European
Commission

ISSN 2443-8022 (online)

# Unlocking Investment in Intangible Assets

Anna Thum-Thysen, Peter Voigt,
Benat Bilbao-Osorio, Christoph Maier
and Diana Ognyanova

DISCUSSION PAPER 047 | MAY 2017

EUROPEAN ECONOMY

Economic and
Financial Affairs

**European Economy Discussion Papers** are written by the staff of the European Commission's Directorate-General for Economic and Financial Affairs, or by experts working in association with them, to inform discussion on economic policy and to stimulate debate.

The views expressed in this document are solely those of the author(s) and do not necessarily represent the official views of the European Commission.

Authorised for publication by Mary Veronica Tovsak Pleterski, Director for Investment, Growth and Structural Reforms.

**LEGAL NOTICE**



This paper exists in English only and can be downloaded from https://ec.europa.eu/info/publications/economic-and-financial-affairs-publications_en.



Luxembourg: Publications Office of the European Union, 2017

KC-BD-17-047-EN-N (online)
ISBN 978-92-79-64885-4 (online)
doi:10.2765/71516 (online)

KC-BD-17-047-EN-C (print)
ISBN 978-92-79-64886-1 (print)
doi:10.2765/960357 (print)

European Commission
Directorate-General for Economic and Financial Affairs

# Unlocking Investment in Intangible Assets

Anna Thum-Thysen, Peter Voigt, Benat Bilbao-Osorio, Christoph Maier and Diana Ognyanova

**Abstract**

Intangible assets are at the heart of what makes firms competitive. They are vital for productivity and economic growth. A key question is whether the factors that tend to hold back investments in Europe are the same for tangible and intangible assets, i.e. is there a need for specific policy measures addressing intangible assets? This paper provides contextual information concerning intangible assets by discussing conceptual aspects, illustrating recent trends in terms of investments in intangibles and their corresponding impact on productivity and Gross Value Added (GVA) growth. With a view at specific characteristics of intangibles, potential drivers and barriers to investments in intangibles are identified and tested.

Evidence from the presented empirical analyses suggests that including intangibles in a source-of-growth framework changes the corresponding growth patterns (GVA tends to grow more rapidly and capital deepening becomes the dominant source of growth). Looking at intangibles also helps to improve the understanding of TFP differentials. As regards investments, structural factors tend to matter generally more for intangibles whereas cyclical factors matter more for tangible assets. Against this backdrop, a series of policy-relevant messages has been derived. Overall, however, there is need to enlarge the general understanding of knowledge creation and to further improve the measurement of intangible assets in order to allow sound and evidence-based policy support.

**JEL Classification:** E01, E22, O34, O4

**Keywords**: investment, innovation, intangible capital, productivity, growth accounting

**Acknowledgements:** We would like to thank Eric Ruscher, Josefina Monteagudo, Emmanuelle Maincent, Roman Arjona Gracia, Jonathan Haskel, Savina Princen and the members of the Economic Policy Committee and the Lisbon Methodology Working Group for very valuable comments.

**Contact:** Anna Thum-Thysen, European Commission, Directorate-General for Economic and Financial Affairs, anna.thum@ec.europa.eu; Peter Voigt, European Commission, Directorate-General for Economic and Financial Affairs, peter.voigt@ec.europa.eu.

# CONTENTS



## LIST OF TABLES

## LIST OF GRAPHS



## LIST OF BOXES



## REFERENCES

## ANNEX I

### Tables and grahps

## ANNEX II

### Methodological approach for growth accounting (including non-NA-intangibles)

# 1. INTRODUCTION

Since the onset of the global economic and financial crisis, the EU has been experiencing low levels of investment. Despite signs of a moderate turnaround since 2014, including in those countries most severely hit by the crisis, the investment recovery remains fragile. Accordingly, across the European Union, remarkable endeavours are being made to stimulate investments, notably to overcome market failures and to address barriers which prevent the total volume of investments reaching a socio-economically optimal level. Undoubtedly, Europe needs investments in order to return to a long-term sustainable growth path: investment is indispensable for stimulating technological progress and increasing productivity, which are, in turn, widely acknowledged as the main drivers of long run growth and catalysts for the competitiveness of firms and the entire economy. The transmission channels through which investments in tangible and intangible assets affect technological progress and TFP are indeed manifold. Conceptually, they could enlarge the boundaries of production possibilities (i.e. affect the technological frontier itself) or they could work towards reducing existing inefficiencies in the economy (i.e. help in terms of catching up towards the efficient frontier / reducing wastes).

While economic analyses have traditionally focused on the role of physical capital in the production process, there is an increasing recognition of the importance of intangible investment[1] as a vital factor for productivity, growth and living standards. Such spending, collectively called investments in 'intangible assets' (or shortly 'intangibles'), are strategic investments in the long-run growth of individual companies and of the economy as a whole. They include investing in human capital, in the form of education and training, as well as public and private research and development expenditures (R&D), market development, and organisational and management efficiency. Empirical evidence confirms the decisive role of R&D, both as a determinant of GDP level as well as a source of (productivity) growth but the importance of intangibles goes well beyond R&D.

Evidence from a growing body of research points to rapid expansion of investment in intangible assets (e.g. in the United States, Japan and also in some European countries) with significant impacts on productivity. In some cases, intangible investment matches or already exceeds investment in traditional capital such as machinery, equipment and buildings. Future growth in advanced economies is assumed to be increasingly dependent on productivity-raising innovation (OECD, 2013a,b), i.e. fostering knowledge creation is crucial. However, there are some specific characteristics that intangible assets appear to have in common, which give rise to the assumption that (at least with regard to some intangible asset types such as R&D and mostly due to market failures) the investments on intangible assets systematically remain below a socio-economically optimal level, thus justifying policy intervention.[2]

In this paper we are interested how to unlock the economic potential of intangible assets. For this purpose we first study their specificities, in particular we reflect on the characteristics of intangibles that make them a special type of asset and examine the role of drivers and barriers specific to intangible assets (Section 2); we present a set of stylised facts in order to understand their order of magnitude and trend patterns (Section 3); we discuss existing and provide new empirical evidence on their contribution to economic growth and productivity (Section 4) and finally we discuss and empirically assess potential drivers of and barriers to investment in intangible assets, in particular we ask whether the transmission mechanisms that hold back more dynamic investment trends are identical across asset types and if not, whether there is need for policy to tackle bottlenecks to investments specific to intangible assets and thus going beyond investments in R&D by looking as well at other types of intangible assets (Section 5). Section 6 provides conlusions and highlights some policy-relevant messages.

---

[1] Intangible assets are assets that do not have a physical or financial embodiment. In the literature, they are (synonymously) termed also ‘intellectual assets’, 'knowledge assets', 'knowledge based capital' or 'intellectual capital'. Much of the focus on intangibles has been on R&D, key personnel and software. But the range of intangible assets is considerably broader as argued in this paper. See Table A1 (Annex I) for a list of intangible assets as currently proposed in the literature.

[2] The IMF estimates that fully internalising R&D externalities would lead to 40% higher investments compared to the *status quo*, i.e. GDP could rise in individual economies by 5% in the longer term and globally by as much as 8% due to international spillovers (IMF 2016a,b).

# 2. WHAT ARE INTANGIBLE ASSETS AND WHAT MAKES THEM SPECIAL?

During the last three decades, there has been a shift from the view that firms' competitive advantage is based on size and power to the view that it is based on corporate and especially rather intangible resources, such as competences and capabilities, and on the assimilation of knowledge. This view is at the heart of the evolutionary theory of the firm, which looks at a firm as a 'social community' whose productive knowledge defines a comparative advantage (Nelson and Winter, 1982). This theory of production is based on differential capabilities, embedded in the personal and organisational structure of firms; i.e. personal skills and routines at the organisational level form the repository of knowledge (embodied knowledge in equipment/machinery and tacit knowledge, capabilities and skills) which, in turn, defines the production possibilities. A fundamental characteristic of this knowledge is that it is not easily transferable between firms. In fact, it is its distribution within the economy that determines the heterogeneity of economic (and firm) behaviour (Hayek, 1945) and substantiates competitiveness (thus conceptually going beyond considerations of mere unit labour costs).

In this section we aim to shed light on what constitutes this new type of assets (Section 2.1) and what are their economic characteristics (Section 2.2).

## 2.1. CONCEPTUAL ISSUES: WHAT CONSTITUTES INVESTMENTS IN INTANGIBLE ASSETS?

The importance of intangible investments for explaining productivity, competitiveness and current and future economic growth has been recognised for some time by the economic literature and statisticians (see Section 4). As a consequence, the conceptual approach towards capturing and accounting for such investments has been continuously broadened. However, amending the accounting standards (i.e. shifting the asset boundary) towards including more and more intangible assets has triggered a controversial debate concerning where to draw the cut-off line; i.e. what is still to be considered as investments in intangible assets (and can be reliably accounted for / captured in statistics) and what not.

Conceptually, the literature considers intangibles as resources that share the durable impact of 'assets' (in contrast to intermediate inputs), irrespective of a company's capacity and/or willingness of 'capitalising' them. Moreover, intangibles are typically hard to codify and to accumulate; and they are not easily transferrable.[3] Besides, they are generally regarded as non-rival assets as they can commonly be deployed at the same time in multiple uses.[4]

Table 1: **Forms of intangible assets**

| Broad category of intangible assets | Type of intangible assets included | Remark | captured in SNA (ESA 2010) |
|---|---|---|---|
| COMPUTERISED INFORMATION | ▪ Software | includes knowledge embedded in computer programmes and computerised databases | ✓ |
| | ▪ Databases | | ✓ |
| INNOVATIVE PROPERTY | ▪ R&D | scientific knowledge embedded in patents, licenses and general know-how (scientific R&D); artistic content of commercial copyrights, licenses and designs (incl. new motion picture films and other forms of entertainment) | ✓ |
| | ▪ Mineral explorations | | ✓ |
| | ▪ Copyright and creative assets | | ✓ |
| | ▪ New product development in financial services | | – |
| | ▪ New architectural and engineering designs | | – |
| ECONOMIC COMPETENCIES | ▪ Brand-building advertisement | value of brand names and other knowledge embedded in firm-specific human and structural resources; expenditures on advertising, market research, firm-specific human capital and organisational change | – |
| | ▪ Market research | | – |
| | ▪ Training of staff | | – |
| | ▪ Management consulting | | – |
| | ▪ Own organisational investment | | – |

Source: Corrado, Hulten and Sichel, 2005

[3] See e.g. Winter, 1987; Kogut and Zander, 1992; Conner and Prahalad, 1996.

[4] See e.g. Itami and Roehl, 1987; Chatterjee and Wernerfelt, 1991; Collis and Montgomery, 1998; Teece, 2000; Hitt *et al.*, 2006; Carmeli and Tisher, 2004; Villalonga, 2004.

There are generally three major forms of intangibles: (i) those created primarily through innovation and discovery, (ii) those that underlie organisation practices (including also investments in customer satisfaction, product quality and brand reputation), and (iii) those related to human capital (see Hand and Lev, 2003). Accordingly, intangible assets comprise investment in R&D, innovation and technology development, training/education of workers, internal organisation structures, customer and institutional networks, market exploration and development (marketing), and software and information technology.

Both business and national income accounting have traditionally treated outlays on intangibles as intermediate expenditure and not as investment.[5] According to the SNA2008/ESA2010 standards, the Systems of National Accounts currently captures under the asset category "intellectual property products" a range of specific intangible assets, namely R&D, mineral exploration, computer software and databases, entertainment, literary and artistic originals. Similar to investments in tangible assets, such as machinery and equipment or dwelling and other structures, expenditures by businesses or government on these intangible assets are treated as gross fixed capital formation (GFCF) and make for a sizable and rising share of overall investment. One of the most significant modifications brought by the ESA 2010[6] reform was changing the way R&D is treated (from intermediate consumption to business sector investment in intangible assets), which reflects the nature of R&D as knowledge to be used in the productive process over multiple periods. Based on the same logic, spending on software and databases was already treated as investment in the national accounts before implementing ESA 2010.

Nevertheless, considering the spending on further types of intangibles as investment (i.e. going beyond the definition according to SNA2008/ESA2010 standards) would be in line with the views of many in the business community who attribute fundamental aspects of corporate success to spending on acquired goods or services, such as e.g. marketing, data, design and business process re-organisation, because this contributes to the production for longer than the taxable year.[7] Some argue to consider also the spending on 'economic competencies' as grouped together in Table 1 as investment in knowledge based capital. And arguably one may go even further than the categories outlined above in Table 1 and broaden the corresponding definitions to also include e.g. public sector intangible assets not currently recorded as investments[8]. And some even argue to go beyond that and suggest including also human capital/skills in a wider sense as well as trust, health, wellbeing / happiness, etc. as further intangible asset types. To do so, however, a range of unresolved conceptual and statistical issues need to be addressed, which so far have kept additional intangible categories from being included in official national accounts.

Due to operational reasons, for this paper, the cut-off line is assumed along the asset types outlined above in Table 1; i.e. what goes beyond that (i.e. which is not falling in any of the mentioned assets classes) is not considered here as intangible assets. We will distinguish those intangibles which are captured already in the SNA (and call them 'NA-intangibles') and those mentioned in Table 1 but not captured in the SNA ('non-NA-intangibles'). Note that the US national accounts do not differ from the EU national accounts according to ESA on the issue on non-NA intangibles. Both follow the SNA 2008 standard (of which ESA 2010 is the codified European version) i.e. neither in the national accounts of the US nor in the EU non-NA intangibles are currently recorded as investments. Finally, note that all corresponding assets types represent knowledge-based capital, which is a notion used in the literature often synonymously to 'intangibles assets' or just 'intangibles'.[9]

---

[5] For instance, when businesses invest to integrate databases and organisational processes, spending on hardware commonly only represents some 20% of total costs. The remaining costs are for organisational changes such as new skills and incentive systems. Most of these costs are not counted as investment, even if they are as essential as the hardware.

[6] The European System of National and Regional Accounts (ESA 2010) is the newest internationally compatible EU accounting framework for a systematic and detailed description of an economy. The ESA 2010 was published in the Official Journal on 26 June 2013 and has been implemented in September 2014. From that date onwards the data transmission from Member States to Eurostat followed ESA 2010 rules. The impact of the implementation of ESA 2010 on key indicators of the national accounts in Europe differs from country to country. An overview is provided in EURONA 2/2014. Detailed ESA 2010 based annual and quarterly European aggregates and Member State data are available in the Eurostat database.

[7] See Corrado *et al*. (2009): Based on the notion that any use of resources that reduces current consumption in order to increase it in future should qualify as an investment, the authors suggest treating the spending on a number of additional types of intangibles as GFCF.

[8] There is a comprehensive FP7 project ongoing which addresses the issue of intangibles in the public sector: SPINTAN – Smart Public Intangibles; see Policy Brief dated 08/02/2016: *The public sector and economic growth in the SNA; http://www.spintan.net/*).

[9] While spending on all these aspects arguably may affect production for longer than the taxable year and given that the related outcome would also be tacit and could be non-rival (thus fulfilling the criteria as set out in the definition of intangible assets outlined above), it is quite controversial how to measure appropriately the corresponding investments and – perhaps even more tricky – how to depreciate corresponding stock variables. The latter appears to be a general issue for intangibles. For instance, the productive life of firm-specific training has been

## 2.2. ECONOMIC CHARACTERISTICS OF INTANGIBLES

Different types of intangibles commonly share some specific features which distinguish them from tangible assets[10]. These defining characteristics are decisive for identifying barriers to investment and may justify policy intervention (see Sections 5 and 6).

The literature suggests a fairly long list of such characteristics. For the sake of simplicity (and at the risk of oversimplification), below these are grouped in three main aspects: (1) specific characteristics of intangibles that may affect competition; (2) risks, uncertainty and high sunk costs characteristically associated with intangibles; and (3) synergies and complementarities among asset types. All these specific characteristics of intangibles can be illustrated well by looking exemplary at R&D (see Box 1).[11] However, it is important to bear in mind that intangibles are indeed quite heterogeneous. Table 2 illustrates this by assessing how these main characteristics apply to various types of intangibles.

### 2.2.1. Competition-related characteristics

Due to specific features which tend to distort competition, markets for intangible assets and industries mainly driven by the relevance of intangible assets are likely to be affected differently and potentially more severely than those rather relying on tangible assets.

Many types of intangibles are characterised by limited appropriability and partial excludability[12]. For instance, property rights of intangible assets typically cannot be as clearly defined and well enforced as it is the case with tangibles. Accordingly, firms struggle to deter other businesses from benefiting from their investments in intangibles ('free-riders'). Due to knowledge diffusion and externalities, social returns to intangible investment tend to be higher than the corresponding private returns, which leads to under-investment. For the firms buying-in intangibles or producing them for their own use (together perceived here as 'investments in intangibles'), some degree of rent-ensuring[13] may be needed to increase the appropriability of the returns to innovation before knowledge diffuses.[14]

Separability[15] and transferability[16] are two necessary features to facilitate mobility of an asset in terms of ownership. In fact, these are pre-conditions for using assets as collateral and also to salvage value in the event of bankruptcy. While the market for patents and licensing agreements provides a mean to acquire codified and legally protected intangibles, firms cannot obtain tacit, human capital-based,[17] or even codified but not legally protected intellectual assets through such channels. In order to obtain intangible capital of this kind, businesses can either do corporate takeovers or selective recruitment (poaching) of specialists. But, both of these strategies entail important risks suggesting that the efficient allocation of intangible capital of a tacit nature is further complicated (Jennewein, 2005).

Moreover, many intangible assets display specific competition features as they can be deployed simultaneously by multiple users (non-rivalry[18]) without engendering scarcity or diminishing their basic

estimated to be 2.7 years (software: 3.2 years; branding: 2.8 years; R&D: 4.6 years; design: 4.0 years; and business process improvement: 4.2 years). Moreover, there are differences among industries: The OECD (2013a) concluded that firms expect investments in organisational capital to last on average 4 to 6 years in services, and between 7 and 10 years in manufacturing.

[10] Reflecting this understanding of investments in intangible assets, Corrado, Hulten and Sichel (2005) define them as 'computerised information', 'innovative property' and 'economic competencies'. See Table A1 in the Annex for details. Note that some of these investments are already included in the National Accounts measure of Gross Fixed Capital Formation (GFCF), especially computerised information and some categories of innovative properties (e.g. mineral exploration, R&D and intellectual property rights). However, according to the System of National Accounts, the spending on other intangible assets is captured as 'expenditures' or 'intermediate consumption' rather than as investment (in particular economic competences, new products and design).

[11] See e.g. Hall *et al*. (2010) for a comprehensive literature review.

[12] An asset is characterised by limited appropriability or partial excludability if other businesses can benefit from it.

[13] That means protecting intellectual property; for instance by means of patents, brands, design, copyright.

[14] Note however that some intangible assets can be generated internally by firms and remain inherently non-marketable. There full value is arguably firm specific because such assets cannot be separated from the original unit of creation without some loss of value (Webster and Jensen, 2006). Brand equity and to a less extent training are examples.

[15] An asset is characterised as separable if it can be separated from the place of creation without loss of value.

[16] Transferability refers here to the degree that knowledge can be transferred across firms. This depends on whether knowledge is tacit or codified. Tacit knowledge could become transferable if it is embodied for instance in human capital.

[17] In fact, tacit knowledge lacks separability, which in turn undermines its transferability. Note that intangible assets generate firm-specific value whose value depends on the firm’s assets being kept together (see Hotchkiss *et al*., 2008; Gilson *et al*., 1990), which suggests further limits with regard to separability.

[18] An asset is non-rival if it can be used simultaneously by multiple users.

usefulness (e.g. software or designs). With a view to business sector knowledge creation, intangibles tend to be rival across firms and rather non-rival within the firm, which leads to increasing returns to scale (scalability)[19] and ultimately to monopolistic competition. Positive network externalities can reinforce this tendency.[20]

The net effect of these competition-related characteristics depends on the situation of each individual business, its competitive environment and the types of intangible assets the company is relying on / investing in. In fact, on the one hand, any investment in knowledge can have positive external effects, all intangible assets give rise to spill-over effects which, augmented e.g. by the effects due to limited appropriability, means that the investing firm must be aware *a priori* that competitors may (partly) benefit from their investment in intangibles. This reduces incentives to invest *ex ante.*[21] On the other hand, the possibility of benefiting from economies of scale and eventually a situation of monopolistic competition, in turn, provides *ex ante* incentives to invest in intangibles.

### 2.2.2. Risk, sunk costs, and uncertainty

Investment in intangibles is associated with systematic risks, costs and uncertainties as this commonly means entering unexplored fields, i.e. testing and verifying multiple options. This often implies failures and large upfront investment requirements. Thus, investments in intangible assets is prevalent throughout the innovation process, but particularly so in the early stages of fundamental research, invention and experimentation where sunk costs can be large, and failure frequent. Moreover, the production of intangible assets – which are often embodied in people – is likely to be more uncertain than tangible capital, which is more conducive to replication through standard routines (Hunter *et al.*, 2005). Finally, lower *ex ante* verifiability[22] of intangibles implies financial constraints. This applies to all intangibles.

### 2.2.3. Synergies and complementarities

Evidence suggests significant synergies and complementarities across different types of intangibles as well as with regard to tangible assets. In fact, certain investments can only be productive if the appropriate complementary assets exist (e.g. hardware + software + training). Accordingly, factors hindering investment in one type of assets may affect the productivity of (and likely also the investment in) complementary assets.

As a summary, Table 2 provides an ad hoc assessment of the main characteristics of intangible assets along the categories of intangibles as grouped according to Corrado, *et al.* 2005. The table is largely illustrative, based on work by the OECD, complemented by own assessment.

The economic characteristics illustrated above are, to various degrees, relevant for the majority of intangible asset types. However, there are also major differences, primarily between those classified under 'computerised information' and 'innovative property' on the one hand, and those included in 'economic competencies' on the other. Assets in the former two categories are, for the most part, fully non-rival, only partly excludable and they can generally be separated from the original firm without substantial loss of value (i.e. they tend to be tradable by means of market-based transactions). In addition, the corresponding type of knowledge capital can be more easily codified and protected through mechanisms that facilitate its transfer.

[19] The initial cost incurred in creating intangible assets (developing new ideas, designs, etc.) may eventually not be re-incurred once combined with other inputs in the production of goods or services. This may give rise to increasing returns to scale, which can be possibly reinforced by network externalities (particularly prevalent in intangible-intensive industries, such as e.g. ICT).

[20] Positive network externalities arise when the value of a good or service increases with the number of users (e.g. subscribers to social or professional networks). This may lead to a winner-takes-all outcome, i.e. network effects can lead to cases of natural monopoly or create high barriers to entry, limiting competition in areas where competitive pressures might raise efficiency.

[21] Privately created knowledge tends to be subject to the forces of diffusion, which cannot be constrained in the same manner as physical assets (Brown and Kimbrough 2008); i.e. intangibles tend to diffuse beyond their place of creation, thus providing wider benefits. Rapid diffusion of knowledge may thus deny firms the market power required to price above marginal costs in order to recover the costs of the knowledge creation. Note that markets, however, tend to fail in properly internalising the positive impact from this diffusion, notably on the productivity of investment in knowledge elsewhere.

