview of the methodology adopted in the INNODRIVE project to measure gross fixed capital formation (GFCF) at the macroeconomic level and illustrates the main data sources used to estimate intangible GFCF for the EU27 countries</i></p>	<p>Macro economic level (EU27) Estimates of software are based on three different data sources: the EU KLEMS database, official national accounts data and the use table from the supply and use framework.</p>	<p>INNODRIVE method</p>
<p><u>Kramer et al. 2009</u> Intangible Assets, Multinational Enterprises and Regional Innovation in Europe</p>	<p><i>"In this paper, we will contribute to the debate on intangibles in two ways: firstly, by defining and exploring the IAs that influence innovation processes in Multinational Enterprises (MNEs) and, secondly, by analysing the regional dimension of such IAs."</i></p>	<p>In-depth interviews With senior staff of flagship MNEs Automotive, Life Science and ICT sector Germany and Uk</p>	<p><i>Focussing on the processes through which investment in IAs occurs and the structures that support those processes within the firm and the regional environment. key dimensions through which the three IAs are enhanced and contribute to the embeddedness of MNEs in regional innovation systems are identified.</i></p>

<p><u>Lev et al. 2005</u> An accounting perspective on intellectual capital. Perspectives on intellectual capital</p>	<p><i>"A key argument against the recognition of intangible assets in balance sheets is the uncertainty of future economic flows from such assets. As a consequence, current accounting systems are more likely to 'front-load the costs' of investing into intangibles and 'delay the recognition' of its benefits. In the late 1980s academics and practitioners started to raise their concerns about this practice and argued that if accounting rules would not adapt to the increasing need to provide relevant information about investments in IC, accounting will lose its relevance (e.g. Johnson and Kaplan, 1987). Both, the views of professional organizations and academic research emphasized the need to adjust the existing accounting practices to keep on providing users with the true and fair view of the firm's financial position and performance"</i></p>	<p>Drawing on government, academic and accounting knowledge.</p>	<p>Providing an accounting perspective on IC</p>	<p>Potential avenues for further development of accounting standards: <i>Academic research supports both the capitalization alternative and a fair value approach. Both approaches have advantages and disadvantages. However, at this stage, regulators are still cautious and prefer to devote efforts to harmonize current practices and develop a framework of voluntary disclosure for intangibles.</i></p>
<p><u>Marrano 2009</u> What happened to the knowledge economy? ict, intangible investment, and Britain's productivity record revisited.</p>	<p><i>"Despite the apparent importance of the "knowledge economy," U.K. macroeconomic performance appears unaffected: investment rates are flat, and productivity has slowed. We investigate whether measurement issues might account for this puzzle."</i></p>	<p>Following CHS in identifying three main intangible asset classes ---based on a broad data spectrum</p>	<p>Analysis of the relative quantities of different types of expenditure and how they have changed over time. Consequences for overall business investment and market sector gross value added Consequences for market sector labor productivity.</p>	<p>The authors find: (a) MGVA was understated by about 6 percent in 1970 and 13 percent in 2004; (b) instead of the business investment/MGVA ratio falling since 1970 it has been rising; (c) instead of the labor share being flat since 1970 it has been falling; (d) growth in labor productivity and capital deepening has been understated and growth in TFP overstated; and (e) TFP growth has not slowed since 1990 but has been accelerating.</p>

<p><u>Marrocu et al. 2012</u> Intangible capital and firms' productivity.</p>	<p><i>"In general, this empirical literature encounters a serious weakness in the lack of connection between the micro approach and the macro one: contributions aimed at studying the effect of intangible assets internal to the enterprises do not usually consider how firms' performance can be affected at the same time by the local external environment. Consequently, the main purpose and novelty of this article is to analyze the internal and the external channels discussed above."</i></p>	<p>Panel of European companies in the manufacturing and service sectors belonging to 116 regions of six countries, considered over the period 2002–2006. Company-data information is taken from the BVD Amadeus database</p>	<p>Levinsohn–Petrin estimation approach</p>	<p><i>The findings highlight the importance of policies which are designed to (i) stimulate the accumulation of intangible capital stocks internal to the firms, and (ii) support the development of an adequate knowledge system at the regional level.</i></p>
<p><u>Mortensen 2013</u> The state of the art in the measurement of intangibles in national accounts statistics.</p>	<p><i>"The measurement problem therefore arises from the failure of most economists to make a clear distinction between "productivity growth" and "technological change". The solution to this measurement problem would lie in the introduction of a much broader concept of investment, including investment in RandD, in the creation of ideas, in training and education, etc."</i></p>	<p>examines the state of the art in the measurement of intangibles in national accounts</p>	<p>in national accounts</p>	<p><i>The review of these measurement problems concludes without ambiguity that the compilation of all these and a number of other indicators poses a host of methodological questions.</i></p>
<p><u>Nakamura 2009</u> Intangible Assets and National Income Accounting: Measuring a Scientific Revolution</p>	<p><i>"How do we measure intangible investment—investment to create new products and processes—in the national income accounts so that it can help us explain measured total factor productivity growth? And how do we measure the economic growth due to new products that arise from intangible investment? In this paper I argue that this dual measurement task for the national income accounts has become central to economics today. Improved measurement is likely to be necessary if we are to understand how best to encourage economic growth via public funds and intellectual property rights and to understand the sources of wealth."</i></p>	<p>Making the case why and how measurement of intangibles can move forward.</p>	<p>Descriptive evidence and economic modelling.</p>	<p><i>The paradigm of perfect competition underlies our national income accounts and is reflected in our theory of price measurement as well as our measures of nominal economic activity. In particular, stocks of private intangible assets have historically not been included in our measures of private wealth, and temporary monopoly, based on intellectual property, is not considered a relevant factor of production. Economic theory and economic measurement will need to develop together if economists are to understand the economic sources of economic growth.</i></p>