[22] Ex-ante verifiability refers here to the fact that the value of an asset cannot easily be determined before it has generated value.

Table 2: **Characteristics of intangibles per asset type**

| | | Specific effects on competition | | | Risks, sunk costs, uncertainty | Synergies, complementarity |
|---|---|---|---|---|---|---|
| | | Appropriability excludability seperability transferability | Non-rivalry scalability network-externalities | Spill-overs | | |
| Computerised information | Computer software | partly excludable, transferable | fully non-rival, scalable, network-external. | high (codified) | high | potentially high |
| | Computerised databases | partly excludable, transferable | fully non-rival, scalable, network-external. | high (codified) | high | potentially high |
| Innovative Property | Scientific R&D | partly excludable, separable / transfer e.g. as patents | fully non-rival, scalable, network-external. | for 'published' results high; partly otherwise | very high | high |
| | Copyrights and creative property | partly excludable (depending on IPR), transferable | fully non-rival scalable | high (codified) | high | potentially high |
| | Design | low excludability for 'visible' items, transferable (IPR) | fully non-rival scalable | high for 'visible' products; partly otherwise | potentially high | potentially high |
| Economic Competencies | Brand equity | high excludability, non separable, transfer via M&A | largely rival scalable | low / firm-specific | high | potentially high |
| | Firm-specific human capital | high excludability, non separable, transfer through staff mobility | largely rival scalable | partly, large if high staff mobility | very high | very high |
| | Organisational capital | partly excludable, non-separable, transfer | largely non-rival, scalable | partly | high | potentially high |
| | Market research[23] | high excludability (if non-disclosure), separable, transfer | fully non-rival, scalable | partly | high | high |

Source: own illustration, adapted and extended from Andrews and de Serres (2012).

In contrast, rivalry and excludability are more prevalent among the types of assets that reflect 'economic competencies'. This is particularly the case with investment in brand equity and human capital, which generate assets that reflect a large degree of corporate or individual embodiment, in addition to being often firm specific and, therefore, not so easily separable. Within 'economic competencies', investments in organisational capital somewhat stand out as being largely non-rival and scalable (within a firm) but less than fully excludable, although attempting to imitate and implement the business model of a successful rival firm is not a simple task. And also the relevance of spill-overs for that asset type is difficult to assess.

Overall, for almost all intangible assets types some characteristics that have specific distorting effects on competition can be confirmed. Also risks, uncertainty and sunk costs appear to be relevant for all types of intangibles (to various degrees). In turn, identifying synergies and complementarities with other intangible and also tangible assets is not trivial. The related assessment in the table remains widely hypothetical and would require further investigations.

[23] Note that 'market research' (e.g. feasibility studies, firm-specific foresight exercises, etc.) is not an explicit asset category according to the definition of Corrado *et al*. (2005). However, it is considered to be relevant here and, since it cannot be easily grouped into any of the other categories, it is added to the corresponding typology.

Box 1: **ECONOMIC CHARACTERISTICS SPECIFIC TO R&D**

Scientific research and development (R&D) is a key intangible asset whose economic characteristics have been comprehensively studied in the literature as they affect the ability and incentives of companies to engage in investment. This box illustrates specific economic characteristics exemplary for R&D:

1) Competition-related characteristics

R&D output is typically hard to codify as it may be ideas or information, many times embedded in people, non-excludable and non-rival, i.e. potentially used in parallel by different agents. This makes it difficult to fully appropriate all benefits from the investment in R&D. Positive externalities and knowledge spillover effects are common (IMF, 2016a) and the inability of a business to deter others from benefiting from these spillovers act as a deterrent to invest in intangible assets.

2) High risks associated with uncertainty and high sunk costs.

R&D activities are systematically associated with high degrees of uncertainty and risks in terms of achieving the expected economic returns. For example, developing a new drug involves formulating working hypothesis on the basis of partial knowledge and with a no guarantee that the activities will end up in the expected result, e.g. a new drug component. A study conducted by Tufts University[24] signals that in the development of a new drug, a company must engage in researching thousands and sometimes millions of compounds that fail (more than 80% of the molecules that are initially investigated). And even then, the overall probability of clinical success (i.e. a drug entering clinical testing will be approved) is estimated to be less than 12%. Accordingly, the costs of developing a new drug are estimated to be around USD 2.6 billion[25], and the process to bring a new chemical compound into a new drug in the market is very long, going from basic research to drug discovery, pre-clinical trials, clinical trials, regulatory reviews and finally the market launch. This process has been estimated to last 17 years in the UK[26].

In addition, achieving a critical mass in terms of knowledge and skills accumulation (associated with high sunk costs, and long maturity processes) are further characteristics of R&I investments.

3) Complementarity with education and training schemes and ICT

The complementarity of scientific research with other intangible assets is high, notably in areas such as skills development via education and/or training schemes. The rate of success of R&D and innovation activities depends on the level of skills and tacit knowledge available in a firm, and at the same time, any further development of these skills (notably via training) is affected by the investment in research and innovation (learning). Based on a large survey of Canadian companies, it is estimated that at least 90% of companies that deploy at least one innovative technology also need to train their workers. The percentage goes up to 99% for those firms that use 5 or more technologies (Scicchinato, 2010). And training is also found to reinforce the effect of R&D on innovativeness and even induce some firms to become innovative (González *et al*. 2012). Investing in both in training and R&D tends to have (a double) impact on firm's productivity, which points to complementarities between R&D and training (Moreira, 2013). In addition, the complementarity between R&D and ICT has also been analysed, for example in French manufacturing and services firms. This analysis revealed that ICT investment is frequently accompanied by R&D (Mairesse *et al*., 2001), pointing to synergies arising from the corresponding investments in intangibles.[27] Moreover, Brynjolfsson *et al*. (2002) have shown the importance of complementary investments in organisational change and training for ICT investments to have wide-ranging productivity effects through change in business models, acting as a general purpose technology. More generally, Corrado *et al*. (2012) show that ICT capital is more productive when complemented by intangible investment.

[24] Full information about the study and the estimates can be found at http://csdd.tufts.edu/files/uploads/Tufts_CSDD_briefing_on_RD_cost_study_-_Nov_18,_2014..pdf

[25] The study, based on research carried out by Tufts university can be found at http://www.phrma.org/sites/default/files/pdf/rd_brochure_022307.pdf

[26] Wellcome (2008): "Medical research: what's wrong? Estimating the economic benefits from medical research in the UK" (https://www.mrc.ac.uk/publications/browse/medical-research-whats-it-worth/)

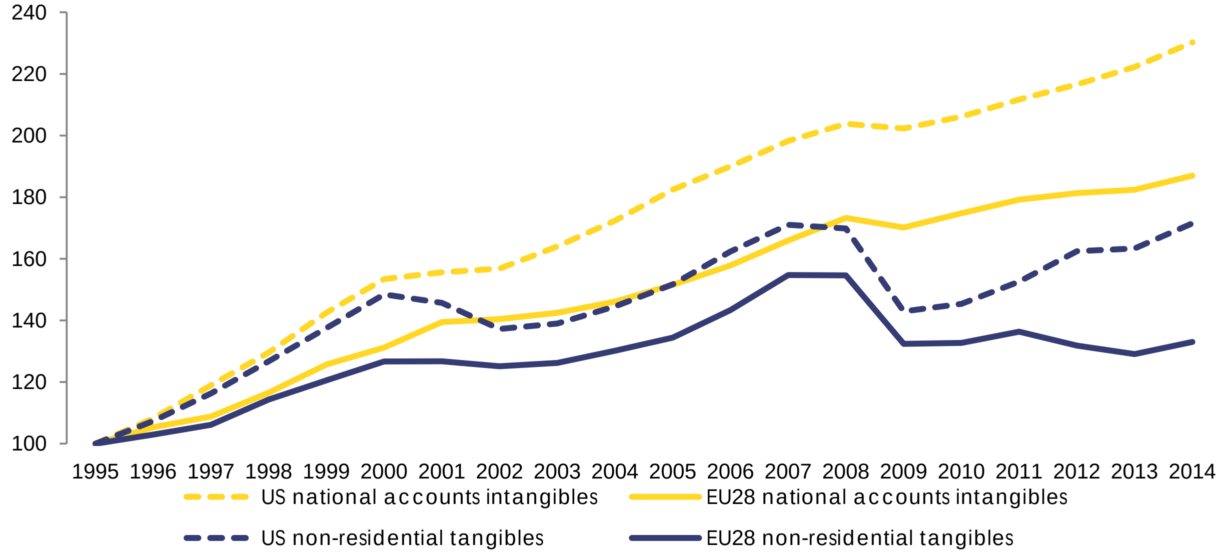
[27] Polder *et al*. (2009) argue that ICT is indeed important for all types of innovations: higher ICT investment increases the probability of having a certain type of innovation.

# 3. INTANGIBLE ASSETS: STYLISED FACTS

Having discussed what defines intangible assets and their economic characteristics, we now turn to presenting a set of stylised facts that provide insights on the order of magnitude and trend patterns of intangible assts. According to the ESA 2010 national accounts data, intellectual property products account for close to 4% of GDP and 19% of total annual fixed investments in the EU-28. When excluding residential investments (i.e. dwellings), the share of intangibles is even higher and currently stands at 25% of total (non-residential) investments. Note that over half of the investments in intangible assets currently recorded by national accounts consist of R&D. By comparison, the GDP share of intellectual property products in the US currently stands at somewhat over 5% and their share in overall non-residential investment at 31%.

Investments in intangible assets are growing more dynamically than investments in (non-residential) tangible assets. In fact, Graph 1 illustrates that over the past two decades, the volume of annual GFCF in intellectual property products increased by 130% in the US and 87% in the EU-28. By comparison, the volume of tangible non-residential investments in the US stands at 70% above the level of 1995 and increased by only 30% in the EU. It appears remarkable that investments in intangible assets were, in general, significantly less affected by the economic crisis that started in 2008.

Graph 1: **Non-residential intangible and tangible investments in the EU-28 and the U.S., total economy; Chain linked volumes, index 1995 = 100**




Sources: Eurostat national accounts for EU-28, BEA for U.S.

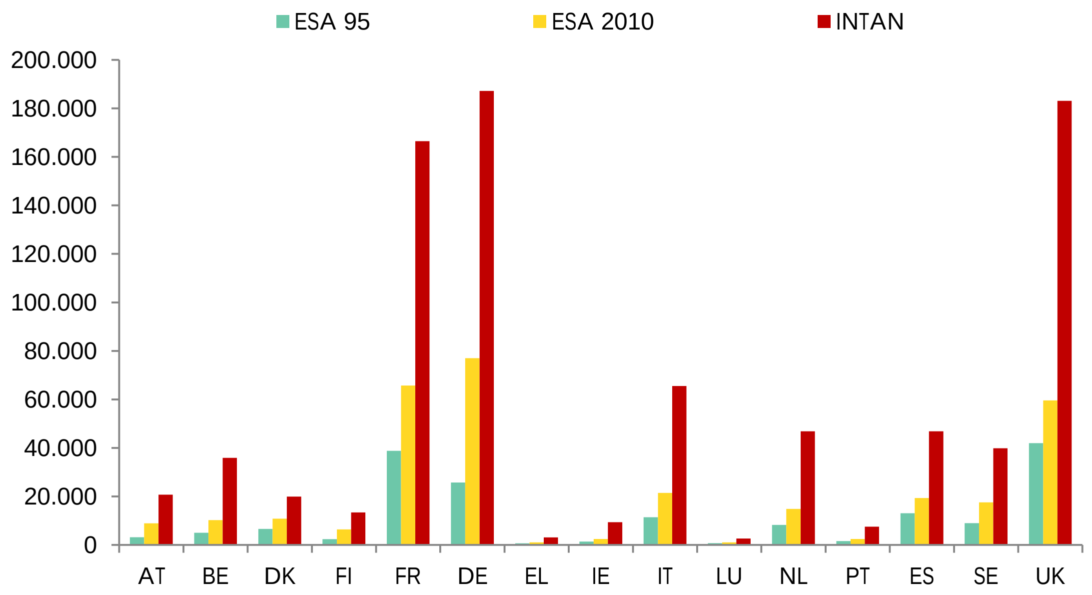
As outlined above, beyond the intangible assets captured already in national accounts ('NA intangibles'), estimates of a series of previously unmeasured asset types ('non-NA intangibles') have been developed, notably in the context of the INTAN-Invest project[28]. The underlying assumptions for calculating this data, together with corresponding challenges, are described in detail in Corrado et. al (2012). For a further discussion of the challenges of capitalising knowledge assets see e.g. also Moulton and Mayerhauser (2015).

The following graphs illustrate the order of magnitude in terms of investments in intangible assets according to (1) ESA 95, (2) ESA 2010, and (3) INTAN-Invest[29] and the composition of gross fixed capital formation per asset type as percent of business sector GVA.

[28] The INTAN-Invest.net database (www.intan-invest.net) is a harmonised (open access) database on macro-economic intangibles across a selection of countries, which complements the work done by the INNODRIVE and COINVEST–projects (both funded by the FP7 SSH programme). The up-dating of the database is based on voluntary cooperation by academic project partners.

[29] Capturing investments in all intangible assets as defined in Table 1, above.

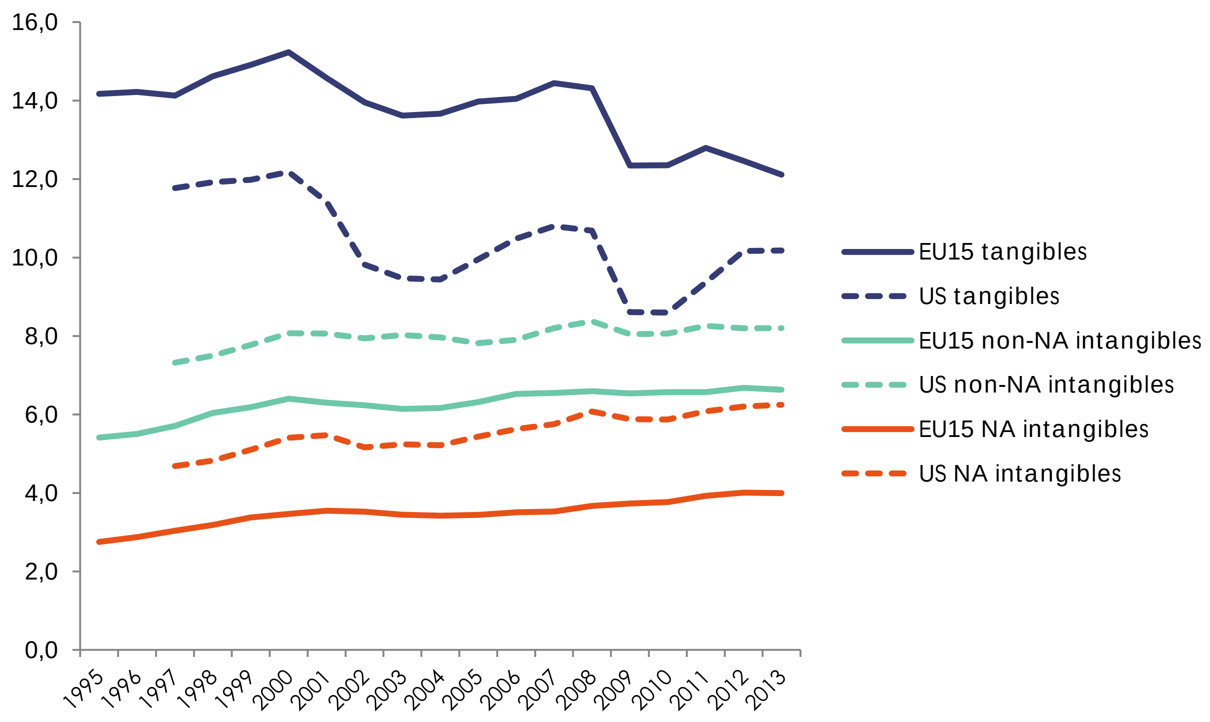
Graph 2: **Investment in business sector intangible assets in EU-15 [2013, million Euros], according to different accounting standards**




Note: Business sector defined as NACE Rev. 2 activities A to N (excluding L) plus R and S. Investments according to ESA 95 were obtained from ESA 2010 (NA-intangibles) diminished by investment in R&D.

Source: INTAN-invest data (intangible GFCF; 'national account intangibles', 'new-intangibles').

Graph 3: **Business sector non-residential GFCF by asset type, EU-15[30] vs. US (% of business sector GVA)**



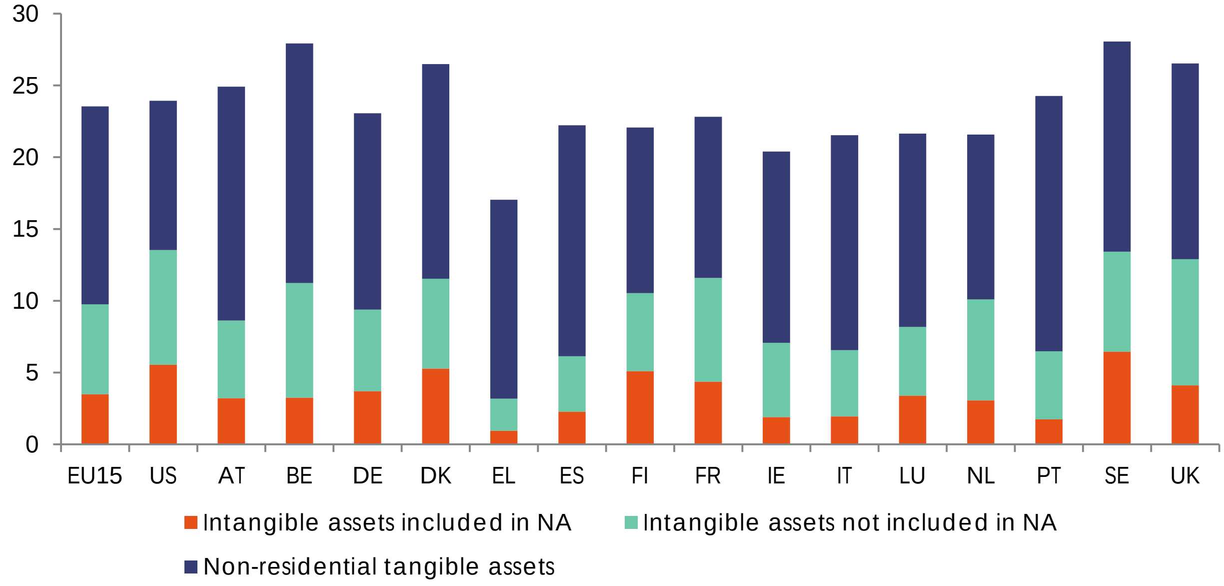

Note: Business sector defined as NACE Rev. 2 activities A to N (excluding L) plus R and S.

Source: Own calculations based on INTAN-invest and Eurostat/BEA national accounts data (business sector GVA).

[30] Data on investment in non-NA intangibles for EU Member States that joined after 2004 are currently not available for the years after 2005.

INTAN-Invest data also provide an indication of the impact on the composition of overall investments and the level of gross value added (GVA) if the asset boundary was expanded to include these non-NA intangibles. Calculations for the non-residential business sector (i.e. excluding dwellings and public sector GFCF, which are both not covered by the INTAN-Invest data), suggest that including non-NA intangibles would, on average, increase the level of corresponding GVA by around 6%[31] in EU-15 member states and 8% in the US. Investments in non-NA intangibles would on average also exceed the value of those intangibles which are already treated as GFCF in national accounts. For some countries such a wider definition of intangible assets (i.e. summing up the NA- and non-NA-intangibles) would imply that close to or even more than half of all non-residential business sector investments would consist of intangibles (NL, FI, US, FR, UK, SE).

Graph 4: **Business sector non-residential GFCF by asset type, average 1995 to 2013 (% of business sector GVA)**




Notes: Business sector defined as NACE Rev. 2 activities A to N (excluding L) plus R and S. US: average 1997 - 2013.

Source: Own calculations based on INTAN-invest and Eurostat/BEA national accounts data (business sector GVA).

As with the NA-intangibles, non-NA intangibles also show a clear positive upward dynamic (although on average not stronger than the NA intangibles) compared to tangible investments. Therefore, and in addition to further increasing the level of overall investments, GVA and GDP, the inclusion of additional (sub-) categories of intangibles can be expected to further increase the already significant contribution of intangible investments to GDP level and growth (see next Section for details).

# 4. ASSESSING THE IMPACT OF INTANGIBLE ASSETS ON PRODUCTIVITY AND ECONOMIC GROWTH

In the light of the order of magnitude and the observed dynamics of investments in non-NA intangibles (as outlined above), a central question is the impact of the tangible capital stock on growth potential. In general, investments in intangibles are vital in two ways: as a production factor and/or as a driver for innovation. Thus, the spending on intangibles has a direct (short run/once-off) effect on output (GVA) level and an indirect (long-run) growth effect through capital accumulation and TFP. This section will

[31] The reason why treating additional intangibles as GFCF would increase the level of business sector GVA and consequently overall GDP is essentially the same which led to the increase of GDP due to the capitalisation of R&D in the context of the recent implementation of SNA2008/ESA2010: Business expenditures on these intangibles are reclassified from intermediate consumption (which are fully used up in the current production process and therefore do not add to GVA in following periods) to gross fixed capital formation.

focus on the long-run growth effect. Section 4.1 presents a growth accounting exercise including various types of intangibles. Section 4.2 provides a complementary econometric analysis which allows departing from some of the assumptions made in the growth accounting exercise.

## 4.1. CAPTURING INTANGIBLES IN GROWTH ACCOUNTING: HOW SENSITIVE ARE THE EMPIRICAL RESULTS?

The advent of the 'knowledge economy' has led to the recognition of intangible assets as essential value creators for companies and enablers of productivity and economic growth. The related evidence is abundant. At the macro-level, the 'new-economy' literature (e.g. Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000) has been supplemented by an increasing number of studies reporting growth-accounting exercises, where e.g. a greater share of labour-productivity growth in the US and EU countries is attributed to intangible capital rather than tangibles, as well as an acceleration in this regard over time (Corrado *et al*., 2016; Corrado *et al*., 2009; Marrano *et al*., 2009; Dal Borgo *et al*., 2012; Jona-Lasinio *et al*. 2011 and Inklaar *et al*. 2005).[32]

To the extent that a significant part of the total spending on intangibles is still accounted as intermediate expenditures, conventional growth accounting cannot control for the total intangibles' component of the considered capital. In general, the omission of relevant intangibles in productivity and growth accounting exercises would tend to overstate the contribution of the other components. In particular, capitalising and including non-NA intangibles as assets in growth accounting exercises usually diminishes the contribution of MFP growth because the contribution of such intangible assets is no longer 'hidden' in the MFP residual.[33] Hence, expanding the asset boundary for additional relevant intangible asset types as outlined above might help to unveil important trends and better explain productivity and growth differentials among countries and across different sectors of the economy, i.e. controlling for intangible capital in growth accounting frameworks could affect the observed patterns of (sources of) economic growth and productivity.

Accordingly, below a series of growth accounting exercises is presented that takes intangible assets explicitly into account (covering the period 1995 – 2013). This analysis allows assessing the contributions to GVA growth which are due to labour and capital input (the latter split into tangible and NA- as well as non-NA-intangible capital) and, measured as a residual, the change in multifactor productivity. Annex II outlines the methodological approach, which follows widely Corrado *et al.* (2009). In particular, it provides information on the recalculation of GDP induced by the extended intangible definition, on the estimate of the stock of intangible assets and on the depreciation rates and the deflators used.

The key research questions are: What is the overall contribution of intangible capital to the observed output growth and how does the inclusion of intangibles affect the attribution of output growth to changes in the input set (i.e. labour component and capital formation)? And what can be said about multifactor productivity? Does the inclusion of so far unobserved intangibles affect the cross-country variance in the MFP residuals?

The results of the corresponding growth accounting (GA) are summarised below in Table 3. To illustrate the numerical differences which result from the conceptual decisions on what is considered as investments in intangibles, Table 3 provides the results of altogether three separate growth accounting exercises: (1) including NA and also non-NA intangibles (labelled GA(1)), (2) excluding non-NA-intangible (i.e. only investments in tangible assets + investments in intellectual property products acc. to ESA 2010) (labelled GA(2)), (3) excluding all intangibles and including only investments in tangible assets (labelled GA(3)).

[32] Corrado *et al*. (2012) investigated the relation between MFP growth and capital deepening (1995 – 2007) and found this to be much stronger for intangible than that for tangible capital. The authors reported correlation coefficients of 0.46 and 0.21 for the contributions of intangible and tangible capital to MFP change, respectively, which were found to be robust to individually dropping outliers, such as e.g. the Czech Republic, Finland and Slovenia. Note that unlike conventional growth accounting exercises, the MFP estimates here are based on a value-added series that capitalise the full set of knowledge-based capital.

[33] See e.g. van Ark, Bart (2015): From Mind the Gap to Closing the Gap: Avenues to Reverse Stagnation in Europe through Investment and Productivity Growth. For empirical evidence see also Corrado *et al*., 2009, p. 680.

Note that the corresponding output measures of GVA had to be adjusted accordingly (see Annex II): the differences in the resulting GVA growth rates illustrate the order of magnitude of the bias in macro-economic growth figures which are due to the conceptual question related to the accounting for intangibles (investment vs. intermediate expenditures, as outlined above in Section 2).

Table 3: **Contributions of supply-side components to GVA growth [1995 – 2013; annualised]**

| | | GVA Growth | Labour Composition | Multifactor Productivity | Capital Composition | *Contribution to capital composition* | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | *Tangible assets* | *NA-Intangibles* | *Non-NA Intangibles* |
| | | (1) | (2) | (3) | (4) | (4a) | (4b) | 4(c) |
| AT | (1) INTAN | 2.123 | 0.144 | 0.975 | 1.004 | 0.515 | 0.217 | 0.272 |
| | (2) NA-IPP | 2.110 | 0.151 | 1.151 | 0.809 | 0.581 | 0.227 | : |
| | (3) NA-TAN | 1.929 | 0.157 | 1.165 | 0.607 | 0.607 | : | : |
| BE[#^] | (1) INTAN | 2.185 | 0.142 | 1.068 | 0.975 | 0.281 | 0.135 | 0.560 |
| | (2) NA-IPP | 1.971 | 0.154 | 1.347 | 0.470 | 0.324 | 0.147 | : |
| | (3) NA-TAN | *2.141* | *0.160* | *1.642* | *0.339* | *0.339* | *:* | *:* |
| DE | (1) INTAN | 1.345 | -0.099 | 0.427 | 1.018 | 0.532 | 0.276 | 0.210 |
| | (2) NA-IPP | 1.295 | -0.105 | 0.496 | 0.904 | 0.612 | 0.291 | : |
| | (3) NA-TAN | 1.225 | -0.110 | 0.682 | 0.654 | 0.654 | : | : |
| DK | (1) INTAN | 1.415 | 0.051 | 0.926 | 0.438 | -0.082 | 0.247 | 0.273 |
| | (2) NA-IPP | 1.385 | 0.055 | 1.162 | 0.168 | -0.095 | 0.263 | : |
| | (3) NA-TAN | 1.159 | 0.058 | 1.204 | -0.102 | -0.102 | : | : |
| EL^ | (1) INTAN | 0.224 | -0.258 | -1.417 | 1.898 | 1.712 | 0.044 | 0.142 |
| | (2) NA-IPP | 0.232 | -0.263 | -1.325 | 1.820 | 1.774 | 0.045 | : |
| | (3) NA-TAN | *0.863* | *-0.265* | *-0.668* | *1.796* | *1.796* | *:* | *:* |
| ES | (1) INTAN | 1.758 | 0.543 | -0.713 | 1.927 | 1.436 | 0.191 | 0.300 |
| | (2) NA-IPP | 1.637 | 0.553 | -0.696 | 1.780 | 1.585 | 0.195 | : |
| | (3) NA-TAN | 1.520 | 0.568 | -0.666 | 1.619 | 1.619 | : | : |
| FI | (1) INTAN | 2.749 | 0.290 | 1.889 | 0.570 | -0.039 | 0.246 | 0.363 |
| | (2) NA-IPP | 2.720 | 0.304 | 2.202 | 0.214 | -0.044 | 0.258 | : |
| | (3) NA-TAN | 2.719 | 0.328 | 2.438 | -0.047 | -0.047 | : | : |
| FR | (1) INTAN | 1.995 | 0.147 | 0.933 | 0.916 | 0.329 | 0.133 | 0.454 |
| | (2) NA-IPP | 1.899 | 0.155 | 1.190 | 0.555 | 0.415 | 0.140 | : |
| | (3) NA-TAN | 1.796 | 0.166 | 1.185 | 0.444 | 0.444 | : | : |
| IE[~^] | (1) INTAN | 4.103 | 0.174 | 0.552 | 3.377 | 1.470 | 1.448 | 0.458 |
| | (2) NA-IPP | 4.336 | 0.179 | 0.973 | 3.185 | 1.701 | 1.484 | : |
| | (3) NA-TAN | *4.136* | *0.182* | *0.812* | *3.142* | *3.142* | *:* | *:* |
| IT | (1) INTAN | 0.487 | 0.028 | -0.827 | 1.286 | 0.999 | 0.078 | 0.210 |
| | (2) NA-IPP | 0.515 | 0.029 | -0.687 | 1.174 | 1.093 | 0.081 | : |
| | (3) NA-TAN | 0.478 | 0.030 | -0.674 | 1.122 | 1.122 | : | : |
| NL | (1) INTAN | 2.154 | 0.267 | 0.462 | 1.424 | 0.708 | 0.277 | 0.439 |
| | (2) NA-IPP | 2.083 | 0.284 | 0.681 | 1.119 | 0.824 | 0.295 | : |
| | (3) NA-TAN | 2.019 | 0.297 | 0.861 | 0.861 | 0.861 | : | : |
| SE | (1) INTAN | 3.273 | 0.260 | 1.098 | 1.915 | 0.941 | 0.415 | 0.559 |
| | (2) NA-IPP | 3.164 | 0.274 | 1.305 | 1.585 | 1.148 | 0.437 | : |
| | (3) NA-TAN | 3.197 | 0.303 | 1.585 | 1.309 | 1.309 | : | : |
| UK[*^] | (1) INTAN | 2.008 | 0.161 | 1.478 | 0.370 | -0.208 | -0.017 | 0.594 |
| | (2) NA-IPP | 1.875 | 0.166 | 2.010 | -0.300 | -0.283 | -0.017 | : |
| | (3) NA-TAN | *3.085* | *0.208* | *3.086* | *-0.209* | *-0.209* | *:* | *:* |
| US | (1) INTAN | 2.034 | -0.041 | 0.604 | 1.471 | 0.685 | 0.193 | 0.593 |
| | (2) NA-IPP | 1.922 | -0.045 | 0.969 | 0.997 | 0.786 | 0.211 | : |
| | (3) NA-TAN | 1.789 | -0.047 | 1.012 | 0.825 | 0.825 | : | : |

Notes: Figures in italics are to be interpreted with caution as they are based on data from varying sources which partly rely on different approaches (see Annex II for further details on data processing and technical notes).

For rows (1) 'INTAN growth accounting': Investments reported in NA were augmented by spending on non-NA intangibles (source: INTAN); GVA figures were adjusted accordingly. For individual countries: Figures in column (1) are average annual percent changes; figures in columns (2) through (4c) are percentage points. (*) starting value 1997 due to missing GVA values; (~) linear interpolation for first years of 'hours worked' series; (^) 'GVA without IPP' series constructed (based on ESTAT data and investment series acc. to INTAN-INVEST).

Different accountings: (1) Investments according to ESA 2010 + spending on non-NA intangibles included
(2) Investments according to ESA 2010 (tangible assets + intellectual property products)
(3) Only investments in tangible assets considered (excluding IPP)

Sources: Computations made by DG ECFIN based on EUROSTAT data (SNA-ESA2010) and the INTAN-investment database (http://intan-invest.net/); ES capital stock data was retrieved from EUKLEMS (forthcoming); data for IE was retrieved from EUROSTAT (SNA-ESA2010), CSO Ireland for capital stock data and the INTAN-INVEST database for intangible investment; data for the US was retrieved from BEA National Accounts data.

The results presented in Table 3 underline that accounting for intangible assets can make remarkable differences for macro-economic figures. In fact, in line with the literature[34], the obtained results suggest that including intangible assets does have a significant effect on the contributions of the observed supply-side components of output growth. In fact, some increase in GVA growth figures is observed, which arises from accounting the spending on intangibles as investments rather than expenditures. This is evident across most of the 14 Member States in the sample (except EL, IE and IT[35]) when moving conceptually from Growth Accounting GA(2) to GA(1), i.e. enlarging the scope of accounting for certain types of intangibles as assets. The observed margins illustrate the corresponding bias in the accounting of GVA in the current SNA (ESA 2010) since GA(2) represents exactly the latter and GA(1) shows what the figures would look like if we were including also non-NA-intangibles. On average across analysed Member States, the difference is about 0.1 percent annual GVA growth. This adds to the one-off level effect (increase in GVA, GDP, etc.) which would be due to capitalising further types of intangibles in the SNA as outlined above in Section 3 on stylised facts.[36]

Furthermore, the observed contribution to output growth which is due to the labour component diminishes in all Member States when conceptually moving from GA(3) > GA(2) > GA(1), i.e. including intangible assets into the growth accounting exercises. By the same token, the capital components (all types of capital assets together) gains importance while the MFP residual is fading.[37] Interestingly, the variance of the obtained MFP values across countries is abating when including intangibles, which suggests that intangibles can indeed explain some part of the unobserved 'measure of our ignorance' and thus help understanding productivity differentials among countries. The corresponding link will be discussed and empirically tested in the following section.

Beyond these general patterns, the numerical differences between the three presented Growth Accounitng exercises and also the observed country specifics in this regard are quite telling as this altogether points to the relative importance of the various production factors, especially the relevance of tangible vs. NA- and non-NA-intangible assets. For instance, as illustrated by columns 4a-4c in Table 3, in a series of countries, intangible assets (NA and non-NA together) contribute already more to the total capital component and thus to GVA growth than tangible capital (BE, DK, FI, FR, IE, NL, SE, UK). Actually, over the period 1995 – 2013, the contribution of the tangible capital component to output growth was found to be even negative in FI, DK and UK, suggesting that in these countries economic growth depends to a large extent on investments in intangibles. In turn, the empirical evidence also points to a comparably low economic importance of intangible assets in EL, ES and IT, where within the capital component tangible capital makes a much larger contribution to the observed growth.

---

[34] Corrado *et al.* (2016). Corrado *et al*. (2009), Corrado *et al*. (2012), van Ark (2015).

[35] Note that in EL, IE and IT the inclusion of non-NA assets in the asset boundary only has a level effect on GVA. In our dataset GVA growth has not increased when moving from growth accounting (2) to (1), which implies for those countries that investment in non-NA intangibles have not been growing faster than GVA not adjusted for the new asset boundary. In BE, EL and UK the growth rate of GVA (3) is above that of GVA (2). Please note that we suggest to interpret the results for GVA(3) for the countries mentioned (including also IE) with some caution since the corresponding calculations, in contrast to all the other results, are based on data from varying sources, which means that they may partly rely on different approaches in terms of data processing and/or statistical definitions (see notes under Table 3).

[36] See Section 3 for illustrating this effect exemplary for the implementation of ESA 2010 (capturing R&D, etc.). According to ESA 2010, intellectual property products (NA-intangibles) account for ca. 4% of GDP and 19% of total GFCF in EU-28. Graph 2 outlines the order of magnitude of changes which would be due to including non-NA-intangibles.

[37] According to the mechanics of a neo-classical growth accounting assuming a Cobb-Douglas production framework and measuring MFP as a residual, the contribution of MFP to output growth diminished from GA(3) > GA(2) > GA(1) since in each step further (potential) components of GVA growth were included and (to various degrees) could explain an additional part of the total observed growth (thus reducing our '*measure of ignorance*' to say it with Solow (respective with Abramovitz (1956, p.11)).

For all countries in the sample (except IE) the relative contribution to the total capital component and thus to GVA growth for non-NA-intangibles was found to be higher than for the NA-intangibles. This suggests that even after implementing the most recent reform of the SNA (ESA-2010), when relying on official figures as provided by EUROSTAT and national statistical offices, more than half of the total contribution of intangibles to the observed GVA growth remains uncounted as such / hidden in other statistical measures. In fact, when incorporating all relevant types of intangibles into the national accounting framework (see GA(1) in Table 3), tangible and (all) intangible capital deepening together becomes the unambiguously dominant source of output growth.[38] Capital deepening is becoming more important because of both the relative dynamics of capital deepening itself and also due to the conceptual extension of the asset boundary (as illustrated empirically by moving conceptually from GA(3) > GA (1)).

As illustrated by means of the Graphs in Section 3 above and the obvious differences that emerge when including non-NA intangibles in the empirical analyses of investments and GVA growth presented in this section, taking into account a broader set of intangible capital could certainly help to better capture the ongoing shift from tangible to intangible investments which – in turn – may serve to improve our understanding of the transition of developed economies into knowledge societies. Extending the national accounts asset boundary with the aim of producing high quality and possibly internationally harmonised data on non-NA intangible assets will, however, depend on solving a range of existing conceptual and measurement challenges, e.g. related to the correct valuation of such assets, identifying appropriate price deflators or measuring their depreciation.[39] Moreover, it is important to appreciate that further capitalisation of intangible assets may also complicate the way in which globalisation – and in particularly large and complex multinational enterprises – are represented in macroeconomic data. The capitalisation of research and development under the ESA 2010 national accounts has led to the situation that intellectual property movements across national borders – which face far fewer obstacles than tangible assets – can have substantial impacts on key macroeconomic data at national level. Accounting for further (and perhaps even more mobile) intangible assets may add complexity in this regard. Corresponding discussions at technical level will take place within the forthcoming multi-annual revision process of the current national accounts systems SNA2008/ESA 2010.

## 4.2. INTANGIBLES, INNOVATION AND PRODUCTIVITY: INTRINSICALLY TIED?

This section explores in more detail the relationship between intangible capital and productivity in a regression framework, which allows relaxing the perfect competition assumption made in the growth accounting exercise in Section 4.1. The link between knowledge capital and productivity is well documented in terms of spending on R&D (see Box 2 below for a brief overview). However, can such a relation be confirmed also for all intangible assets?

Several empirical studies confirm the importance of intangibles for productivity, on macro-, meso- and micro-level. For instance, at macro-level, based on a panel data analysis of a sample of EU countries, Roth and Thum (2013) confirmed a positive and significant relationship between intangible capital investment and labour productivity growth[40], which proved to be robust to a range of alterations and also holds when addressing the issue of endogeneity. The empirical analysis thus confirms previous findings of Corrado *et al*. (2009) that business intangible capital increases the rate of change of output per hour worked. Roth and Thum's (2013) estimated elasticity of intangibles on labour productivity growth is 0.29, which is relatively close to the typically assumed capital elasticity of 0.35. Niebel *et al.* (2013) conducted both growth accounting and growth regressions for sectoral data on intangibles and find estimated output elasticities between 0.1 and 0.2 across sectors. These estimates are higher than the

[38] Note that Corrado *et al*. (2009) found exactly the same result based on an analysis of US growth figures over period of about 50 years.
[39] For an overview see Moulton and Mayerhauser (2015): The future of the SNA's asset boundary.
[40] This is consistent with the possibility of total factor productivity spillovers from intangible investments beyond GDP (as suggested e.g. by van Ark, 2015) and corresponding empirical evidence (Corrado *et al*., 2013).

factor income shares retrieved from the growth accounting exercise, which the authors take as evidence for complementarities or spill-over effects of intangibles.[41]

At meso-level, several studies examine more closely the breakdown of the effect of intangibles on productivity in either different types of assets or across sectors. Regarding a comparison across different types of assets, based on hiring data for Finland, Ilmakunnas and Piekkola (2014) compared returns to three types of intangibles-related jobs and report a significant effect of organisational capital on productivity. Regarding sectoral comparisons of the productivity effects of intangibles, Niebel *et al.* (2013) identified the manufacturing and the finance sector as the sectors in which intangibles are the most productive in Europe. Chen *et al.* (2016) found that ICT-intensive industries are those benefitting most from intangibles in Europe.

At micro-level[42], the productivity impact of intangibles, as shown in a number of econometric studies especially for R&D (see Box 2 and e.g. Mairesse and Sassenou, 1991; Hall *et al*., 2009), has been recently demonstrated also for a wider set of intangible assets including, for instance, computerised information (software and databases), human capital, organisational capital, and customer capital (see e.g. Black and Linch, 2001; Bontempi and Mairesse, 2008; Marrocu *et al*., 2012).[43] The empirical relevance of intangibles for productivity gains arguably differs from company to company, across intangible asset types (as demonstrated below in this section based on new regression results) and, as evidence suggests, also from sector to sector (see e.g. Marrocu *et al*., 2012).

In general, knowledge-based industries tend to achieve higher productivity by combining investment in fixed capital, intangible assets such as e.g. new computer software and human capital so as to create new organisational structures and business models, and sometimes entirely new products. Business models can, however, vary substantially across sectors and firms. For instance, an EIB study (Uppenberg and Strauss, 2010) pointed out that services sector innovation, in contrast to that in manufacturing, draws less on in-house knowledge creation in the form of (scientific) R&D. In fact, services industries tend to innovate in interaction with customers, suppliers and competitors, i.e. for ensuring innovativeness and productivity gains they rather rely on other forms of intangibles (non-R&D).

Overall, the empirical literature on productivity and efficiency analyses has confirmed the role played by intangible assets – such as software, R&D, economic competences, training of employees – in determining firms' output. This has been complemented at the macro-level by analyses of regional economic performance, which have consistently stressed on the relevance of local intangible endowments, like human, social, knowledge, and institutional capital. By generating self-reinforcing localised externalities, in general, these assets favour the agglomeration of economic activities and enhance the economic performance at the local level (and beyond). Nevertheless, further research is needed in this regard since many studies (mostly due to data limitations) rely empirically on rather aggregated figures, do not distinguish intangible asset types and/or analyse the impact of only one asset type exemplary (most prominently R&D).

[41] Note that Roth and Thum (2013) and Niebel *et al.* (2013) base their research on intangible capital estimates from the INTAN-INVEST database, which includes the intangible asset categories defined by Corrado *et al.* 2009 (computerised information (software and databases), innovative property (mineral exploration, scientific R&D, entertainment and artistic originals, new products/systems in in financial services and design) and economic competences (advertising, market research, employer-provided training and organisational structure)).

[42] In fact, while research has advanced in the measurement of aggregate business investment in intangibles in the context of growth accounting studies, the empirical evidence concerning their role at firm level is still relatively limited (see Box 1 for micro studies on R&D). The literature on intangible assets typically seeks to explain and estimate the relationship between intangible resources as an input and a set of outcomes such as productivity, market value, and new products. In this context, special attention has been dedicated to the analysis of the strategic role that companies attribute to their intangible assets, by dedicating internal rather than external resources to their development. Related to this are the specific roles that intangible assets have in companies' innovation projects and the general role they have in terms of day-to-day business performance and competitive advantages. A step ahead in the direction towards more micro-oriented empirical evidence on intangibles has been the publication of the Eurobarometer 2013, which was designed to explore companies' investment in a range of intangible assets, i.e. the extent to which internal or external resources were used when investing in intangibles, the observed length of benefits from investing in such intangible assets, the barriers perceived when making such investments, etc..

[43] For a more detailed reflection of these studies see e.g. Hunter *et al*. (2005).

**Box 2: LITERATURE ON THE EFFECT OF INTANGIBLES, AND IN PARTICULAR R&D, ON PRODUCTIVITY GROWTH**

Among all intangibles R&D plays a special prominent role because it is associated to a number of different market failures (Arrow 1962, Nelson 1959, Martin & Scott 2000), that lead to a socially sub-optimal level of investments in R&D and which justify state intervention[44]. The IMF estimates that fully internalising the externalities of R&D would lead to 40% higher investments compared to the statu quo. Such an increase could lift GDP in individual economies by 5% in the long term - and globally by as much as 8% due to international spillovers (IMF 2016). R&D activities are also characterised also by a high degree of uncertainty, encompassing technological uncertainty and a market uncertainty. Furthermore, due to imperfect and asymmetric information, private investors may be reluctant to finance valuable projects. Uncertainty, asymmetric information and the lack of the traditional collateral banks require for lending place a constraint on firms investing in R&D and aiming at accessing external finance, which leads to lower investments.

At the macro level, a series of academic studies have attempted to estimate the impact of R&D activities on indicators of economic performance, such as GDP, Labour- or Total Factor Productivity. The rate of return of both private and public R&D investment – i.e. the effect of 1 EUR invested in R&D on the economic performance indicator – is found to be positive and significant, despite variation in the estimated value depending on the sample and the methodology used (Hall *et al.* 2010). Using INTAN data, Bravo-Biosca *et al*. 2013 estimate that innovation contributes between two-thirds and four-fifths of economic growth in developed countries and in Europe it accounted for 62% of all economic growth between 1995 and 2007.

Kokko *et al*. (2015) run a meta-analysis and used 49 country-specific studies assessing the impact of R&D on growth. The authors concluded that the US has been able to generate more systematic benefits from its R&D spending during the past decades than the EU. This is most probably linked to the higher share in the US of private investments in R&D spending (which reflects differences in the industrial structures and in the dynamics of the renewal of the economic fabric between the US and the EU).

Indeed, empirical analyses generally find that the returns of private R&D investments are higher than for public R&D. For the latter, smaller and also sometimes negative or insignificant results can be found in the literature, even though on average the impact is found to be positive (van Elk *et al*. 2015, Radosevic 2016). There is a controversial debate concerning the different impact attributed to private vs. public investment in R&D. It has been argued that empirical analyses are likely to capture only the direct impact, but tend to miss indirect effects, such as the societal impact that public R&D investment may have in areas such as healthcare, quality of life, environment, defence and social protection, where an increase in GDP or productivity is not the primary aim (Radosevic 2016, Veugelers 2016).[45] Furthermore, lags may not be properly captured: public R&D can feed into private R&D with very long lag as the example of the time lag between the Arpanet and the Internet shows.