<p><u>Niebel et al. 2017</u> The Contribution of Intangible Assets to Sectoral Productivity Growth in the EU.</p>	<p><i>“Following the pioneering work by Corrado et al. (2005, 2009) in estimating total intangible investments for the U.S., estimates of intangible assets at the aggregate level of European countries have recently become available through the INTAN-Invest platform (Corrado et al., 2012). To date, there are few estimates available at the sector level. In this paper, we make a first attempt to quantify the importance of intangible assets, defined from the perspective of national accounting, at the sector level for European countries.”</i></p>	<p>INTAN invest and INNODRIVE data broken down to sectoral level. (=INDICSER data). To get from investments to assets a deflator from EU KLEMS was used.</p>	<p>An assessment of the contribution of intangibles to productivity growth based on growth accounting and econometric estimation of production functions.</p>	<p><i>The growth accounting contribution of intangibles to labor productivity growth is generally highest in manufacturing and finance. The estimated output elasticity of intangibles lies between 0.1 and 0.2, above factor shares but considerably below values found in previous research using aggregate data.</i></p>
<p><u>Peters and Taylor 2017</u> Intangible capital and the investment-q relation.</p>	<p><i>“The neoclassical theory of investment has mainly been tested with physical investment, but we show that it also helps explain intangible investment.”</i></p>	<p>Compustat - firm level – data from 1975 to 2011, although we use earlier data to estimate firms' intangible capital.</p> <p>Intangible capital= Knowledge C + Organisational C KC= perpetually inventorized RandD OC = perpetually inventorized SGandA</p>	<p>Regressions of lagged investment on Tobin's q</p>	<p><i><u>At the firm level</u>, Tobin's q explains physical and intangible investment roughly equally well, and it explains total investment even better. Compared with physical capital, intangible capital adjusts more slowly to changes in investment opportunities. The classic q theory performs better in firms and years with more intangible capital: Total and even physical investment are better explained by Tobin's q and are less sensitive to cashflow.</i></p> <p><i><u>At the macro level</u>, Tobin's q explains intangible investment many times better than physical investment. We propose a simple, new Tobin's q proxy that accounts for intangible capital, and we show that it is a superior proxy for both physical and intangible investment opportunities.</i></p>

<p><u>Piekkola 2018</u> Broad-based intangibles as generators of growth in Europe.</p>	<p><i>"In recent years, there has been increasing interest in broad-based intangible assets and their effects on firm performance. The notion that research and development (RandD) investment is a driver of productivity growth is supported by a long tradition in the empirical literature. Battisti, Belloc, and Del Gatto (2015) argue that technical improvement from RandD is only one part of revenue maximization."</i></p>	<p>European industries during the 2008–2013 financial crisis period. Country-Industry level analysis. Eurostat data.</p>	<p>Production function estimates</p>	<p><i>This study shows that the broad estimates adopted here give an overall IC output elasticity of approximately 30–34%. The value of the IC investment value-added share of 29.6% exceeds the GDP share of expenditures for ICs of 16%.</i></p>
<p><u>Piekkola 2016</u> Intangible Investment and Market Valuation</p>	<p><i>"This paper analyzes the performance of own account production of intangible goods of the following types: organizational capital, research and development (RandD), and information and communications technology (ICT). The benchmark approach is the expenditure-based approach, which utilizes a measure of innovation input rather than innovation output. We evaluate not only RandD and ICT capital but also organizational capital, the value of which can be poorly reflected in book values. Several studies, such as Stiroh (2005), have stressed the omitted variable problem" resulting from failing to include organizational capital (improved work- place practices and firm re-engineering) to explain the large returns obtained in the production function estimates of ICT and RandD."</i></p>	<p>Company level based on Finnish linked employer–employee data for the 1997–2011 period.</p>	<p>Quantitative – regression – analysis</p>	<p><i>The performance-based organizational investment in value added is approximately 3 percent; RandD and ICT investment shares are lower. Intangible capital is shown to be an important missing factor in q-theory.</i></p>
<p><u>Roth and Thum 2013</u> Intangible capital and labor productivity growth: Panel evidence for the EU from 1998-2005.</p>	<p><i>"As highly developed economies transform more and more into knowledge economies, the input of intangible capital has become vital for the future competitiveness of their economies (Corrado et al., 2005; World Bank, 2006), as well as the competitiveness of their firms ...This paper focuses on intangible capital investment by businesses."</i></p>	<p>data on business intangible capital investment generated within the INNODRIVE project... the dimensions of business intangible capital were generated along the framework originally proposed by Corrado et al. (2005)</p>	<p>Econometric analysis</p>	<p>The paper detects a positive and significant relationship between business investments in intangible capital and labor productivity growth within the business sector. Economic competencies being the most important dimension.</p>