The micro-level literature (i.e. based on firm data) has mostly focused on the effects of private and public spending on R&D and innovation on productivity. Following the seminal work of Griliches (1979), empirical results are consistent with findings at the macroeconomic level. In general, R&D activities are found to significantly contribute to enhancing firms' productivity, with the magnitude of the effect strongly depending on firms' characteristics (e.g. firm size, past R&D investments, sector, export intensity; Hervas and Amoroso, 2016).

[44] For example, R&D generates benefits for society and the wider economy in the form of positive externalities, such as knowledge spillovers or enhanced opportunities for other economic actors to develop complementary products and services. If purely left to the market, a number of projects might have an unattractive rate of return from a private perspective, although they would be beneficial from a welfare perspective, because profit seeking undertakings cannot sufficiently appropriate the benefits of their actions when deciding about the amount of investment in R&D. In general, consumers are willing to pay for the direct benefit of new products and services while firms can appropriate the benefits from their investment through instruments, such as IPR. In some cases, however, those means are imperfect and leave a residual market failure which is a justification for government intervention. This is for example the case for fundamental research: it may be difficult to exclude others from gaining access to the results of some activities, which might therefore have a (quasi) public good character.

[45] Moreover, a large body of the related empirical literature aims to assess whether public R&D is complementary or substitute to private investment (additionality vs. crowding out). Findings vary across countries, but on average tax incentives and subsidies are found to have a positive impact on firms' investment in R&D and the hypothesis of crowding out is commonly rejected. In addition, public research and education are found beneficial to private R&D because of knowledge spillovers from university research. See Becker (2015) for a review of the most recent literature.

Empirical evidence, for instance from the EU R&D Scoreboard (tracing the economic and innovation performance of the top 2,500 R&D investors worldwide), reveals that investment in R&D improves firms' productivity through various channels. Productivity gains are found especially in the services and high-tech manufacturing sectors (Hervas and Amoroso, 2016). This partly explains the existing gap between the EU, Japan and the US since the latter two countries are generally more specialised in services and high tech activities. Beyond effects of the sector composition, there is apparently also a framework component. In fact, evidence suggests that productivity gains from investing in R&D are halved for Scoreboard's companies located in the South of Europe (Spain, Greece, Italy and Portugal) (ibidem). Moreover, Kancs and Silverstovs (2012) pointed out that the impact of R&D on firms' productivity is non-linear. The authors suggested that the more the technological sophistication of the firm, the higher the impact of investment in KBC (notably R&D) on productivity, while a critical mass level of R&D is necessary to trigger the relationship. In addition, the authors confirmed that for medium and low-tech sectors physical capital appears to be more important than knowledge and intangible assets for increasing firm's productivity. This again highlights the importance of taking into account the industrial structure and its dynamics while trying to understand the link between R&D and productivity.

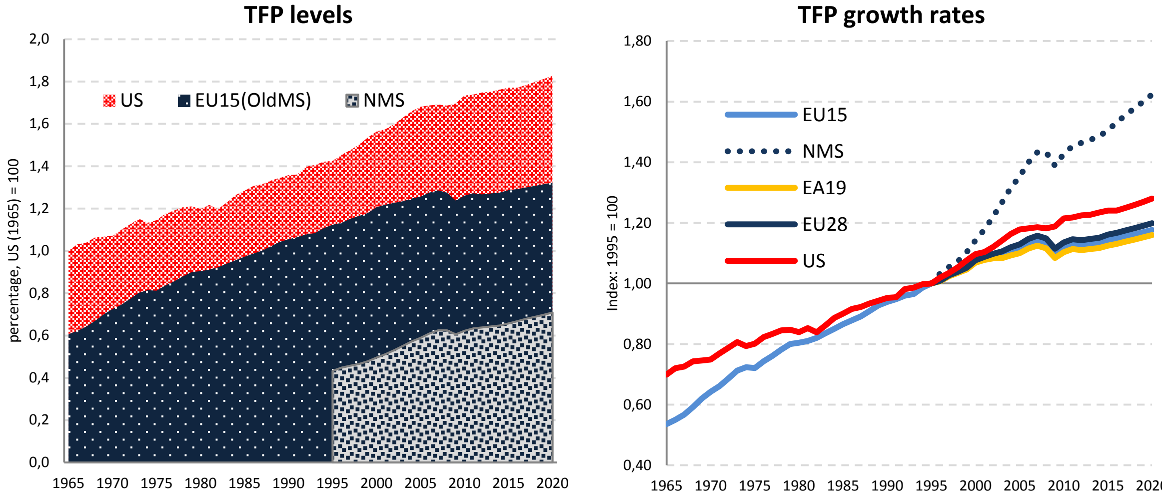
Another strand of the academic literature assesses the impact of intangibles (notably R&D) on productivity and firm performance in three conceptual steps: (1) explaining the propensity to invest in R&D based on a set of determinants, (2) estimating the impact of input (R&D spending) on innovation output, and (3) including innovation into the productivity equation as an explanatory variable. This approach is based on a methodology developed in a seminal paper by Crépon, Duguet and Mairesse (1998) and referred to as the CDM framework[46]. By using such a CDM approach, e.g. Mohnen and Hall (2013) report some evidence on the impact of intangibles (R&D and beyond) on productivity. In particular, they assess the impact of technological (product and process) and organisational and marketing innovations on productivity growth. A new product can be understood as an innovation to the market or to the firm and can give rise to scale economies and new source of demand. Process innovations are instead expected to have a straightforward positive effect on productivity by reducing production costs. Finally, other intangible improvements, such as organisational innovation and marketing, can further affect firms' productivity. An empirical drawback in assessing the impact of intangible assets of this kind is that they are measured by a dichotomic index, informing whether the firm has realised an innovation improvement. No details concerning the intensity are thus available. The authors find that product, process, organisational and marketing innovations contribute to a better productivity performance and that some complementarities between the different kinds of intangible assets exist.

To complement findings in the literature, which focus mainly on labour productivity, a regression analysis is conducted to empirically test the link between investments in intangibles and in particular TFP growth estimates. It is based on forthcoming analysis of trend TFP determinants by Thum-Thysen and Racibosrki (2017). The TFP estimates are obtained from ECFIN's production function methodology (see Havik *et al*., 2014). To control for business cycle effects, a de-trended measure of TFP referred to as 'trend TFP' is employed.

Graph 5 illustrates the dynamics of TFP over a period of about 50 years and includes forecasts for further developments until 2020. Arguably, such TFP developments may also be determined by (the dynamics of investments in) intangible capital, particularly if not captured as such in the SNA. In this context it needs to be recalled that TFP is commonly measured as a (Solow-) residual, i.e. the output changes not explained by changes of the input set.

[46] See Crépon *et al*. (1998)

Graph 5: **TFP growth (EU-15, US, NMS, EA, EU-28)**




Notes: Aggregates for EU15 and New Member States (NMS; i.e. member states that joined after April 30th 2004) represent weighted country-wise TFP growth rates (estimated SOE residuals); estimates for NMS available for years after 1995 only; growth rates for 2015 - 2020 are DG ECFIN forecasts

Source: TFP calculations acc. to ECFIN estimates, based on ECFIN's production function methodology for estimating the output gap

We estimate an error-correction model (ECM) in order to take into account long-run and short-run dynamics of TFP. This regression framework is based on a set of assumptions about the dynamics of TFP growth. In the standard ECM we expect cross-country convergence in productivity in the long-run, which could be understood as a catching-up process with the technological frontier, i.e. a country considered as a forerunner in terms of technological progress. Following, for instance, Nicoletti and Scarpetta (2003) and Domenech and de la Fuente (2006), we assume the US to be the corresponding benchmark (frontier setter). Convergence can occur through different channels such as imitation (Aghion and Howitt 2006) or innovation. Long-run convergence in TFP is typically expected to be conditional in the sense that differences in structural factors with the frontier country can still persist. The implication is that structural characteristics determine long-run TFP and that differences in structural indicators with respect to the frontier remain.

The model described above relies crucially on co-integration of the variables included in the long-run relationship. As unit root and co-integration tests on our data indicate, co-integration seems to persist rather in TFP growth rates than in TFP levels. This means that we can observe long-run (upward or downward) convergence with the US in growth rates but growth does not seem to be high enough to lead to converge in terms of levels in the long-run. Indeed, the data shows that the standard catching-up model in levels does not seem to hold. We therefore estimate our model based on convergence in TFP growth rates, which entails writing the short-run relationship in terms of the acceleration of TFP growth. Convergence in growth rates can driven on the one hand by technology spill-overs but also by global trends such as the economic crisis. The latter can slow down growth in the US but also in EU member states or growth in the EU member states could slow down because of catching-up in levels. We cannot distinguish the two latter cases in our model.

The model can be described by the following equation:

$$\Delta^2(TFP^{TR})_{it} = \beta_{0i}[\Delta(TFP^{TR}_{it-1}) - \Delta(TFP^{TR}_{Lt-1}) - \alpha_i - \beta_2(INT_{it-1}\text{-}INT_{Lt-1})] + \beta_{1i}\Delta^2(TFP^{TR})_{Lt} + \varepsilon_{it} \qquad (1)$$

$\Delta^2(TFP^{TR})_{it}$ denotes the acceleration of trend TFP growth in country $i$ in time $t$ and $\Delta^2(TFP^{TR})_{Lt}$ denotes the acceleration of structural trend TFP growth in the frontier-setting country $L$ in time $t$. $\Delta(TFP^{TR}_{it-1})$ denotes TFP growth in country $i$ in time $t$ and $\Delta(TFP^{TR}_{Lt-1})$ denotes TFP growth in leader country $L$[47];

[47] The gap in TFP growth is therefore defined as the difference between TFP growth of the respective Member State and TFP growth of the US.

$INT_{it-1}$ denotes investment in intangible assets and $c$ and $\alpha_i$ denote a constant term and a country fixed effect[48], respectively, which capture time-invariant differences across countries. $\beta_0, \beta_1, \beta_2$ denote coefficents on the respective explanatory variables. Finally, $[\Delta TFP_{it-1}^{TR} - \Delta TFP_{Lt-1}^{TR}]$ indicates the impact of convergence with the leading economy (US) and $\Delta^2(TFP^{TR})_{Lt}$ indicates the impact of spill-overs from the leading economy (US). For convergence to be confirmed by the data (and the crucial co-integration assumption to hold), $\beta_{0i}$ must be negative. We estimate the model by a Pooled Mean Group (PMG) estimator allowing for cross-country heterogeneity in the speed of convergence. Note that due to the importance of parsimony in our model (i.e. relatively short series) it is not possible to capture both, short- and long-run effects of the structural variable $INT_{it-1}$. Structural variables should have long-run effects while their short-run effects are more debatable. For this reason we only model long-run effects of structural variables.[49]

Before turning to the regression results we examine the relationship between the variables TFP growth and investment in intangible assets – as speficied in equation (1) - graphically. Indeed, for several EU-15 countries there seems to be a clear relationship between convergence of TFP growth rates towards TFP growth rates in the US and gaps in investment in intangible capital (see Figure A1 in the Annex). In countries such as BE, DK, FR, ES, PT and to some extend also AT and IT the intangible investment gap vis-à-vis the US is closing as TFP growth converges towards the US. In other countries such as the NL, both the TFP growth gap and the gap in investments in intangibles are increasing over the whole sample. In SE the positive gap in intangibles and in TFP growth are increasing until the dotcom bubble in 2000 when both the respectively positive gaps in investments in intangibles in TFP gap are declining. Both indicators pick up again in the aftermath of the economic crisis.

Table 4 below presents the results obtained from the regression analysis. The first two rows display the short-run effects $\beta_{0\bar{i}}$ and $\beta_{1\bar{i}}$ while the remaining rows display the long-run effects $\beta_2$. The first column shows a baseline model which controls only for respective convergence (upward or downward) and spill-over effects with respect to the US. Findings indicate that TFP growth in a Member State tends to pick up if this growth rate lies below that of the US. Furthermore spill-overs with the US are found to be strongly positive, i.e. faster speed of TFP growth in the US is associated with faster speed of TFP growth in the EU Member States.

Table 4: **Regression results of an error-correction model estimated by pooled-mean-group estimation of trend TFP growth**

| | baseline | all intangible investment | splitting the asset types |
|---|---|---|---|
| TFP growth gap | -0.0336* | -0.0935*** | -0.0840** |
| | (0.0194) | (0.0274) | (0.0378) |
| Spill-over US (differenced TFP growth US) | 0.836** | 1.137*** | 0.940** |
| | (0.385) | (0.427) | (0.375) |
| Intangible investment gap US - "All" | | 0.0455*** | |
| | | (0.00512) | |
| Intangible investment gap US - "non-NA" | | | 0.0155** |
| | | | (0.00637) |
| Intangible investment gap US - "NA" | | | 0.0370*** |
| | | | (0.00380) |
| Constant | -0.000132 | 0.00146 | 0.000677 |
| | (0.000234) | (0.000933) | (0.00120) |
| Countries | EU-15 | EU-15 | EU-15 |
| Years | 33 | 33 | 33 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Commission services

[48] Note that the presence of fixed effects basically shows that there are some factors other than the ones we add that explain the difference between the frontier and a given country and that the given country converges to the frontier.
[49] Even if there are short-run effects, their omission decreases the efficiency of the estimates, but does not bias them (note that the omission of a valid long-run effect would generally lead to a biased estimate).

In the second column a measure of investment in intangible assets over GVA is added. The results provide evidence for a positive and significant relationship between intangible investment and TFP growth. In the third column we split intangibles into the two asset types non-NA-intangibles and NA-intangibles. The coefficients of both asset types turn out to be positive and significant, with the NA-coefficient being slightly larger.[50]

# 5. INVESTMENT IN INTANGIBLES: DRIVERS AND BARRIERS

In this section we take a closer look at investments in intangible asstes – with the ultimate objective of identifying drivers and barriers specific for investments in intangible assets. A summary of this section is presented in Thum-Thysen *et al*. (2017).

The economic characteristics identified in Section 2.2 suggest a range of drivers of and barriers to investment in intangibles. In this section a non-exhaustive list of altogether five sets of drivers and barriers is presented, drawing on the relevant literature[51] and on the mapping of the characteristics identified in Section 2 into drivers and barriers: (1) regulatory framework conditions and a pivotal role for re-allocation, (2) financial conditions, (3) availability of human capital and knowledge stocks, (4) direct and indirect public intervention and (5) macro-economic conditions. Some of the identified drivers and barriers are common to all intangibles but to the extent possible the analysis is broken down per asset type in Section 5.2.

## 5.1. DRIVERS AND BARRIERS

### 5.1.1. Regulatory framework

This driver or barrier follows from generally higher uncertainty for intangibles, but also from their competition-related characteristics which may lead to sub-optimal investment (rent seeking behaviour and positive externalities not captured by investors, see Section 2).

While efficient resource allocation is important for all types of investment, the high growth potential and higher uncertainty of intangible assets due to their often exploratory nature increase the importance of an efficient mobilisation of resources. Indeed, compared to tangibles, investment in intangibles is relatively more uncertain, which implies that commercialising an idea for a new product may require swiftly deploying resources (see Andrews and Serres, 2012). To the extent that the production of intangible goods requires investment in intangible assets, this is at the heart of the Schumpeterian creative destruction and it means that impediments to entry and exit and to the quick deployment of resources (capital, labour, human) are ever more crucial for unlocking investment in intangibles.

Beside flexible product- and labour market regulations, the development of capital markets such as a European Capital Market Union[52] and a large internal market such as the European Single Market can also effectively help channel resources towards the most productive investments and facilitate the scale-up of companies.

Flexible and pro-competitive product market reforms can also foster knowledge diffusion, as theoretical as well as recent firm-level evidence by the OECD (2016) suggests. For instance, pro-competitive product market reforms can raise the incentives for incumbent firms to adopt new technologies. The OECD (2016) suggests indeed that there is a rising gap between technologically leading firms (frontier setters) and all the others, which could be driven by the difficulty for some firms to transit to the economy of ideas.

---

[50] Note that when computing TFP as the Solow residual, we actually already account for both the growth and productivity effects of the NA-intangibles since their stocks are part of the capital component. Therefore, the positive effect of NA-intangibles should be interpreted as evidence for having assumed a capital elasticity slightly on the low side.

[51] Andrews and de Serres (2012), Hao and Haskel (2011), European Commission (2013), Montresor and Vezzani (2014)

[52] An EU-wide action to promote competition among national capital markets is estimated to free up to €1.8 trillion in cash and deposits to invest cross-border in more profitable and riskier projects (Valiante 2016).

Competition policy should be designed in such a way that incentives for companies to invest in intangible assets are created by addressing potential market failures. Andrews and de Serres (2012) for instance argue that the network effects inherent to intangible assets have implications on competition policy design, in particular in terms of the criteria employed to identify anti-competitive behaviour and in terms of technology standards. Competition can also create incentives to improve management and efficiency thus increasing investment in organisational capital (see Hao and Haskel, 2011).

However, the relation between regulation and intangible investment may not be linear: some product market regulations may provide incentives to innovators to invest by ensuring high *ex-post* rents (Hao and Haskel 2011[53]). Similarly, some forms of employment protection may increase investment in training as firms have higher incentives to invest in human capital if workers are less likely to leave after the training (ibidem). Such non-linearities suggest that low levels of product and labour market regulation should be complemented by appropriate measures, for instance effective intellectual property rights (IPR) systems (i.e. technological patents, industrial designs or brands) ensuring an improved appropriation of returns.

### 5.1.2. Financial conditions

This driver or barrier follows from the higher uncertainty due to the exploratory nature of investment in intangible assets and the generally lower transferability and lower *ex-ante* verifiability[54] due to the lack of physical embodiment of intangibles compared to tangibles.

Higher uncertainty and lower *ex-ante* verifiability imply that even if intangible investments can ultimately be lucrative, they might not be financed or realised, as the private capital sector sometimes lacks the ability to understand or assess the risks these investments may entail. Indeed, financial conditions such as the interest rate, debt-to-equity ratio and leverage of the banking sector are important drivers of investment (as shown in Section 5.3). Furthermore, the lack of (tangible) collateral when accessing credit markets is one of the obstacles frequently identified by investing firms (see for instance Montresor and Vezzani 2014). To facilitate access to finance, improving accounting standards for the valuation of intangibles (both in corporate and national accounts) could allow companies to more easily assess the value they have in terms of intangibles. Other improvements of the mechanisms to disclose information on intangible assets in corporate reporting could be narrative reporting[55] as put forward for instance by the OECD (2012). Finally, the development of alternative sources of finance such as venture capital, crowd-funding and public-private co-financing such as provided in the European Fund for Strategic Investment (EFSI)[56] could be useful policy tools in that respect.

### 5.1.3. Human capital and knowledge stocks

This driver or barrier follows from the synergies or complementarities of intangible assets with other types of capital such as human capital.

An existing high level of generic and for some intangibles in particular tertiary or technical skills is a pre-requisite for successful intangible investment, as most types of intangible assets are human-capital intensive. For some assets, such as R&D, achieving a critical mass in terms of specific knowledge and skills accumulation is necessary to achieve optimal results. Furthermore, a strong science base is needed to allow new business R&D investments to build on the "shoulders of giants" i.e. the available public R&D/knowledge stock[57] In this regard, public R&D is a major driver of business R&D investments and can play even a more important role in fostering business R&D than (direct and indirect) public funding for business R&D (European Commission, 2016a). The efficiency and effectiveness of the public R&D can be improved by the use of performance criteria in distributing institutional funding and international peer review standards in the allocation or competitive peer reviews to allocate project-based funding.

---

[53] Aghion *et al*. (2006) also provide evidence for an inverted U-shaped relationship between competition and innovation.

[54] Ex-ante verifiability refers here to the fact that the value of an asset cannot easily be determined before it has generated value.

[55] Narrative reporting is a descriptive section in the annual reports that uses non-financial information to give a picture of a firm's business, market position, strategy, performance, and future prospects.

[56] https://ec.europa.eu/priorities/jobs-growth-and-investment/investment-plan_en

[57] See e.g. Caballero and Jaffe (1993) who show that new R&D investments can benefit from an existing stock of R&D investments.

Public R&D also plays a crucial role in building knowledge stocks through strong business-science linkages and enhancing knowledge transfer that are crucial to support research and innovation capacity overall. A recent study found that support for R&D co-operations, next to direct and indirect support to business R&D, investments in university research and high-skilled human capital, indeed increase private R&D (Becker, 2015).

### 5.1.4. Direct and indirect public intervention

This driver or barrier follows from limited appropriability, spill-overs, and other market failures identified in the context of investment in intangible assets (including also the failure of capital markets to assess risks and cost-benefit relations correctly). Government intervention can mitigate market failures by lowering the risks and associated costs a company faces (directly through grants and public investment or indirectly through tax incentives). In particular, governments can stimulate investment in R&D directly by supporting firms in getting access to finance for R&D activities (e.g. by loan guarantees, state backed venture capital or public procurement). Recent evidence supports this positive impact[58], although in some cases, the results are divergent. The ambiguity of these results is partly attributable to the large array of policy instruments used[59] and their effectiveness depends on many factors, in particular their design and implementation. This includes the appropriate targeting of various types and instruments of support, as well as the complementarity of instruments. This type of public support to private investment could be extended to other types of intangible assets (e.g. firm-specific training or potentially computerised information). Direct public support also includes investment in infrastructure, public R&D or the public education system (see also Section 5.1.3).

Many EU member states use the tax system to stimulate R&D and training. This indirect set of government instruments includes (R&D) tax incentives[60], which are indeed found to be effective in stimulating business investment in particular in R&D, but their effectiveness depends heavily on the corresponding design, administration, and implementation (Criscuolo *et al*. 2016). Box 3 discusses the particular role of tax incentives in the context of unlocking investment in intangible assets with a special focus on R&D and training.

Box 3: **TAX INCENTIVES AS DRIVER OR BARRIER TO INVESTMENT IN INTANGIBLE ASSETS**

Given that returns on R&D and training are highly uncertain and that knowledge externalities make it difficult for businesses to capture the full return on their investment, companies often invest less in R&D and training than socially desirable. To compensate for the imperfect functioning of the market, the majority of Member States offer targeted tax incentives and/or direct subsidies to encourage investment in R&D and training. Opinions differ as to which approach is more effective and most countries adopt a combination of both instruments. In its Fiscal Monitor, the International Monetary Fund (IMF, 2016b) confirms that the cost-effectiveness of fiscal R&D incentives very much depends on their design. A lot of the incentives could therefore benefit from a re-design or a scale-back.

A study on R&D tax incentives carried out for the European Commission (see CPB, 2014) and another one carried out by the European Commission (2016b) to support the effective design of R&D tax schemes[61] find that tax incentives designed to encourage spending on R&D can be effective in stimulating additional investment. Most firm-level studies conclude that tax incentives spur investments[62], although the quantitative effects vary widely, ranging from partial crowding out of private investment[63] (i.e. one euro of foregone tax revenue on R&D tax incentives raising expenditure on R&D by less than one euro) to substantial additionality. This highlights the importance of a careful

[58] See Becker (2015).
[59] Aristei *et al*. (2015).
[60] Note that the tax system as a whole – such as corporate income taxation - can also function as a driver of or barrier to intangible investment, which is part of the regulatory framework.
[61] This report is part of the work undertaken to support mutual learning exercises across EU governments for better R&I policies (Horizon 2020 Policy Support Facility: https://rio.jrc.ec.europa.eu/en/policy-support-facility/mle-administration-and-monitoring-rd-tax-incentives).
[62] See e.g. Becker (2015).
[63] See e.g. Belitz (2016).

design, administration, implementation and regular evaluation of such tax instruments. As regards the indirect effect of tax incentives, there are no conclusive findings as to the effect on productivity although R&D expenditures are found to play a key role in determining the differences in productivity across firms and the evolution of firm-level productivity over time[64]. An ongoing study conducted by the OECD and the European Commission will help provide better evidence in this respect[65]. There is some evidence of a positive effect on innovation, however, this is only true for tax incentives linked to input (i.e. tax relief on R&D expenditure) and not for those linked to output (i.e. patent boxes), as they could contribute to harmful tax competition. For an overview of the different R&D tax relief regimes in EU Member States see Table 3.7, "Tax Reforms in EU Member States", 2015.

A study on tax incentives to promote education and training (CEDEFOP, 2009) shows that about half of the EU Member States uses corporate tax incentives for education and training. Tax incentives can have different forms, such as a tax allowance for education or training expenditures, a tax credit against relevant spending or a tax exemption for income accrued by specific groups (such as apprentices). Assessment of the effectiveness of tax incentives on education and training supply and demand is rare.

Finally, public policy can also help strengthen relevant links with the creation of knowledge hubs through cooperation programmes or intermediary institutions that can act as bridges between individual actors (e.g. public research centres, universities, private companies).

Note that while intangibles such as R&D are indeed characterised by potentially high social returns, the market failure argument and thus the justification for policy intervention may not be valid for some type of intangibles, particularly in cases where more investment is not socially desirable (e.g. investment in certain types of economic competences, which by being firm-specific can create barriers to entry and exclude competitors from accessing information and technology).

### 5.1.5. Macro-economic conditions

This driver or barrier only partly follows from the specific characteristics of intangible assets discussed in Section 2 and it is seen a more general characteristic. In fact, macroeconomic uncertainty is an obstacle for all kinds of investment but as intangible investment is affected by additional inherent risk, demand uncertainty may affect intangibles relatively more than tangibles[66].

In addition, the sectoral composition of the economy could also affect investment in intangible assets. Evidence on whether a more service-oriented economy tends to be more intangible-intense is mixed. Corrado *et al*. (2014) find that investment in intangibles has grown more strongly in the services sector, while the OECD (2013b) shows that in some countries investment in intangibles is higher in the manufacturing sector. A reason for the latter fact could be that the manufacturing sector involves an increasing amount of services that could indirectly increase the role of intangibles in that sector. Finally, the degree of digitalisation of an economy can also determine investment in intangible assets.

## 5.2. THE ROLE OF DRIVERS AND BARRIERS BY TYPES OF INTANGIBLE ASSETS

The drivers and barriers discussed above may affect the respective types of intangible assets differently. Therefore, Table 5 provides, per intangible asset type, an *ad hoc* assessment of the role of the barriers and drivers identified above. The table is based on work by the OECD complemented by ECFIN's own assessment. It is characterised by a very high degree of simplification and should be seen as illustrative, i.e. conveying the general message that the identified drivers and barriers may affect the respective intangible asset types heterogeneously.

---

[64] Doraszelski and Jaumandreu (2013).

[65] The joint OECD-European Commission study on the Incidence and Impact of Tax Support for Research and Innovation will provide new evidence on the incidence and design of R&I tax incentives, building internationally comparable evidence on the size and nature of incentives provided by governments to support R&D and innovation through their tax systems; deliver new evidence on the impact of R&I tax incentives, deepening our understanding of the impacts of R&D tax incentives on business innovation and economic performance, and foster knowledge sharing on the incidence, design and analysis of impact of R&D tax incentives.

[66] Bontempi (2016) shows on the basis of a theoretical model and Italian firm-level data that uncertainty may delay in particular R&D investment due to a caution effect which incentivises firms to wait and do nothing in cases of demand uncertainty.

Table 5: **Drivers and barriers to intangible investment by asset type (emerging from Sections 5.1.1-5.1.5)**

| | | Public support | | Financial conditions[67] | Regulatory framework | Availability of human capital | Macro-economic conditions |
|---|---|---|---|---|---|---|---|
| | | Need for action? | | Do these drivers and barriers affect the respective asset types? | | | |
| | | Direct grants, etc. | Indirect e.g. tax incentives | | | | |
| Computerised information | Computer software | potentially* | potentially | yes, as difficult to collateralise but easily transferable (codified) | yes, to strike the right balance between addressing competition distortion (i.e network externalities) and protecting rents to cover uncertainty | yes, mainly technical skills | yes |
| | Computerised databases | potentially | potentially | yes, as difficult to collateralise but easily transferable (codified) | yes, to strike the right balance between addressing competition distortion (i.e. network externalities) and protecting rents to cover uncertainty | yes, mainly technical skills | yes |
| Innovative Property | Scientific R&D | yes | yes | yes, as difficult to collateralise, uncertainty but easily transferable if patented | yes, to strike the right balance between addressing competition distortion and protecting rents to cover uncertainty | yes, mainly high skills; knowledge stock and knowledge transfer are equally important | yes |
| | Creative property | potentially | no | yes, as difficult to collaterise but easily transferable (codified) | yes, to strike the right balance between addressing competition distortion and protecting rents to cover uncertainty | yes, mainly creative skills | yes |
| | Design | potentially | potentially | yes, as difficult to collaterise but easily transferable (codified) | yes, to strike the right balance between addressing competition distortion and protecting rents to cover uncertainty | yes, mainly creative skills | yes |
| Economic Competencies | Brand equity | no | no | yes, as difficult to collaterise; transferable via firm ownership | yes, as competition can act as a driver to create a brand | yes, mainly creative skills | yes |
| | Firm-specific human capital | yes | yes | yes, as difficult to collaterise; transferable via hiring | yes, as competition can act as a driver to improve human capital | yes, mainly generic skills complementary to specific skills learned during training | yes |
| | Organisational capital | no | no | yes, as difficult to collaterise and not easily transferable | yes, as competition can act as a driver to innovate management techniques | yes, mainly interpersonal skills | yes |
| | Market research[68] | no | no | yes, as difficult to collaterise; transferable via firm ownership | yes, as competition can act as a driver | yes, mainly analytical skills | yes |

Notes: (*) "potentially" stands for cases in which there are clear trade-offs; for instance in the case of unlocking investment in computer software, small and medium enterprises could be subsidised when using new technology but these subsidies could lead to lock-in effects as they do not give firms the incentive to grow.

Source: own illustration, adapted and extended from Andrews and de Serres (2012).

*Direct public support and tax incentives* are identified to be most useful in the case of scientific R&D and firm-specific human capital, which are both asset types that are generally characterised by high social returns (relative to private returns). For assets in computerised information, public support may play a role in promoting small and medium enterprises to invest in new technologies. However, these policy tools may also lead to a lock-in situation, in which the subsidised firms do not have the incentive to grow further (European Commission, 2012). Economic competences serving to build monopoly rents such as brand equity should not be targeted by public support. *Financial conditions* matter for all intangibles as they are difficult to collaterise but may be more important for those assets which are not

[67] The assignment of the degree of transferability in this column is taken from Andrews and de Serres (2012).

[68] Note that 'market research' (e.g. in the sense of feasibility studies, firm-specific foresight exercises, etc.) is not an explicit asset category according to the definition of Corrado *et al.* (2005). However, it is considered to be relevant here and, since it cannot be easily grouped into any of the other categories, it is added to the corresponding typology.

easily transferable or verifiable such as organisational capital. The *regulatory framework* should on the one hand promote a competitive and flexible environment but at the same time allow for intellectual property protection to ensure some rents to cover uncertainty in the investments. This holds mainly for the production of computerised information and innovative property, while for most economic competences intellectual property protection should be less of a focus point as these assets are mainly firm-specific. Finally, different types of *human capital* are necessary for each asset category: while scientific R&D is more intensive in tertiary graduates, computer software rather needs technical skills and design would need creative skills.

## 5.3. AN EMPIRICAL ASSESSMENT OF DRIVERS AND BARRIERS TO INVESTMENT

This section aims at verifying the relevance of the determinants identified above. A regression analysis is performed relating investments in intangible assets to a series of variables under the broad categories of drivers and barriers distinguished in Section 5.1 - namely *regulatory framework (flexible markets), availability of human capital, other forms of public intervention* and *financial conditions*[69]. The macro analysis presented below is complemented with some further empirical evidence on R&D (see Box 4).

To test the potential drivers of intangible investment empirically, we estimate an investment equation based on an accelerator model[70] as described in IMF (2015). Investment in time t and country i $I_{it}$ (intangible or tangible) is commonly modelled as a function of a desired capital stock $K^*_{it}$, potentially some lags thereof (to account for a slow adjustment of the capital stock to its desired level) and depreciation $\delta_i$ (see Oliner *et al.* 1995)[71]:

$$I_{it} = \sum_{j=0}^{J} \omega_j \Delta K^*_{it-j} + \delta_i K_{it-1} \qquad (2)$$

where j indicates the respective number of time lags. Based on the accelerator model, which postulates that changes in capital are proportionally related to changes in economic output, we can write:

$$\Delta K^*_{it} = c\Delta Y_{it} \qquad (3)$$

Inserting equation (3) in equation (2), dividing equation by $K_{it-1}$, introducing an error term $\varepsilon_{it}$ and a fixed effect $\gamma_i$, and lagging the output term by one year to somewhat correct endogeneity problems, yields the following econometric model:

$$\frac{I_{it}}{K_{it-1}} = \gamma_i + \sum_{j=1}^{N} \beta_{1j} \frac{\Delta GVA_{it-j}}{K_{it-1}} + \varepsilon_{it} \qquad (4)$$

This model is augmented by other potential explanatory factors of investment such interest rates, debt to equity ratios, product market regulation (PMR), employment protection legislation (EPL), financial regulations, taxation, education, public investment, access to finance etc. denoted by $DRI_{it-1}$ (drivers):

$$\frac{I_{it}}{K_{it-1}} = \gamma_i + \sum_{j=1}^{N} \beta_{1j} \frac{\Delta GVA_{it-j}}{K_{it-1}} + \beta_2 DRI_{it-1} + \varepsilon_{it} \qquad (5)$$

The model is estimated using a fixed-effect panel estimator with standard errors corrected for autocorrelation, heteroscedasticity and intra-group correlation and is based on annual data for the EU-15[72] Member States over the period 1995-2013 (the final sample size depends on the availability of the data for measuring drivers to intangible investment). The data for intangible investment stems from experimental academic data elaborated by the INTAN-Invest database[73]. Data for the accelerator term

---

[69] Framework conditions were also tested with the share of the service sector in total value added. Findings suggest that investment in intangible assets seems to be more strongly associated with the service economy. However, as previous evidence is mixed, this result would require further investigation.

[70] The accelerator describes the relation between an increase in income and a resulting increase in investment. As described in Knox (1970), the principle of accelerator postulates that with increasing income demand for consumer goods increases. Consequently, investment must increase to raise the productive capacity to meet the increased demand.

[71] IMF (2015) suggests adding a constant in equation (1). This specification was tested, but the constant was found to be insignificant. Similarly, further lags of the capital stock were tested, but, beyond the first lag, no significant results were found.

[72] Note that data for the total capital stocks in the business sector are not available for Luxemburg (in previous year prices) and Portugal and these Member States therefore needed to be dropped from the sample.

[73] The INTAN-Invest.net database (www.intan-invest.net) is a harmonised (open access) database on macro-economic intangibles across a selection of countries, which complements the work done by the INNODRIVE and COINVEST–projects (both funded by the FP7 SSH programme). The up-dating of the database is based on voluntary cooperation by academic project partners.

are taken from ECFIN's AMECO database and drivers of intangible investment are taken from Eurostat, the OECD, the Labour Force Survey and the World Bank. For definitions and more detailed data sources of the respective variables see Table A2.

Table 6 below presents results from the regression model described in equation (4) per asset type (i.e. tangibles and intangibles but also two sub-categories of intangibles, namely intangibles included in the national accounts measure of Gross Fixed Capital Formation (GFCF) (NA intangibles), namely computerised information and some categories of innovative properties, and those still counted as expenditure in the national accounts (non-NA intangibles)) and adding several weakly interrelated drivers jointly. Tables A3-A6 in the Appendix show results per asset type when adding each potential investment barrier separately to avoid issues arising from multi-collinearity (see again equation (4)).[74] Estimated coefficients refer to country averages (EU-15), i.e. can hide some country heterogeneity. While the results represent correlations and maybe causal relationships, we do not claim causality. Note, however, that the EIB – based on a comprehensive survey at firm level – arrives to very similar results concerning drivers and barriers to investment in intangible assets.[75]

Table 6: **Fixed effect regressions, introducing selected determinants per category (public support, availability of human capital, finance and regulation) by asset type**

| | (1) Total intangibles | (2) NA-intangibles | (3) Non-NA intangibles | (4) Tangibles |
|---|---|---|---|---|
| Accelerator term | 0.121*** | 0.0771*** | 0.0444*** | 0.336*** |
| | (0.0287) | (0.0195) | (0.0125) | (0.0402) |
| Tertiary education | 0.0744*** | 0.0363** | 0.0381*** | 0.0238 |
| | (0.0200) | (0.0152) | (0.00874) | (0.000415) |
| Long-term interest rate | -0.0667** | -0.0502** | -0.0165* | -0.200*** |
| | (0.0274) | (0.0214) | (0.00810) | (0.0240) |
| EPL | -0.643*** | -0.0292 | -0.613*** | 0.203 |
| (strictness of collective dismissals) | (0.160) | (0.231) | (0.165) | (0.214) |
| Constant | 5.388*** | 2.422** | 2.966*** | 7.878*** |
| | (0.587) | (0.796) | (0.563) | (0.552) |
| Country dummies | yes | yes | yes | yes |
| Time trend | insignificant | insignificant | insignificant | yes |
| Crisis control | yes | yes | yes | yes |
| Observations | 194 | 194 | 194 | 194 |
| R-squared | 0.487 | 0.362 | 0.512 | 0.696 |
| Number of countries | 13 | 13 | 13 | 13 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: Explanatory variables are added in lag-form as described in the main text. All variables are expressed in percentages except EPL, which is expressed on a scale of 0-6. NA-intangibles refer to those intangible asset types that are included in the national accounts' measure of Gross Fixed Capital Formation (GFCF), namely computerised information and some categories of innovative properties (e.g. mineral exploration, R&D and intellectual property rights). Non-NA intangibles refer to those intangible asset types that are captured as expenditure or intermediate consumption in the national accounts. We include country dummies (fixed effects) as well as a control for the economic crisis in 2009 (specified as a crisis dummy and an interaction term between the year dummy and the acceletor term). An additional time trend turns out to be insiginificant for most assets except for tangible assets. We include the time trend in the regression when it is significant.

Source: Commission services

[74] More indicators were tested such as indicators for alternative financing (venture capital, gross-operating surplus, debt-to-equity ratios and surplus-to-debt ratios of non-financial corporations), taxation indicators (corporate income tax rates, implicit tax rates), quality of IPR, shares of SMEs and allocative efficiency but within the fixed effects framework with robust error terms (robust to heteroscedasticity and intra-group correlation) these variables do not seem to be significantly correlated with investment in intangible assets.

[75] See European Investment Bank (2017): EIBIS 2016/2017 - EIB Group Survey on Investment and Investment Finance Country Overview: Surveying Corporate Investment Activities, Needs and Financing in the EU.

With a view at the results presented above in Table 6, firstly, tangible capital tends to be more sensitive than intangible capital to developments in GDP; i.e. the regression results indicate that the accelerator model seems to hold more strongly for tangible capital. Potential reasons could be that the general upswing in intangible investment resulting from a sectoral shift to the knowledge economy is a more important determining factor than the business cycle; or the very long lags between the launch of the investment and the associated returns could imply that short-term cyclical fluctuations matter less (e.g. R&D activity in general); or, finally, that the demand for the goods or services produced with intangible assets are relatively immune to cyclical fluctuations (e.g. pharmaceuticals).

Secondly, all the dimensions tested are significant, which confirms the importance of the barriers such as regulatory framework, financial conditions, human capital and other forms of public intervention. In particular public R&D intensity and science-business linkages matter in terms of public support; tertiary education matters in terms of the availability of human capital, flexibility in both product- and labour markets matters in terms of the regulatory framework and the long-term interest rate and the debt-to-equity ratio matter in terms of financial conditions.

Thirdly, drivers significantly differ between investment tangible and intangible assets. These differences are described below.

Our measures of financial conditions seem to matter generally more for tangible than for intangible capital[76]. A reason may be that intangible capital tends to be rather financed by internal funds and venture capital than other external funds (and lacks the types of collateral that would allow easy external funding). Moreover, tangible capital is more cyclical than intangible capital, which would imply a stronger correlation with relatively cyclical variables such as financial indicators. When comparing the effect of financial variables across intangible asset types, the results suggest that the long-term interest rate matters statistically more for NA-intangibles than for non-NA intangibles, which would imply that R&D and software are the types of intangible assets that could be financed by external funds, even if many times, they tend to be largely financed by internal sources.

The regulatory framework (both product and labour market) is found to matter more for intangibles than for tangibles, which confirms findings by Hao and Haskel (2011) though Alesina *et al*. (2005) model a theoretical and provide evidence for an empirical relationship between regulation and tangible investment for using a sample that does not yet include the economic crisis. Based on an error-correction framework Egert (2017) suggests a long-run relationship between investment and regulation. Most of the measures used as proxies for the regulatory framework turn out to have statistically insignificant effects on tangible investment, while the effects on intangible investment are found to be significant with the expected signs (see Tables A3-A6 in the Appendix). A higher stringency in product market regulations is associated with lower investment in intangible capital while being closer to the country with the lowest stringency in terms of Doing Business is also associated with higher investment in intangibles. Finally, more stringent employment protection legislation is associated with less investment in intangible capital. This observation is even stronger for non-NA-intangibles, which would appear to indicate that flexible resource allocation[77] is particularly important for uncertain investments with short maturities, e.g. advertising and market research.

In terms of public intervention measures tested in the model, evidence suggests that tertiary education is vital for intangible investment (both NA and non-NA equally), while it does not seem to have a significant effect on tangible investment. This observation can be explained by the fact that intangible capital is potentially more skill-intensive than tangible capital. Furthermore, under- and over-qualification measured on the basis of all three qualification groups (low, medium and high) are found to matter negatively (in the case of under-qualification) and positively (in the case of over-qualification) for intangible investment (see Tables A3-A6 in the Appendix). Note that other types of skills such as vocational training, generic cognitive and non-cognitive skills could also play a role in particular for non-NA intangibles. This could be subject to further analysis. Furthermore, intangible assets also include firm-specific human capital which is bound to be correlated with tertiary education and

[76] This observation applies especially to the interest rate but also to the leverage of the banking sector and the debt-to-equity ratio of financial corporations.

[77] See also McGowan and Andrews (2015), who suggest that excessive EPL restricts efficient factor reallocation and can reduce productivity.

qualification but the result captures more than this correlation as it applies to both NA and non-NA intangibles.

The results also indicate that public R&D intensity seems to matter mostly for NA-intangibles. This finding is intuitive as NA intangibles includes private R&D, which is known to benefit highly from public R&D. In terms of science-business linkages, which are proxied by public-private co-publications, the results suggest that they matter for intangible investment (statistically equally for NA and non-NA intangible investments).

Evidence also suggests strong complementarities between intangible and tangible assets and also among certain types of intangible assets. This result holds both in terms of simple correlations and when controlling for the accelerator effect and other controls in the regressions (see Tables A7 and A8). The regressions[78] show a strong relationship between tangible and intangible capital, while complementarity among intangibles seems weaker.

Further evidence, including micro-level analysis for R&D investment, generally confirms the results above but adds some more nuanced insights (see Box 4). Indeed, the macro-level regression analysis does not allow measuring some more micro-economic features of investment in intangible assets. Empirical analysis discussed in Box 4 suggests for instance that the relationship between employment protection legislation and R&D investment depends on wage-bargaining schemes and the type of industry. The analysis also provides evidence for the importance of alternative funding schemes such as venture capital, which complements the findings in the regressions that financial conditions matter. The analysis further suggests that corporate skills – in addition to tertiary education – are a driver for R&D investment. Finally, the analysis provides empirical evidence for the positive role of policies to foster science-business linkages as well as R&D tax incentives though their effect depends on the policy design (as highlighted in Box 3).

Box 4: **DRIVERS AND BARRIERS OF R&D INVESTMENT: FURTHER EMPIRICAL EVIDENCE BASED ON LITERATURE**

1. The regulatory framework

Empirical research on the effects of product and labour market regulation on R&D investment corroborate the results from the econometric model and provide more nuances in some instances. In a study of 18 manufacturing industries in 18 OECD countries, Bassanini and Ernst (2002) found that product market regulation[79] is associated with negative levels of R&D intensity, i.e. the more regulation, the less R&D investment. This finding is also corroborated by a more recent study by Barbosa and Faria (2011). Studies at the sectoral level have also found a negative relation between product market regulation and R&D investment or innovation performance. For example, Eger and Mahlich (2015) found this negative effect for the pharmaceutical industry in the EU and Schmitt and Kucsera (2013) for the electricity utilities sector. In terms of protection of intellectual property rights, Bassanini and Ernst (2002) found that these are associated with higher levels of R&D intensity.

As for the relationship between labour market institutions and R&D investment, most empirical evidence indicates that, in general, labour market flexibility is positively associated with R&D intensity, although there are some nuances. For example, Bassanini and Ernst (2002) found a positive relationship between labour flexibility and R&D investment in low-tech industries and in countries with decentralised wage-bargain with little coordination between industrial partners, i.e. between employers and employees. However, they also found that the relationship between job protection and R&D investment was more ambiguous in countries with high coordination. In these countries, greater employment protection correlates with higher R&D investment in certain industries, especially in those characterised by a routinised technological regime. The reason for this is that the high costs of hiring and firing may lead to high levels of in-company training that can support higher levels of R&D investment.

[78] Note that these results are meant to figure as a first exploration and should be taken with caution as we suspect strong endogeneity issues, which would preclude any inference on causality.
[79] Economic regulation encompasses regulations associated to competition policies, price regulations, market entry regulations, and the regulation of natural monopolies and public utilities.

2. Financial conditions

The econometric results presented in this paper show that financial conditions affect more investment in tangible assets than in intangible assets. However, for the specific case of R&D investment, there is evidence that a bearish business cycle with restrictive financial conditions also affects negatively business R&D investment. During the financial and economic downturn, for example, private R&D investment in the EU fell by 3.4% in absolute terms in 2009, when the financial conditions became particularly tight for companies in many countries. The fall was even sharper for countries with protracted tight financial conditions like Spain or Portugal, where private R&D investment continues to be severely affected. In these countries, private R&D fell by 16.7% and 17.7% respectively since their peak and they have not yet recovered. Financial constraints play a particular negative role for R&D investment in small and young firms (IMF, 2016b).