<p><u>Saam et al. 2010</u> Review of measures and data sources on intangibles, ICT use and innovation in European service sectors</p>	<p><i>“Recent research has shown that intangible investments such as software, RandD, brand equity and firm specific investments explain nonnegligible proportions of GDP in industrialized countries.... An important part of intangible investments is linked to service activities.”</i></p>	<p>Review of the measurement and data availability for indicators on intangibles, ICT use and innovation in service sectors</p>	<p><i>This paper has reviewed measurement and data availability of indicators on intangibles, ICT use and innovation in service sectors. Although coverage varies by country, sector and time period, there are plentiful data available to provide useful indicators</i></p>
<p><u>Ståhle et al. 2011</u> Value added intellectual coefficient (VAIC): a critical analysis</p>	<p><i>“The purpose of this study is to analyse the validity of the value added intellectual coefficient (VAIC) method as an indicator of intellectual capital.”</i></p>	<p>Development of a method to calculate the VAIC Testing whether the VAIC correlates with company's stock market value</p>	<p>VAIC indicates efficiency of firms' investments into labour and capital, and has no relation with IC. VAIC does not significantly correlate with stock market value. Lack of consistency in earlier VAIC results are found.</p>
<p><u>Squicciarini, and Mouel 2012</u> Defining and Measuring Investment in Organisational Capital.</p>	<p><i>“...literature further suggests that measuring organisational capital requires looking at a number of occupations, including but not limited to managers, who perform activities that shape a firm's organisational capabilities. The present paper pursues this idea further and seeks to quantify investment in organisational capital by looking at the task content of occupations.”</i></p>	<p>Employment and earnings data from the 2002 to 2010 US Current Population Surveys ONET, CPS, SAS and JOLTS datasets</p>	<p>Calculating the investment in organisational capital at both the country and 2-digit sector levels. It does so following CHS (2005)</p> <p>Estimates sector-specific depreciation rates for organisational capital.</p> <p><i>Task-based estimates of investment in organisational capital appear on average 90% higher than the estimates of CHS. At the sectoral level, services, especially health, professional and technical services, educational services and finance clearly emerge as large investors in organisational capital, in absolute terms. Once the size of the sector is accounted for, chemicals, petroleum and electronics manufacturing also appear as high investors in organizational capital. Results suggest that organisational capital depreciates at a slower rate than previously thought: between 10% and 25% for most sectors as compared to the 40% suggested in the literature.</i></p>

<p><u>Van Ark et al. (2009)</u> Measuring intangible capital and its contribution to economic growth in Europe.</p>	<p><i>“Still, the full range of value-building intangible assets is not likely to be accorded the same treatment as software and RandD in the national accounts, even though economic research and surveys show that assets such as management capability, marketing and employee-training expenditures are important co-investments with RandD and information and communication technologies (ICT). The challenges concerning the conceptualization of intangible capital, its measurement on the input and output sides, and their integration into a production function or growth accounting framework are substantial indeed (van Ark 2002; van Ark and Hulten 2007).”</i></p>	<p>We use a wide range of data sources including national accounts and surveys from statistical offices and trade associations. The decomposition of Intangibles is alla CHS.</p>	<p>In this study we discuss the state of the art in the measurement of intangible capital and its contribution to economic growth, with a focus on international comparisons currently available.</p>	<p>Intangible capital explains about a quarter of labour-productivity growth in the US and in the larger EU countries. <-> Our analysis suggests that higher rates of investment in intangibles (as a share of GDP) are often associated with higher growth rates of GDP per capita, which might be attributed to a higher propensity to invest in higher-income (and productivity) countries...</p>
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