In addition to the overall financial conditions, investments in R&D are also affected by the availability of specialised financing schemes, such as venture capital, that help channel available financing into R&D activities. In this regard, venture capital accounted for 8 percent of industrial innovations in the decade ending in 1992 (Kortum and Lerner, 2000) and recent entrepreneurial surveys have continued to emphasise their decisive role, notably for R&D related start-ups and small and medium-sized enterprises that identified financial constraints largely as one of the key bottlenecks to increase their research and innovation investment (OECD, 2012).

3. Availability of human capital

The high levels of complementarity between R&D investment and skills accumulations, e.g. via on the job training, have already been illustrated in Box 1, demonstrating that higher levels of skills accumulation drive higher levels of R&D investment. In addition, Piva and Vivarelli (2007) also demonstrated the positive impact of skills accumulation[80] in determining the business decision to engage and/or increase their R&D investment. In their study for Italian manufacturing companies between 1995 and 2000, they found that a 100% increase in the white collar/blue collar ratio of employees would result in an increase of 23% in R&D investment. These findings corroborate the results of the econometric analysis in this note that has shown the positive impact of high levels of tertiary education on investments in intangible assets.

4. Public support

The present econometric analysis has shown the positive impact of some policy support measures to foster investment in intangible assets in the areas of R&D. At the macroeconomic level, for a wide range of countries and time periods, the effects of public R&D investment on private R&D have generally been estimated to be positive.

In addition, efficient investments in the public science base and policies to strengthen science-business cooperation have also been demonstrated to be drivers of business R&D investments. A recent paper provides a systematic review of the effectiveness of major public R&D policies in increasing private R&D investment and finds that, next to direct and indirect support to business R&D, support for science-business cooperation, investments in university research and high-skilled human capital significantly increase private R&D (Becker, 2015).

Finally, other instruments of public support for boosting R&D investment that have been widely researched in the literature and that were not included in the econometric analysis due to lack of sufficient comparative data are R&D tax incentives or direct subsidies. Overall, these are believed to be successful in stimulating private R&D, as covered in Box 3. The efficiency of these instruments to boost business R&D depends on many factors, in particular their design and implementation. This includes the appropriate targeting of various types and instruments of support, as well as the complementarity of instruments. R&D tax incentives can complement direct subsidies to support later stages of the innovation process.

[80] In this study, skills are defined as a dichotomous variable, indicating whether a worker is white or blue collar.

# 6. CONCLUSION

In this paper we set out to study the specificities of intangible assets, in particular what makes them a special type of asset; present a set of stylised facts in order to understand their order of magnitude and trend patterns; discuss existing and provide new empirical evidence on their contribution to economic growth and productivity; and finally we assess potential drivers of and barriers to investment in intangible assets. Several conclusions can be drawn from the conceptual and empirical findings:

**The stylized facts presented in Section 3 show that investments in industrialised countries tend to be shifting away from traditional areas of physical assets towards more intangible / knowledge-based capital** as comparably high growth rates of investment in intangible assets show. However, the EU is lagging behind the US in terms of investments in intangibles.

**The results show, moreover, that trends of investments in intangibles have been rather stable even during the recent crisis,** which may imply that the emerging *knowledge economy* is a strong driver for investment in intangibles. The econometric findings suggest that macro-economic conditions do affect investments, although this is observed for intangibles to a lesser degree than for tangible assets.

**Intangibles are found to be vital for productivity and economic growth** and can help explain productivity differentials (e.g. across Member States) as intangibles are at the core of what makes firms competitive. In the EU-15, the contribution of total intangible assets to output growth is between one and three times as high as the contribution from tangible assets. Moreover, closing the gap in investment in intangible assets *vis-à-vis* the US was found to contribute positively to closing the TFP gap *vis-à-vis* the US.

**The analysis of 'what makes intangible assets special', presented in Section 2, suggests that knowledge-based industries raise new issues for competition policy, particularly through network effects, which may play an important role in the digital economy.** Non-rivalry of intangible assets (within the firm) may lead to increasing returns to scale and, in extreme cases, ultimately to monopolistic competition. Positive network externalities (i.e. value of and demand for goods or services increases with number of network users) can reinforce this tendency. Indeed, due to these specific characteristics of intangible assets, there is a risk that investment remains below the social optimum.

**The assessment of the determinants of investment in different asset types presented in Section 4 suggests that tangible and intangible assets appear to be affected differently by some key drivers and barriers:** human capital, public investments in R&D and higher education and regulation matter more for intangible assets, while financial conditions tend to have a stronger effect on tangible investment. Moreover, a barrier to investment relevant for one asset type may indirectly impede investment in other assets too as there are synergies among different asset types, notably between tangible and intangible assets but also between the individual intangible asset types. In particular, training and human capital formation is essential.

**Finally, our analysis provides evidence that investments in intangible assets tend to be underestimated**. The System of National Accounts captures only about half of the total investment in intangible assets and also corporate financial reports provide only limited information on companies' investments in intangibles.

These conclusions raise several policy implications for public authorities which go well beyond the intangible sector, i.e. facilitating the emergence of the knowledge economy. More specifically, the following can be identified:

- **Both policy and statistical offices should adopt an enlarged understanding and corresponding measurement of knowledge creation and the notion of intangible capital**, including R&D but also taking into account the relevance and complementarity/synergies of other intangibles such as computerised information and economic competences. A comprehensive understanding of intangibles as a source of growth at macro-economic level is needed. Policy can help by developing common measurement guidelines (to be applied by statistical offices).[81]

- **The regulatory framework plays a crucial role in unlocking investment in intangible assets. In that regard, policy needs to strike an appropriate balance between promoting flexible and competitive markets and the need to constantly modernise intellectual property rights (IPR).**[82]

  Regulation enabling flexible allocation of resources and flexible markets is pivotal for investments in intangibles (given the uncertain nature of intangibles), and thus implicitly also for the creation and retention of high-value jobs in global value chains. Furthermore, knowledge diffusion can be improved by pro-competitive regulations and integrating markets. Well-functioning markets are therefore essential; i.e. policy needs to ensure appropriately designed framework conditions.

  However, appropriability is an issue for investments in intangibles and, therefore, IPR are an increasingly important framework condition for investing in knowledge-based capital. IPR rules need to therefore be constantly modernised to keep pace with technological change and factor in relevant needs of intangible-intense industries. Finding the right balance between aiming at eliminating unnecessarily anti-competitive product market regulation (PMR) and effectively enforcing competition law - which together will protect and encourage innovation - is thus fundamental for investments in intangible assets *ex ante*.

- **Crowding-in private investments may be an effective tool to ensure a socio-economically optimal level of investment in intangible assets despite challenges commonly emerging when investing in intangibles** (i.e. higher uncertainty, significant sunk costs, lack of 'second-hand' markets for intangible assets).[83]

  Efforts to support investment in intangible assets are already embedded in the EU's financing schemes. For example, instruments such as the Equity Product under the Small- and Medium-sized Enterprises window of the European Fund for Strategic Investments (EFSI), or the Pan-European Venture Capital Fund-of-funds Programme aim to stimulate early-stage equity finance, venture capital, crowd funding, and business angels. The EFSI also supports a large number of projects in the Research, Development and Innovation sectors. Further measures using the EFSI and other EU instruments will be explored, depending on the take-up, success of implementation and evaluation of the existing instruments in this regard.

  Also important is an improvement of systematic reporting of investments in all relevant intangibles and as a driver of value creation for individual firms. This may also facilitate getting access to finance (capitalised intangibles might be used as collateral), improve corporate governance and market transparency. In fact, evidence suggests that the market value of a firm tends to be increasingly driven by its productive stock of intangibles than by the firm's tangible assets.[84] Policy can help by suggesting new standards for accounting and corporate disclosure.

- **Policy may stimulate investment in intangible assets and the creation of a knowledge-based economy.**

  This can be done by means of direct public support (e.g. investing in public R&D and building a strong science base), by tailoring taxation schemes accordingly, public procurement[85] and promoting business-science linkages and knowledge transfer.

  In addition, investing and stimulating investment in education, skills and training is a crucial dimension of policies, i.e. there is a need for well-integrated education and training systems targeting

---

[81] Note that, in this regard, the OECD encourages countries to develop additional measures via satellite accounts so as to maintain the international comparability of GDP (OECD, 2013a,b).

[82] The OECD (2013a) argues in this context that pro-competition policies and efficient judicial systems are needed and that, moreover, appropriate steps measures should be implemented to address the erosion of patent quality (patents should reflect genuinely novel innovations). The OECD also states that there is a need for greater mutual recognition and comparability across IPR systems internationally.

[83] For the economic rationale of crowding-in private investment by public R&I funding see European Commision (2017).

[84] Note that the link between market and book value of a company increasingly decoupled over the recent decades (Lev and Gu, 2016) while there is evidence of a positive correlation between the market value of a firm and its investment in intangible assets (total).

[85] See in this regard also the comprehensive analyses conducted in the context of the INTAN and SPINTAN FP7-projects (www.INTAN-Invest.net and www.SPINTAN.net)

early as well as lifelong learning. Growing investment in intangibles amplifies the importance of getting in particular human capital policies right as this general trend may also have profound implications for employment and earnings inequality. For instance, a knowledge-based economy rewards certain types of skills, including also corporate skills, and those who perform non-routine manual and cognitive tasks (while rewarding as well investors who ultimately own much of the intangibles; see OECD, 2013b).

However, to be effective and to avoid crowding-out, a careful design, administration, implementation and regular evaluation of in particular the tax policy instruments to support business investment in intangibles is of paramount importance.

## REFERENCES


Abdih, Y. and F. Joutz, (2008)," The Impact of Public Capital, Human Capital, and Knowledge on Aggregate Output", IMF Working Paper WP/08/218.

Abramovitz, M. (1956) "Resource and Output Trends in the United States since 1870." American Economic Review, (Papers and Proceedings), 46(2), 5-23.

Aghion, P. and P. Howitt (2006), "Appropriate growth policy: A unifying framework", Journal of the European Economic Association, No. 4 (2-3), p. 269-314

Alesina, A., Ardagna, S., Nicoletti, G., and Schiantarelli, F. (2005). Regulation and investment. Journal of the European Economic Association, 3(4), 791-825.

Andrews, D., de Serres (2012), "Intangible assets, resource allocation and growth", OECD Economics Department Working Papers No. 989, OECD Publishing.

Aristei, D., Sterlacchini, A., Venturini, F. (2015): The effects of public supports on business R&D: firm-level evidence across EU countries. MPRA Paper No. 64611, University Library of Munich, Germany.

Arrow, K. J. (1962). Economic welfare and the allocation of resources for invention. In R. Nelson (Ed.), The Rate and Direction of Inventive Activity: 609-626: Princeton Univ. Press, Princeton, NJ.

Barbosa, N. and A.P. Faria (2011), "Innovation across Europe: How importante are institutional differences?", Research Policy, 40(9): 1157-1169.

Bassanini, A and E. Ernst (2002), "Labour market institutions. Porduct market regulation and innovation. Cross country evidence", Economic Department Working Papers 316, OECD.

Becker B. (2015). Public R&D policies and private R&D investment: a survey of the empirical evidence. Journal of Economic Surveys 29(5): 917-942.

Belitz, H. (2016). Support for Private Research and Development in OECD Countries on the Rise but Increasingly Inefficient. DIW Economic Bulletin 8. 2016.

Black, S. E., Lynch, L. M., 2001. How to compete: the impact of workplace practices and information technology on productivity, in: Review of Economics and Statistics, 83(3), 434-445.

Bontempi, M. E., Mairesse, J., 2008. Intangible capital and productivity: an exploration on a panel of Italian manufacturing firms, in: National Bureau of Economic Research, No. 14108.

Bontempi, M. (2016), "Investment–uncertainty relationship: differences between intangible and physical capital ",Economics of Innovation and New Technology Vol. 25 , Iss. 3, 2016.

Bravo-Biosca A, Marston L, Mettler A, Mulgan G, Westlake S (2013). Plan Innovation for Europe. Delivering Innovation-led digitally-powered growth. NESTA. The Lisbon Council.

Brown, N.C., Kimbrough, M.D. (2008), "An examination of differences in the excludability of tangible and intangible assets." Harvard Business School Mimeo.

Brynjolfsson, E., Hitt, L.M., Yang S., 2002. Intangible assets: computers and organisational capital. Brooking Papers on Economic Activity 1, 2001.

Caballero R, Jaffe AB (1993), "How high are the Giants' Shoulders: An Empirical Assessment of Knowledge Spillovers and Creative Destruction in a Model of Economic Growth", NBER Research Papers.

Carmeli, A., and Tisher, A., 2004. "Resources, Capabilities, and the Performance of Industrial Firms: A Multivariate Analysis", Managerial and Decision Economics 25(6-7): 299-315, September 2004

CEDEFOP (2009) Using tax incentives to promote education and training, Luxembourg Publications Office, VI.

Chatterjee, S., and Wernerfelt, B. 1991. "The link between resources and type of diversification: Theory and evidence", Strategic Management Journal , 12: 33-48.

Chen, W., T. Niebel and M. Saam (2016), Are Intangibles More Productive in ICT-Intensive Industries? Evidence from EU Countries, Telecommunications Policy Volume 40, Issue 5, 471-484.

Collis, D.J, and Montgomery, C.A., 1998. "Creating corporate advantage", Harvard Business Review, 1998 May-Jun, 76(3):70-83.

Conner, K. R., and Prahalad, C. K. "A resource-based theory of the firm: Knowledge versus opportunism," Organisation Science (7:5), Sep/Oct, 1996, pp. 477-501.

Corrado, C., Hulten and D. Sichel (2005), "Measuring capital and technology: an expanded framework", in Measuring capital in the new economy, C. Corrado, J. Haltiwanger and D. Sichel, eds., *Studies in Income and Wealth*, Vol. 65, Chicago: The University of Chicago Press.

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

Corrado, C., Haskel, J., Jona-Lasinio, C., Iommi, M., 2012. Intangible capital and growth in advanced economies: Measurement methods and comparative results, in: IZA DP Working Paper, No. 6733. www.INTAN-Invest.net.

Corrado, C., J, Haskel and C. Iona-Lasinio (2013), "Knowledge spillovers, ICT and productivity growth", available from www.intan-invest.net

Corrado, C., J. Haskel, C. Jona Lasinio and M. Iommi (2014), "Intangibles and industry productivity growth: Evidence from the EU", Paper prepared for the IARIW 33rd General Conference, Rotterdam, The Netherlands, August 24-30, 2014.

Corrado, C., Haskel J., Jona-Lasinio, C. and Iommi, M. (2016): "Intangible investment in the EU and the US before and since the Great Recession and its contribution to productivity growth", EIB Working Papers 2016/08, European Investment Bank, Luxemburg.

CPB (2014) A study on R&D tax incentives. Final Report. Study commissioned by the European Commission. Taxation Working Paper 52.

Criscuolo C, Bajgar M, Appelt S, Galindo-Rueda F. (2016), "R&D tax incentives: design and evidence." Organisation for Economic Co-operation and Development. DSTI/IND/STP(2016)1

Crépon, B., Duguet, E., Mairesse, J. (1998). Research, Innovation And Productivi ty: An Econometric Analysis At The Firm Level. Economics of Innovation and new Technology, 7(2), 115-158.

Dal Borgo, M., Goodridge, P., Haskel, J., Pesole, A., 2012. Productivity and growth in UK industries: An intangible investment approach, in: Oxford Bulletin of Economics and Statistics, on-line as DOI: 10.1111/j.1468-0084.2012.00718.x.

Domenech, R. and A. De la Fuente, (2006), "Human capital in growth regressions: how much difference does data quality make?," Journal of the European Economic Association, No. 4(1).

Doraszelski, U., Jaumandreu, J. (2013). R&D and productivity: Estimating endogenous productivity, The Review of Economic Studies, 8(4):1338-1383.

Eger S and J Mahlich (2015). Pharmaceutical regulation in europe and its impacts on corporate R&D. Health Econ Review 4:23.

Egert, B. (2017), Regulation, institutions and aggregate investment: new evidence from OECD countries, CESifo Working Paper No. 6415, March 2017.

EURONA 2/2014: EUROSTAT Review on national accounts and macroeconomic indicators - Special issue on the implementation of the European System of Accounts (ESA 2010), European Union, 2014

European Commission (2012), Tax reforms in EU Member States: tax policy challenges for economic growth and fiscal sustainability, European Economy 6.

European Commission (2013), Flash Eurobarometer 369. Investing in Intangibles: Economic assets and Innovation. Drivers for growth.

European Commission (2016a), Science, Research and Innovation performance of the EU. A contribution to the Open Innovation, Open Science, Open to the World agenda.

European Commission (2016b): Administration and monitoring of R&D tax incentives.

European Commission (2017): The economic rationale for public R&I funding and its impact, *Research and Innovation Policy Brief Series*, March 2017.

European Investment Bank (2016): The Third Pillar at Ground-level: Case studies and other evidence related to investment barriers under the third pillar of the Investment Plan for Europe. *http://www.eib.org/attachments/thematic/breaking_down_investment_barriers_en.pdf*

European Investment Bank (2017): EIBIS 2016/2017 - Surveying Corporate Investment Activities, Needs and Financing in the EU. *http://www.eib.org/attachments/efs/eibis_2016_report_en.pdf*

Gilson, S.C., K. John and L.H.P. Lang (1990), “Troubled debt restructurings: An empirical study of private reorganisation of firms in default”, Journal of Financial Economics 27, pp. 315-353.

Griliches, Z. (1979). Issues in assessing the contribution of research and development to productivity growth. The bell journal of economics, 92-116.

González X, Miles-Touya D, and Pazó C (2012), "R&D, worker training, and innovation: Firm-level evidence." Universidad de Vigo.

Hall, B.H., Mairesse, J., Mohnen, P., 2009. Measuring the returns to R&D, NBER Working Paper No. 15622.

Hall, B., Mairesse, J, Mohnen, P. (2010): Measuring the returns to R&D. In: Elsevier Handbook of the Economics of Innovation, B. H. Hall and N. Rosenberg (eds.) Burlington: Academic Press.

Hao and Haskel (2011), "Intangibles and product market reforms". *http://www.ceriba.org.uk/pub/CERIBA/IntangHaskelHaoXcountry/intangibles_crosscountry_Hao_Haskel_2March2011.pdf*

Hand J.R.M., Lev B., 2003. Intangible Assets. Values, measures, and risks. Oxford Management Readers, Oxford, UK.

Hayek 1945, F. A., 1945. "The Use of Knowledge in Society", American Economic Review, 35(4): 519–530.

Havik, K., K. McMorrow, F. Orlandi, C. Planas, R. Raciborski, W. Roeger, A. Rossi, A. Thum-Thysen and V. Vandermeulen (2014), "The Production Function Methodology for Calculating Potential Growth Rates and Output Gaps", European Economic Papers, Nr. 535.

Hervas F., Amoroso S. (2016). Do Research and other sources of innovation drive productivity gains in top European R&D investors?. Science, Research and Innovation performance of the EU. A contribution to the Open Innovation, Open Science, Open to the World agenda.

Hitt, M.A., Uhlenbruck, K., and Shimizu, K., 2006. “The importance of resources in the internationalisation of professional service firms: the good, the bad, and the ugly’, Academy of Management Journal, 49 (6): 1137-1157

Hotchkiss, E.S., K. John, R.M. Mooradian and K.S. Thorburn. (2008), Bankruptcy and the resolution of financial distress”, Handbook of Empirical Corporate Finance, Vol. 2, pp. 2-22, Elsevier.

Hunter, L., Webster, E., Wyatt, A., 2005. Measuring intangible capital: a review of current practice, in: Australian Accounting Review, 15(36), 4-21.

Ilmakunnas, P., H. Piekkola (2014), Intangible investment in people and productivity, Journal of Productivity Analysis, No. 41, p. 443-456.

Inklaar, R., O'Mahony, M., Timmer, M., 2005. ICT and Europe's productivity performance: industry-level growth account comparisons with the United States, Review of Income and Wealth, No. 51 (4), p. 505-536.

International Monetary Fund (2015): Investment in the Euro Area: Why Has It Been Weak? Bergljot Barkbu, S. Pelin Berkmen, Pavel Lukyantsau, Sergejs Saksonovs, and Hanni Schoelermann. IMF WP/15/32.

International Monetary Fund (2016a): Fiscal policies for innovation and growth.

International Monetary Fund (2016b). IMF Fiscal Monitor. Acting Now, Acting Together.

Itami, H., and Roehl, T.W., 1987. "Mobilising invisible assets", Harvard University Press, Cambridge, MA (1987)

Jennewein, K (2005), Intellectual property management: The role of technology-brands in the appropriation of technological innovation. Physica-Verlag HD: Heidelberg.

Jona-Lasinio, C., M. Iommi and S. Manzocchi (2011),"Intangible capital and productivity growth in European countries", Innodrive Working paper No. 10, Roma, Italy.

Jorgenson, D.W., Stiroh, K.J., 2000. Raising the speed limit: U.S. economic growth in the information age, in: Brookings Papers on Economic Activity, 1, 125–211.

Kancs, D. A., Siliverstovs, B., (2012). R&D and Non-linear Productivity Growth of Heterogeneous Firms. JRC-IPTS Working Papers, Joint Research Centre. European Commission

Kogut, B., and Zander, U. "Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology," Organisation Science (3:3), August, 1992, pp. 383-397.

Kortum S, Lerner J (2000). Assessing the contribution of venture capital to innovation. Boston University and National Bureau of Economic Research. RAND Journal of Economics, Vol. 31, No. 4.

Kokko, A., Tingvall, P. G., Videnord, J. (2015). The growth effects of R&D spending in the EU: A meta-analysis. Economics, 9(40), 1.

Knox, A. D. (1970): The Acceleration Principle and the Theory of Investment: A Survey. In Shapiro, Edward. Macroeconomics: Selected Readings. New York: Harcourt, Brace & World. pp. 49–74.

Lev, B., Gu, F. (2016): The End of Accounting and the Path Forward for Investors and Managers. Wiley Finance Series.

Mairesse, J., Sassenou, M., 1991. R&D and productivity: a survey of econometric studies at the firm Level, in: Science-Technology Industry Review, Paris, OECD, n. 8, 9- 43.

Mairesse J, Greenan N, Topiol-Bensaid A (2001). Information Technology and Research and Development Impacts on Productivity and Skills: Looking for Correlations on French Firm Level Data. NBER Working Paper No. 8075.

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

Marrocu, E., Paci, R., Pontis, M., 2012. Intangible capital and firms' productivity, in: Industrial and Corporate Change, 21(2), 377-402.

Martin, S., Scott, J. T.(2000). The nature of innovation market failure and the design of public support for private innovation. Research Policy, 29(4–5): 437-447.

McGowan, M. A., & Andrews, D. (2015). Labour market mismatch and labour productivity: Evidence from PIAAC data. *OECD Economic Department Working Papers*, (1209).

Mohnen, P., Hall, B. H., 2013. Innovation and productivity: an update. Eurasian Business Review, 3(1), 47-65.

Montresor, S., Vezzani, A. (2014): Intangible investments and innovation propensity. Evidence from the Innobarometer 2013. European Commission's Joint Research Centre - *IPTS Working Papers on Corporate R&D and Innovation* – No 03/2014.

Moreira Vaz R.A (2013). Job Training Determinants, R&D and Effects on Firms' Productivity Evidence from Firm-Level Data in Latin America. Católica-Lisbon, School of Business and Economics

Moulton, B., Mayerhauser, N., 2015. The future of the SNA's asset boundary. Paper prepared for the IARIW-OECD Special Conference: "W(h)ither the SNA?". Available at: http://iariw.org/papers/2015/moultonmayerhauser.pdf

Nelson, R. R. (1959). The Simple Economics of Basic Scientific-Research. Journal of Political Economy, 67(3): 297-306.

Nelson, R. R., and Winter, S. G. An evolutionary theory of economic change, Belknap Press of Harvard University Press, Cambridge, Mass., 1982.

Nicoletti, G. and S. Scarpetta (2003), "Regulation, productivity and growth: OECD evidence", OECD Economics Department Working Papers, No. 347, OECD Publishing.

Niebel, T., O'Mahony, M., & Saam, M. (2013). The contribution of intangible assets to sectoral productivity growth in the EU (ZEW Discussion Paper 13-062).

OECD (2012), Corporate reporting of intangible assets: a progress report. OECD Publishing.

OECD (2013a): Supporting Investment in Knowledge Capital, Growth and Innovation, OECD Publishing. *http://dx.doi.org/10.1787/9789264193307-en*, ISBN 978-92-64-19309-3 (print)

OECD (2013b): New Sources of Growth: Knowledge-Based Capital – Synthesis Report.

OECD (2016): Technological slowdown, technological divergence and public policy: A firm level perspective. ECO/CPE/WP1(2016)26.

Oliner, S., Rudebusch, G., Sichel, D. 1995. New and Old Models of Business Investment: A Comparison of Forecasting Performance. *Journal of Money, Credit, and Banking*, 27:3, pp. 806–26.

Oliner, S.D., Sichel, D.E., 2000. The resurgence of growth in the late 1990s: Is information technology the story?, in: Journal of Economic Perspectives, 14, Fall, 3–22.

Piva M and M Vivarelli (2007). Corporate skills as an ex-ante incentive to R&D investment. IZA Working Papers 2562.

Polder M, Van Leeuwen G, Mohnen P, Raymond W (2009). "Productivity Effects of Innovation Modes", Statistics Netherlands Discussion Paper n° 09033.

Radosevic S. (2016). The role of public research in economic development. Science, Research and Innovation performance of the EU. A contribution to the Open Innovation, Open Science, Open to the World agenda.

Roth, F., Thum, A.-E. (2013). Intangible capital and labor productivity growth: Panel evidence for the EU from 1998–2005. Review of Income and Wealth, Series 59, Number 3, September 2013, pp. 486 – 508. DOI: 10.1111/roiw.12009

Schmitt A and D Kucsera (2013). The impact of regulatory reform process on R&D investment of European Electricity utilities" Beitage zur Sachrestagung Wirtshaftsordung- Session regulated industries, N A14-V3.

Scicchitano S (2010). Complementarity between heterogeneous human capital and R&D: can job-training avoid low development traps? Empirica, 37:361-380.

Solow, R.M., 1957. "Technical Change and the Aggregate Production Function", The Review of Economics and Statistics, 39(3): 312-320, (August 1957), The MIT Press.

Teece, D.J., Pisano, G., Shuen A., (1990), Firm capabilities, resources, and the concept of strategy, Working paper 90/9, University of California at Berkeley.

Thum-Thysen, A., P. Voigt, B. Bilbao-Osorio, C. Maier and D. Ognyanova (2017): Unlocking investment in intangible assets in Europe, Quarterly Report of the Euro Area 16(1), pp. 23-35.

Thum-Thysen, A., and R. Raciborski (2017), Determinants of trend TFP, Quarterly Report of the Euro Area No. 16(2), June 2017.

Tufts Centre for the study of drug development (2014). The cost of developing a new drug. http://csdd.tufts.edu/files/uploads/Tufts_CSDD_briefing_on_RD_cost_study_-_Nov_18,_2014.pdf

Uppenberg, K., Strauss, H. (2010): Innovation and productivity growth in the EU services sector, in: EIB Working Paper Series, 07/2010. ISBN 978-92-861-1254-6 <link>

Valiante, D. (2016). Europe's Untapped Capital Market: Rethinking integration after the great financial crisis, CEPS Paperback, London: Rowman & Littlefield International.

Van Ark, B., 2015. From Mind the Gap to Closing the Gap: Avenues to Reverse Stagnation in Europe through Investment and Productivity Growth, European Economy, Discussion Paper 006, 09/2015.

Van Elk, R., Verspagen, B., Ter Weel, B., Van der Wiel, K., & Wouterse, B. (2015). A macroeconomic analysis of the returns to public R&D investments. CPB Netherlands Bureau for Economic Policy Analysis, 313.

Veugelers, R. (2016). Getting the most from public R&D spending in times of budgetary austerity. Bruegel Working Paper 2016/01.

Villalonga, B., 2004. Intangible resources, Tobin’s q, and sustainability of performance differences. Journal of Economic Behaviour & Organisation 54, 205-230.

Webster, E., Jensen, P.H. (2006): Investment in Intangible Capital: An Enterprise Perspective. The Economic Record, Vol. 82, No. 256.

Wellcome (2008). Medical research: what's wrong? Estimating the economic benefits from medical research in the UK. Link: https://www.mrc.ac.uk/publications/browse/medical-research-whats-it-worth/

Winter, S.G., 1987. Knowledge and competence as strategic assets. In: Teece, D.J. (Ed.), The Competitive Challenge: Strategy for Industrial Innovation and Renewal. Ballinger, Cambridge, MA.Aghion, P., Bloom, N., Blundell, R., Griffith, R., Howitt, P. (2005), “Competition and Innovation: an Inverted-U Relationship”, The Quarterly Journal of Economics 120(2), pp. 701-28.

# ANNEX I: TABLES AND GRAPHS

Table A1: **Types of intangible assets**

| | |
|---|---|
| ***Computerised information*** | |
| Computer software | Covers expenses of software developed for a firm's own use; based on NIPA data that include three components: own use, purchased, and custom software. |
| Computerised databases | Own use likely is captured in NIPA software measures; data from the Services Annual Survey (SAS) suggest that the purchased component is small. |
| ***Innovative property*** | |
| Science and engineering R&D (costs of new products and new production processes, usually leading to a patent or license) | Mainly R&D in manufacturing, software publishing, and telecom industries. The census collects data on behalf of the National Science Foundation (NSF). Industrial R&D data are available from the early 1950s and cover work in the physical sciences, the biological sciences, and engineering and computer science (excl. geophysical, geological, artificial intelligence, and expert systems research). |
| Mineral exploration (spending for the acquisition of new reserves) | Mainly R&D in mining industries.<br>a. Mineral exploration, Census of Mineral Industries and NIPAs.<br>b. Other geophysical and geological exploration R&D in mining industries, estimated from census data |
| Copyright and license costs (spending for the development of entertainment and artistic originals, usually leading to a copyright or license) | Mainly R&D in information-sector industries (excl. software publishing). No broad statistical information, proxied by:<br>a. Development costs in the motion picture industry<br>b. Development costs in the radio and television, sound recording, and book publishing industries are crudely estimated to be double the new product development costs for motion pictures. (No estimate for the arts is included.) |
| Other product development, de- sign, and research expenses (not necessarily leading to a patent or copyright) | Mainly R&D in finance and other services industries. No broad statistical information, proxied by:<br>a. New product development costs in the financial services industries, crudely estimated as 20 percent of intermediate purchases.<br>b. New architectural and engineering designs, estimated as half of industry purchased services (revenues of the industry as reported in SAS).<br>c. R&D in social sciences and humanities, estimated as twice industry purchased services (revenues as reported in SAS). |
| ***Economic competencies*** | |
| Brand equity (advertising expenditures and market research for the development of brands and trademarks) | a. Purchases of advertising services; advertising expenditures<br>b. Outlays on market research, estimated as twice industry purchased services (revenues of the market and consumer research industry as reported in SAS). |
| Firm-specific human capital (costs of developing workforce skills, i.e., on-the-job training and tuition payments for job-related education) | Broad surveys of employer-provided training were conducted by the Bureau of Labour Statistics (BLS) in 1994 and 1995.[g]<br>a. Direct firm expenses (in-house trainers, outside trainers, tuition reimbursement, and outside training funds)<br>b. Wage and salary costs of employee time in formal and informal training |
| Organisational structure (costs of organisational change and development; company formation expenses) | No broad statistical information and no clear consensus on scope.<br>a. Purchased "organisational" or "structural" capital, estimated using SAS data on the revenues of the management consulting industry.<br>b. Own-account component, estimated as value of executive time using BLS data on employment and wages in executive occupations. |

Source: Corado *et al.* (2005).

Table A2: **List of variables used in Section 5.3**

| Name | Variable Description | Source | Remarks |
|---|---|---|---|
| | ***Main Variables*** | | |
| Tangible investment – dependent variable | Total tangible investment over lagged total capital stock (total capital stock = tangible + new intangible + na intangible) | National accounts | GVA deflator used from Eurostat ("National Accounts aggregates by industry (up to NACE A*64)" [nama_10_a64]) |
| Intangible investment – dependent variable | Total intangible investment over lagged total capital stock (total capital stock = tangible + new intangible + na intangible) | INTAN-INVEST and national accounts | Int. stocks were computed with PIM in million Euros and real terms; investment was adjusted accordingly: GVA deflator and exchange rate used from Eurostat ("National Accounts aggregates by industry (up to NACE A*64)" [nama_10_a64]) |
| NA-intangible investment – dependent variable | National accounts intangible investment over lagged total capital stock (total capital stock = tangible + new intangible + na intangible) | INTAN-INVEST and national accounts | See above. |
| Non-NA intangible investment – dependent variable | Non-national accounts ("new") intangible investment over lagged total capital stock (total capital stock = tangible + new intangible + na intangible) | INTAN-INVEST and national accounts | See above. |
| Accelerator term | $\frac{\Delta GVA_{t-1}}{K_{it-1}}$ based on total capital stock and GVA respectively including also non-NA intangibles | INTAN-INVEST and national accounts | Accelerator term linking investment to output (see IMF 2015). INTAN-INVEST GVA data is provided in nominal terms and million Euros. A GVA deflator in Euros based on own calculations of a GVA price index was applied. Note that this measure of GVA includes non-NA intangibles as investment. |
| | ***Drivers - public sector support and public-private collaboration*** | | |
| Public R&D intensity | Public R&D intensity (GOVERD plus HERD as % of GDP) | Eurostat and calculations by DG RTD | Interpolation and breaks in the series |
| Public private copublications | The 'public-private co-publications' variable (or academia-corporate collaborations) is the number of publications whose affiliation information contains both academic and corporate organisation types. The variable is calculated inside SciVal tool using the full counting method. As denominator, the total population (based on latest available Eurostat data) is used. | DG RTD | Starting in 1996 |
| | ***Drivers - financial data and access to finance*** | | |
| Long-term interest rate | Long-term interest rate | AMECO | |
| Leverage of the banking system | Leverage of the banking sector: "This ratio is a measure of financial leverage and long-term solvency. It can be used to ascertain the overall financial stability of the banking sector.<br>Banks engage in leverage by borrowing to acquire more assets, with the aim of increasing their return on equity. But high leverage ratio may increase a financial institution's exposure to risk and cyclical downturns." | OECD Financial Dashboard | |
| Debt to equity ratio | Debt equity ratio financial corporations: "This indicator is calculated by dividing the debt of financial corporations by the total amount of shares and other equity liabilities of the same sector. It measures the financial leverage of financial corporations, or the extent to which their activities are financed out of their own funds. The higher (lower) the ratio, the higher (lower) the leverage and the greater is the risk for corporations' creditors." | OECD Financial Dashboard | |
| | ***Drivers – human capital*** | | |
| Tertiary education | Share of tertiary educational attainment among the population aged 25-64 | Eurostat/LFS | |
| Overqualification | Share of people who are either in ISCO-classified jobs that require a lower ISCED level | Eurostat/LFS and calculations by B3 | |
| Underqualification | Share of people who are either in ISCO-classified jobs that require a higher ISCED level | Eurostat/LFS | |

| *Drivers - regulation* | | | |
|---|---|---|---|
| PMR | Product market regulation indicator | OECD | Starting in 1998 and linearly interpolated |
| Doing Business: construction permits | Dealing with construction permits (WB Doing Business Indicators) | Worldbank | Only available from 2004 |
| Doing Business: Trade across borders | Trading across borders (WB Doing Business Indicators) | Worldbank | Only available from 2004 |
| EPL | EPL – collective dismissals | OECD | This indicator proved to be the most strongly significant one among the EPL indicators. |

Table A3: **Fixed effects regressions; total intangible investment**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Accelerator term | 0.177*** | 0.145*** | 0.153*** | 0.0275 | 0.00885 | 0.126*** | 0.117*** | 0.127*** | 0.0751*** | 0.119*** | 0.125*** |
| | (0.0279) | (0.0242) | (0.0358) | (0.0278) | (0.0427) | (0.0192) | (0.0105) | (0.0125) | (0.0175) | (0.0194) | (0.0193) |
| Tertiary education | 0.0906*** | | | | | | | | | | |
| | (0.0251) | | | | | | | | | | |
| Overqualification | | 0.145** | | | | | | | | | |
| | | (0.0618) | | | | | | | | | |
| Underqualification | | | -0.0575* | | | | | | | | |
| | | | (0.0286) | | | | | | | | |
| Long-term interest rate | | | | -0.125** | | | | | | | |
| | | | | (0.0459) | | | | | | | |
| Debt to equity ratio | | | | | -0.0704* | | | | | | |
| | | | | | (0.0372) | | | | | | |
| PMR | | | | | | -0.673* | | | | | |
| | | | | | | (0.331) | | | | | |
| Doing business: Construction permits | | | | | | | 0.0556*** | | | | |
| | | | | | | | (0.00634) | | | | |
| Doing business: trade across borders | | | | | | | | 0.0125* | | | |
| | | | | | | | | (0.00653) | | | |
| EPL | | | | | | | | | -0.698* | | |
| | | | | | | | | | (0.368) | | |
| Public R&D intensity | | | | | | | | | | 3.381*** | |
| | | | | | | | | | | (1.056) | |
| Public-private copublications | | | | | | | | | | | 0.0129*** |
| | | | | | | | | | | | (0.00290) |
| Constant | 2.587*** | 3.626*** | 6.998*** | 5.428*** | 5.452*** | 6.142*** | 1.170** | 4.249*** | 7.416*** | 2.724*** | 4.157*** |
| | (0.660) | (0.588) | (0.981) | (0.126) | (0.206) | (0.521) | (0.476) | (0.567) | (1.216) | (0.713) | (0.187) |
| Country dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Crisis control | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Observations | 218 | 217 | 217 | 219 | 213 | 195 | 91 | 91 | 195 | 219 | 219 |
| R-squared | 0.415 | 0.256 | 0.229 | 0.314 | 0.124 | 0.182 | 0.549 | 0.386 | 0.136 | 0.199 | 0.423 |
| Number of countries | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The specification in Table A3 does not include a time trend. The time trend renders the trending variables for human capital insignificant and PMR has an unexpected sign. Explanatory variables are added in lag-form. All variables are expressed in percentages except EPL, which is expressed on a scale of 0-6.

Source: Commission services

Table A4: **Fixed effects regressions; tangible investment**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Accelerator term | 0.475*** | 0.471*** | 0.454*** | 0.345*** | 0.412*** | 0.326*** | 0.459*** | 0.478*** | 0.490*** | 0.461*** | 0.475*** | 0.464*** |
| | (0.0385) | (0.0391) | (0.0344) | (0.0445) | (0.0553) | (0.0591) | (0.0331) | (0.104) | (0.104) | (0.0375) | (0.0353) | (0.0388) |
| Tertiary education | -0.00535 | | | | | | | | | | | |
| | (0.0408) | | | | | | | | | | | |
| Overqualification | | -0.0324 | | | | | | | | | | |
| | | (0.0775) | | | | | | | | | | |
| Underqualification | | | 0.0385 | | | | | | | | | |
| | | | (0.0371) | | | | | | | | | |
| Long-term interest rate | | | | -0.195*** | | | | | | | | |
| | | | | (0.0276) | | | | | | | | |
| Leverage of the banking sector | | | | | -0.0480** | | | | | | | |
| | | | | | (0.0215) | | | | | | | |
| Debt to equity ratio | | | | | | -0.170*** | | | | | | |
| | | | | | | (0.0248) | | | | | | |
| PMR | | | | | | | 1.096 | | | | | |
| | | | | | | | (0.619) | | | | | |
| Doing business: Construction permits | | | | | | | | 0.0519** | | | | |
| | | | | | | | | (0.0223) | | | | |
| Doing business: trade across borders | | | | | | | | | 0.0118 | | | |
| | | | | | | | | | (0.0109) | | | |
| EPL (collective dismissals) | | | | | | | | | | -0.493 | | |
| | | | | | | | | | | (0.372) | | |
| Public R&D intensity | | | | | | | | | | | -3.752 | |
| | | | | | | | | | | | (2.713) | |
| Public-private copublications | | | | | | | | | | | | 0.00765 |
| | | | | | | | | | | | | (0.00708) |
| Constant | 7.814*** | 7.987*** | 6.170*** | 8.939*** | 8.376*** | 8.595*** | 5.488*** | 5.346*** | 8.142*** | 9.576*** | 9.867*** | 7.655*** |
| | (0.739) | (0.592) | (1.585) | (0.264) | (0.475) | (0.285) | (1.362) | (1.479) | (0.891) | (1.255) | (1.493) | (0.234) |
| Country dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Crisis control | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Time trend | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Observations | 218 | 217 | 217 | 219 | 207 | 213 | 195 | 91 | 91 | 195 | 219 | 219 |
| R-squared | 0.597 | 0.605 | 0.610 | 0.682 | 0.613 | 0.650 | 0.627 | 0.690 | 0.681 | 0.620 | 0.618 | 0.609 |
| Number of countries | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The specification in Table A4 includes a time trend as it turns out to be significant in Table 6, which implies that even when adding indicators jointly they do not explain the trend. Explanatory variables are added in lag-form. All variables are expressed in percentages except EPL, which is expressed on a scale of 0-6.

Source: Commission services

Table A5: **Fixed effects regressions; NA-intangible investment**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| Accelerator term | 0.0674*** | 0.0487*** | 0.0489** | -0.00430 | 0.0463*** | 0.0255** | 0.0308*** | 0.0148 | 0.0485*** | 0.0459*** |
| | (0.0143) | (0.0112) | (0.0219) | (0.0147) | (0.00837) | (0.00961) | (0.00918) | (0.00904) | (0.0107) | (0.0116) |
| Tertiary education | 0.0456*** | | | | | | | | | |
| | (0.0129) | | | | | | | | | |
| Overqualification | | 0.0647** | | | | | | | | |
| | | (0.0216) | | | | | | | | |
| Underqualification | | | -0.0233 | | | | | | | |
| | | | (0.0136) | | | | | | | |
| Long-term interest rate | | | | -0.0581** | | | | | | |
| | | | | (0.0249) | | | | | | |
| PMR | | | | | -0.391** | | | | | |
| | | | | | (0.149) | | | | | |
| Doing business: Construction permits | | | | | | 0.0207*** | | | | |
| | | | | | | (0.00579) | | | | |
| Doing business: trade across borders | | | | | | | 0.0126*** | | | |
| | | | | | | | (0.00255) | | | |
| EPL | | | | | | | | -0.592 | | |
| | | | | | | | | (0.347) | | |
| Public R&D intensity | | | | | | | | | 2.343*** | |
| | | | | | | | | | (0.639) | |
| Public-private copublications | | | | | | | | | | 0.00724*** |
| | | | | | | | | | | (0.00179) |
| Constant | 0.658* | 1.256*** | 2.679*** | 2.071*** | 2.530*** | 0.493 | 0.950*** | 3.891*** | 0.288 | 1.394*** |
| | (0.338) | (0.201) | (0.462) | (0.0731) | (0.233) | (0.434) | (0.225) | (1.150) | (0.429) | (0.115) |
| Country dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Crisis control | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Observations | 218 | 217 | 217 | 219 | 195 | 91 | 91 | 195 | 219 | 219 |
| R-squared | 0.385 | 0.187 | 0.141 | 0.248 | 0.189 | 0.236 | 0.172 | 0.203 | 0.288 | 0.485 |
| Number of countries | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The specification in Table A5 does not include a time trend. The time trend renders the trending variables for human capital, public R&D intensity and PMR insignificant. Explanatory variables are added in lag-form. All variables are expressed in percentages except EPL, which is expressed on a scale of 0-6.

Source: Commission services

Table A6: **Fixed effects regressions; non-NA-intangible investment**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Accelerator term | 0.109*** | 0.0962*** | 0.104*** | 0.0318 | 0.0288 | 0.0800*** | 0.0915*** | 0.0963*** | 0.0603*** | 0.0709*** | 0.0791*** |
| | (0.0168) | (0.0181) | (0.0197) | (0.0188) | (0.0234) | (0.0140) | (0.00707) | (0.00893) | (0.0119) | (0.0140) | (0.0125) |
| Tertiary education | 0.0450** | | | | | | | | | | |
| | (0.0153) | | | | | | | | | | |
| Overqualification | | 0.0804* | | | | | | | | | |
| | | (0.0439) | | | | | | | | | |
| Underqualification | | | -0.0342* | | | | | | | | |
| | | | (0.0179) | | | | | | | | |
| Long-term interest rate | | | | -0.0666** | | | | | | | |
| | | | | (0.0256) | | | | | | | |
| Debt to equity ratio | | | | | -0.0372* | | | | | | |
| | | | | | (0.0178) | | | | | | |
| PMR | | | | | | -0.282 | | | | | |
| | | | | | | (0.228) | | | | | |
| Doing business: Construction permits | | | | | | | 0.0349*** | | | | |
| | | | | | | | (0.00418) | | | | |
| Doing business: trade across borders | | | | | | | | -8.36e-05 | | | |
| | | | | | | | | (0.00434) | | | |
| EPL (collective dismissals) | | | | | | | | | -0.105 | | |
| | | | | | | | | | (0.115) | | |
| Public R&D intensity | | | | | | | | | | 1.038 | |
| | | | | | | | | | | (0.839) | |
| Public-private copublications | | | | | | | | | | | 0.00561** |
| | | | | | | | | | | | (0.00236) |
| Constant | 1.930*** | 2.370*** | 4.319*** | 3.357*** | 3.356*** | 3.613*** | 0.677** | 3.299*** | 3.525*** | 2.436*** | 2.762*** |
| | (0.406) | (0.422) | (0.615) | (0.0734) | (0.0989) | (0.359) | (0.309) | (0.375) | (0.384) | (0.572) | (0.159) |
| Country dummies | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Crisis control | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Observations | 218 | 217 | 217 | 219 | 213 | 195 | 91 | 91 | 195 | 219 | 219 |
| R-squared | 0.304 | 0.221 | 0.220 | 0.261 | 0.135 | 0.134 | 0.514 | 0.392 | 0.100 | 0.113 | 0.255 |
| Number of countries | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The specification in Table A6 does not include a time trend. The time trend renders the trending variables for human capital, public R&D intensity insignificant. Explanatory variables are added in lag-form. All variables are expressed in percentages except EPL, which is expressed on a scale of 0-6.

Source: Commission services

Table A7: **Fixed-effect regressions; complementarities between different asset types – baseline model**

| | (1) Total intangibles | (2) NA-intangibles | (3) Non-NA intangibles | (4) Tangibles |
|---|---|---|---|---|
| Accelerator term | 0.0372 | 0.0402** | 0.0656** | 0.297*** |
| | (0.0258) | (0.0150) | (0.0227) | (0.0260) |
| Tangible investment | 0.277*** | | | |
| | (0.0608) | | | |
| Non-NA intangible investment | | 0.274** | | |
| | | (0.110) | | |
| NA intangible investment | | | 0.538* | |
| | | | (0.268) | |
| Total intangible investment | | | | 1.080*** |
| | | | | (0.228) |
| Constant | 1.972*** | 0.658* | 1.957*** | 3.286*** |
| | (0.590) | (0.328) | (0.444) | (1.006) |
| Country dummies | yes | yes | yes | yes |
| Time trend | yes | yes | yes | yes |
| Crisis control | yes | yes | yes | yes |
| Observations | 219 | 219 | 219 | 219 |
| R-squared | 0.591 | 0.509 | 0.386 | 0.721 |
| Number of countries | 13 | 13 | 13 | 13 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Explanatory variables are added in lag-form. All variables are expressed in percentages.
Source: Commission services.

Table A8: **Fixed-effect regressions; complementarities between different asset types – with controls**

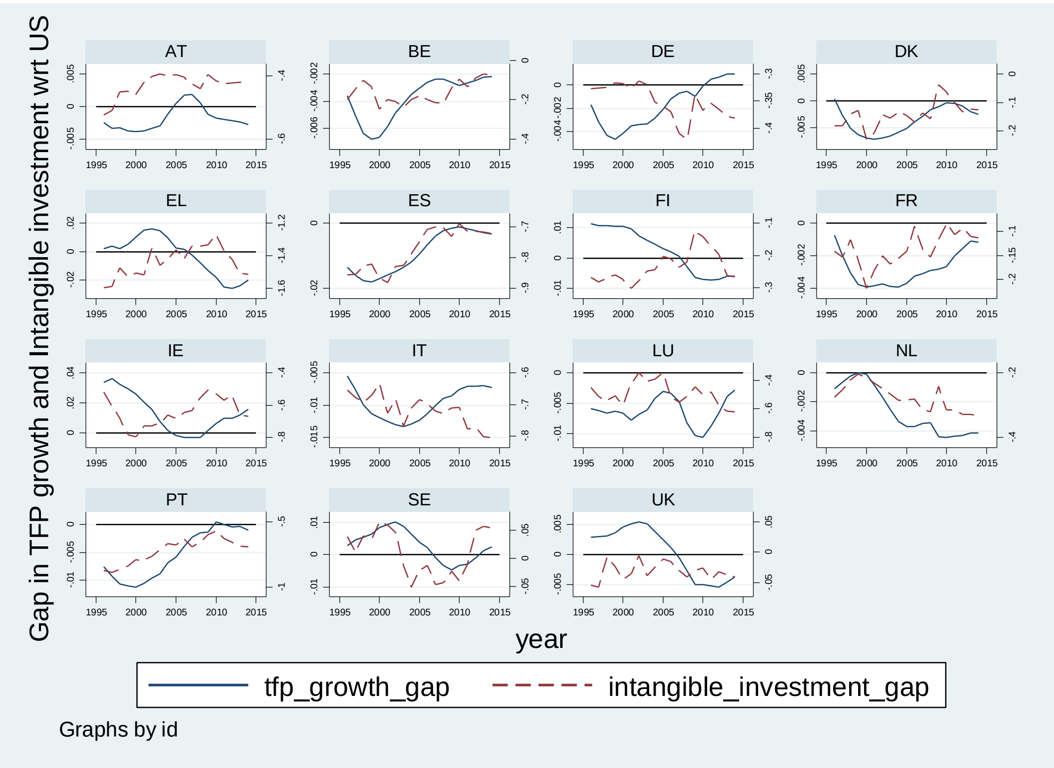
| | (1) Total intangibles | (2) NA-intangibles | (3) Non-NA intangibles | (4) Tangibles |
|---|---|---|---|---|
| Accelerator term | 0.0395* | 0.0519** | 0.0286*** | 0.210*** |
| | (0.0190) | (0.0201) | (0.00913) | (0.0373) |
| Tertiary education | 0.00103*** | 0.000146 | 0.000307*** | -0.000390 |
| | (0.000205) | (0.000146) | (8.02e-05) | (0.000430) |
| Long-term interest rate | -0.000280 | -0.000408** | -6.19e-05 | -0.00135*** |
| | (0.000261) | (0.000184) | (7.90e-05) | (0.000255) |
| EPL (strictness of selective dismissals) | -0.00829*** | 0.00320 | -0.00608** | 0.00804** |
| | (0.00156) | (0.00298) | (0.00204) | (0.00323) |
| Tangible investment | 0.227*** | | | |
| | (0.0508) | | | |
| Non-NA intangible investment | | 0.570* | | |
| | | (0.275) | | |
| NA intangible investment | | | 0.205* | |
| | | | (0.0966) | |
| Total intangible investment | | | | 1.021*** |
| | | | | (0.260) |
| Constant | 3.558*** | 0.732 | 2.471*** | 2.361 |
| | (0.831) | (1.188) | (0.804) | (1.588) |
| Country dummies | yes | yes | yes | yes |
| Time trend | no | no | no | yes |
| Crisis control | yes | yes | yes | yes |
| Observations | 194 | 194 | 194 | 194 |
| R-squared | 0.602 | 0.436 | 0.569 | 0.775 |
| Number of countries | 13 | 13 | 13 | 13 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: A time trend is only included in model (4) as Table 6 indicates that time trends are insignificant for the intangibles' models when including the control variables above. Explanatory variables are added in lag-form. All variables are expressed in percentages except EPL, which is expressed on a scale of 0-6.

Source: Commission services

Graph A1: **Gaps in terms of total factor productivity growth (left axis; %/100) and intangible investment (right axis; %), EU-15 compared to the US**




Note: The right hand side scale refers to intangible investment gap, the left hand side scale to TFP growth gap.

Source: Commission services

# ANNEX II: METHODOLOGICAL APPROACH FOR GROWTH ACCOUNTING (INCLUDING NON-NA-INTANGIBLES)

Growth accounting is a procedure first introduced by Solow (1957) applied to measure the contribution of different production factors (usually capital and labour) to economic growth; commonly referred to as sources of growth. It also allows indirectly computing productivity growth, measured as a residual. A key finding emerging from different growth accountings is that economic growth is not solely explained by growth in capital and labour respectively, but that a substantial part is due to technological progress.

The growth accounting approach relies on two crucial assumptions: (1) the economic production process can be represented by a Cobb-Douglas production function and (2) perfect competition. While the first assumption has a mere impact on the functional form of the growth accounting, the second assumption has a strong implication for the results from growth accounting. Perfect competition implies that input factor elasticities are equal to factor shares, i.e. input factors are remunerated at their productivity level. Making this assumption amounts to postulate that the input factors are productive. While making this assumption for traditional input factors capital and labour is widely accepted, it is admittedly a strong assumption for intangible capital. Nevertheless, relevant literature argues, based on empirical investigations and corresponding estimates of the factor elasticities of intangible capital, that it is a plausible assumption. For instance, Abdih and Joutz (2008) estimated a production function for the US including a measure of knowledge and find an important impact of knowledge capital proxied by patent applications with an estimated long run elasticity of 0.13 (consistent with studies on the return to R&D). Roth and Thum (2013) suggested a positive contribution of intangibles to labour productivity growth. Several other findings mentioned in Section 4.2 further confirm this finding.

***Basic growth accounting***: Based on Solow's (1957) Sources-of-Growth framework (SOG) and the growth accounting framework in Corrado, Hulten and Sichel (2009) we can write for each EU member state (or country or aggregate of interest)[86]

$$\begin{aligned} g_t^Y &= s_t^C g_t^C + s_t^I g_t^I \\ &= s_t^K g_t^K + s_t^L g_t^L + g_t^A \end{aligned} \tag{1}$$

where $g_t^X$ equals the real growth rate of the respective variables $X = \{Y, C, I, K, L, A\}$ where Y (gross value added), C (consumption), I (investment), K (capital), L (labour) and A (TFP) in time t and $s_t^K$ and $s_t^L$ equal the respective income shares defined as:

$s_t^K = \frac{P_t^K K_t}{Y_t}$ and $s_t^L = \frac{P_t^L L_t}{Y_t}$

The income shares $s_t^K$ and $s_t^L$ are assumed to equal the corresponding output elasticities. $P_t^X X_t$ denotes a variable in nominal terms[87].

We can rewrite equation (1) as:

$$g_t^A = g_t^Y - s_t^K g_t^K - s_t^L g_t^L \tag{2}$$

***Adding National-Accounts(NA)-intangibles (including Intellectual Property Products)***

When adding intangible capital to (1) we write (see Corrado, Hulten and Sichel 2009):

$$\begin{aligned} g_t^Y &= s_t^C g_t^C + s_t^I g_t^I + s_t^N g_t^N \\ &= s_t^K g_t^K + s_t^L g_t^L + s_t^R g_t^R + g_t^A \end{aligned} \tag{3}$$

Where $N$ denotes NA-intangible investment and $R$ denotes NA-intangible capital.

The factor income shares become:

$s_t^K = \frac{P_t^K K_t}{Y_t + N_t}$ and so forth for $L$ and $R$.

We can rewrite equation (3) as:

$$\begin{aligned} g_t^{A^*} &= g_t^Y + s_t^N g_t^N - s_t^K g_t^K - s_t^L g_t^L - s_t^R g_t^R \\ &= g_t^{Y^*} - s_t^K g_t^K - s_t^L g_t^L - s_t^R g_t^R \end{aligned} \tag{4}$$

where $g_t^{Y^*}$ is GVA including investment in intellectual property products (IPP).

***Adding new-intangibles (extending the current asset boundary to economic competences)***

When adding new-intangible capital to (3) we write:

$$\begin{aligned} g_t^Y &= s_t^C g_t^C + s_t^I g_t^I + s_t^N g_t^N + s_t^{N'} g_t^{N'} \\ &= s_t^K g_t^K + s_t^L g_t^L + s_t^R g_t^R + s_t^{R'} g_t^{R'} + g_t^A \end{aligned} \tag{5}$$

Where $N'$ is an new-intangible output good and $R'$is new-intangible capital.

The income shares become:

$s_t^K = \frac{P_t^K K_t}{Y_t + N_t + N_t'}$ etc.

[86] For expositional simplicity we disregard growth effects due to import and/or exports and the distinction between public and private consumption.

[87] Note that we express factor shares in real terms as outlined above.

We can rewrite equation (3) as:

$$g_t^{A^{**}} = g_t^Y + s_t^N g_t^N + s_t^{N'} g_t^{N'} - s_t^K g_t^K - s_t^L g_t^L - s_t^R g_t^R - s_t^{R'} g_t^{R'}$$
$$= g_t^{Y^{**}} - s_t^K g_t^K - s_t^L g_t^L - s_t^R g_t^R - s_t^{R'} g_t^{R'} \quad (6)$$

where $g_t^{Y^{**}}$ is GVA including investment in intellectual property products (IPP) and new-intangibles (economic competences).

The ultimate goal is to compute equation (2), (4) and (6) to compare the three:

$$g_t^A = g_t^Y - s_t^K g_t^K - s_t^L g_t^L$$

$$g_t^{A^*} = g_t^{Y^*} - s_t^K g_t^K - s_t^L g_t^L - s_t^R g_t^R$$

$$g_t^{A^{**}} = g_t^{Y^{**}} - s_t^K g_t^K - s_t^L g_t^L - s_t^R g_t^R - s_t^{R'} g_t^{R'}$$

# DATA SOURCES, DATA PROCESSING AND ASSUMPTIONS MADE FOR THE GROWTH ACCOUNTING

***Gross value added, hours worked, compensation of employees***

Data was taken from Eurostat for the EU-15 member states and from the Bureau of Economic Analysis (BEA) for the US. For some countries GVA adjusted for intangible investments was not available and needed to be constructed by using the INTAN-Invest database, notably EL, IE and the UK (see Table 3).

***Deflators***

For the deflation of the non-NA intangible stock data we use a GVA deflator based on 2010 prices from Eurostat in national currencies (Eurostat data set "National Accounts aggregates by industry (up to NACE A*64)" [nama_10_a64]).

For compensation of employees we use the GVA price index in Euros calculated on the basis of GVA series in current and in previous-year-prices (note that we need to deflate compensation of employees as we express income shares in real terms – see above). Due to some missing values in the GVA series, we needed to adjust GVA by IPP and new intangible investments for some countries (see above).

The GVA series as well as the series for tangible and NA-intangible stocks were chain-linked (see above) and therefore no deflator needed to be applied. Hours worked are obviously already expressed in real terms.

***Capital stocks and investments (National Accounts)***

Data for both tangible assets (ex. dwellings) and NA-intangibles ('intellectual property products') denoted in current replacement costs as well as previous year prices were mainly taken from the national accounts in Eurostat ("Cross-classification of fixed assets by industry and by asset (stocks)" [nama_10_nfa_st]).The capital stock series were chain-linked based on 2010 prices.

However, for some countries (e.g. DE, NL, UK and the New Member States) missing values appeared, especially for years before 2000. Missing capital stocks have been computed (where possible) by using the perpetual inventory method (PIM), thus relying on the national accounts data on investments ("Cross-classification of gross fixed capital formation by industry and by asset (flows)" [nama_10_nfa_fl]). Depreciation rates were derived from gross vs. net capital stocks based on the assumption that investments in year 't' take effect at the beginning of that year and will be depreciated together with the remaining capital stock in that same year 't'. Empirically, these computed depreciation rates proved to be rather constant over time (with the exception of depreciation rates for intangible assets in SK before 2004). Hence, the most recent available depreciation rate was assumed as constant in order to calculate net and gross capital stocks for the missing years. Note that no values for for PL and LU in 1995 – 1998 and for the UK in 1995 – 1996 could be computed due to missing data. Interpolations were made in cases where only one or few observations were missing to avoid dropping the entire series.

Note that as mentioned in Table 3, for the US and some EU-15 member states we needed to retrieve the data from other sources than the national accounts data in Eurostat.

***Capital stocks and investments (non-National Accounts)***

Investments in and stocks of non-NA intangible capital (aggregated as well as per asset types) were taken from the FP7-supported INTAN-Invest database which provides such data for the EU-15 member states and the US for 1995 – 2010. In addition, updated but yet to be published INTAN-Invest investment data (covering the period 1995 – 2013) were used. The currently publicly available data from INTAN-Invest are available at http://www.intan-invest.net/. A detailed description of the underlying sources and methods and the associated challenges can be found in Corrado *et al*. (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results" Working Paper, June (available at: http://www.coinvest.org.uk/pub/IntanInvest/WebHome/Methods_and_Comparative_Data_-_June_2012-7.pdf). For a more general discussion of the existing conceptual and measurement challenges with respect to non-NA intangible assets see Moulton and Mayerhauser (2015): The future of the SNA's asset boundary.

The given stocks (1995 – 2010, in volume terms million national currency, reference year 2005) were rebased to represent chain-linked volumes with reference year 2010 by using the non-farm business sector GVA deflator series (ex-dwellings) as suggested by Corrado *et al*. (2009).[88] Data series denoted in million national currency values were also chain linked (reference year 2010) and then converted into millions of Euro by using the 2010 conversation rates (as provided by Eurostat).

To obtain stock estimates for the years 2011 – 2013, the perpetual inventory method (PIM) was applied, thus using the investment estimates as provided by INTAN and converted as described above and the depreciation rates suggested by Coinvest (for details see the table below). Accordingly, estimates of accumulated intangible assets (volume terms in million Euro, chain-linked, reference year 2010) were calculated. This procedure was applied for all individual intangible assets types as provided by INTAN, which were then aggregated to obtain measures for the categories 'computerised information', 'innovative property' and 'economic competences' as well as for 'NA-intangibles' (acc. to ESA 2010) and 'New-intangibles' (obtained as difference from the sum of 'all intangible assets' – 'NA-intangibles').

[88] Note that for deflating stocks and investments in tangible assets a calculated price index for GFCF was used that can be derived from Eurostat data. Arguably, using the y-o-y price changes of the NA-intangibles (available as current and previous year prices in Eurostat) for deflating the investments in intangible assets / INTAN capital stocks could have been a better approximation of corresponding price trends (compared to the GVA deflator). However, the corresponding data is available only for few countries / years. Notwithstanding, applying different deflation methods / deflator concepts across countries / years appeared to be not straightforward. Therefore, we decided to rely on the GVA deflator as the second best (available) option, which could certainly be improved once a better price deflator would be available. However, this procedure is in line with Corrado *et al*., 2009. Note that for some countries (US and some new EU member states) no GVA deflator series were available either. Instead, GDP deflator series as provided by the Worldbank were used.

Table A9: **Assumed depreciation rates used for the Perpetual Inventory Method (PIM)**

| Asset type | Depreciation Rate |
|---|---|
| *Computerised information* | |
| 1. Software | .315 |
| 2. Databases | .315 |
| *Innovative property* | |
| 3. Mineral exploration | .075 |
| 4. R&D (scientific) | .150 |
| 5. Entertainment and artistic originals | .200 |
| 6. New product/systems in financial services | .200 |
| 7. Design and other new product/systems | .200 |
| *Economic competencies* | |
| 8. Brand equity | |
| a. Advertising | .550 |
| b. Market research | .550 |
| 9. Firm-specific resources | |
| a. Employer-provided training | .400 |
| b. Organisational structure | .400 |

Source: http://www.coinvest.org.uk/pub/IntanInvest/WebHome/Methods_and_Comparative_Data_-_June_2012-7.pdf

To calculate corresponding capital stocks for those countries for which the updates provided by INTAN-Invest reported investments in intangible assets per asset type, but no corresponding capital stocks (acc. to the 'cap-stock'-file 1995 - 2010), PIM was applied from 1995 onwards. A non-trivial assumption is thus the starting value in 1995. As an approximation for the PIM-starting values in 1995 a weighted multiple of the corresponding investments was assumed. Thus, the multiplier was approximated by the ratio of investments/capital stocks as observed over the period 1995 - 2010 for those countries both values have been reported by INTAN Invest. By applying this procedure we obtained the following multipliers: software (2.25), R&D (4.71), design (3.75), 'Entertainment, Literary and Artistic originals + Mineral Explorations' (4.98), New Financial Products (3.5), Brand equity (1.5), training (2.03), and Organisational capital (2.01). Accordingly, the starting values for those countries for which no capital stocks were reported by INTAN-Invest were calculated from the investments in 1995 (deflated, reference year 2010) and the mentioned multipliers. For any following year (1996 – 2013), the PIM as outlined above was applied to obtain stocks of intangible assets per asset type (in million Euro reference year 2010).

Remark: Arguably the procedure of setting start values for the PIM may cause a bias in the base line values of the corresponding capital stocks. However, given the comparably high depreciation rates, this bias empirically phases out after few years (latest in year 2000). In turn, applying the PIM by setting the starting value to zero (as done e.g. by Corrado *et al*., 2009) would have meant excluding the initial years until the biased true value of the benchmark will have depreciated away (1995 - 2000), thus shortening the scope of the corresponding growth accounting analyses. Arguably, although this procedure affects (initially) the absolute values of the corresponding capital stocks, the decision to assume a multiple of investments as starting point for the PIM has arguably little effect on the envisaged growth accounting analysis since (i) we are interested in the relative dynamics of the stocks rather than in its absolute amount and (ii) because the so introduced bias anyway depreciates quickly away (as argued above and also by Corado *et al*., 2009, p. 675).

Note: Since INTAN-Invest revised the figures for investments in intangible assets for the US for the years 1995 – 2010 (for all other countries this remained untouched), the entire capital stock series for the US was recalculated by applying PIM (starting from the stock value given for 1995 and using the revised investment figures and the depreciation rate for each of the asset type classes).

***Income shares***

The income shares for labour were computed as compensation per employee over GVA. Income share for capital were computed as capital services over GVA. Capital services were computed per type of capital (tangible, NA-intangibles and non-NA intangibles) as the respective user cost of capital times the capital stocks (see below for the computation of user cost of capital).

Note that income shares are computed in real terms. This may entail a small bias as we use different deflators for the factors and the income series respectively. The reason for computing income shares in real terms is that it was not possible to extend the intangible capital stocks series based on PIM in current replacement costs beyond 2010 (intangible capital stocks are not available in previous-year-prices). For consistency we decided to compute all shares in real terms.

***User cost of capital***

Corrado, Hulten and Sichel (2009) (henceforth CHS) employ the Jorgensonian user cost for intangibles given by the expression

$$P_t^R = (r_t + \delta - \pi)P_t^N$$

We compute our capital stocks in real terms (see above), which makes the use of the deflator $P_t^N$ obsolete - and we treat the expected capital gain or loss π as infinitesimally small or else as being zero on average and can therefore simplify the user cost to:

$$P_t^R = r_t + \delta$$

For the net rate of return $r_t$ we use the AMECO long-term real interest rates. For the depreciation rate $\delta$ we assume simple averages by respective asset class NA-intangibles (assets 1-7 above) and non-NA intangibles (assets 8 and 9 above) based on CHS (2009) and the depreciation rates mentioned above: we assume 0.25 for NA intangibles and 0.5 for non-NA intangibles.

## EUROPEAN ECONOMY DISCUSSION PAPERS

European Economy Discussion Papers can be accessed and downloaded free of charge from the following address:
https://ec.europa.eu/info/publications/economic-and-financial-affairs-publications_en?field_eurovoc_taxonomy_target_id_selective=All&field_core_nal_countries_tid_selective=All&field_core_date_published_value[value][year]=All&field_core_tags_tid_i18n=22617

Titles published before July 2015 under the Economic Papers series can be accessed and downloaded free of charge from:
http://ec.europa.eu/economy_finance/publications/economic_paper/index_en.htm

Alternatively, hard copies may be ordered via the “Print-on-demand” service offered by the EU Bookshop: http://bookshop.europa.eu.

## HOW TO OBTAIN EU PUBLICATIONS

**Free publications:**

- one copy:
  via EU Bookshop (http://bookshop.europa.eu);

- more than one copy or posters/maps:
  - from the European Union's representations (http://ec.europa.eu/represent_en.htm);
  - from the delegations in non-EU countries (https://eeas.europa.eu/headquarters/headquarters-homepage/area/geo_en);
  - by contacting the Europe Direct service (http://europa.eu/europedirect/index_en.htm) or calling 00 800 6 7 8 9 10 11 (freephone number from anywhere in the EU) (*).

(*) The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

**Priced publications:**

- via EU Bookshop (http://bookshop.europa.eu).

KC-BD-17-047-EN-N

Publications Office

ISBN 978-92-79-64885-4