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From:	ERAC Secretariat
To:	ERAC (European Research Area and Innovation Committee)
Subject:	ERAC plenary 16-17 March 2017 - agenda item 6 (Standing Information Point) Unlocking investment in Intangible Assets

ERAC Members will find attached the SIP Note (Unlocking investment in Intangible Assets) relating to item 6 on the agenda of the ERAC plenary on 16-17 March 2017 in Malta.

ERAC - Standing Information Point
Unlocking investment in Intangible Assets

33rd Plenary meeting
Agenda Item 6
St. Julian's, 16-17 March 2017

*The attached note **"Unlocking investment in intangible assets"** has been jointly produced by DG Research & Innovation and DG Economic and Financial Affairs, and was presented on 23 January 2017 at the Economic Policy Committee in Brussels[1].*

It constitutes one of the main work streams of the European Commission to advance analysis and measurement of Intangible Assets for policy formulation. It is part of a series of studies that aim to provide analytical support to the removal of barriers to investment under the Third Pillar of the Investment Plan for Europe.

The note argues that intangible assets are at the core of what makes firms competitive and are thus vital for productivity and economic growth. However, due to the specific characteristics of intangible assets, there are reasons to believe that overall investment in intangibles tends to remain systematically below the social optimum. Notably the investment gap between the EU and the US may mask a higher under-investment with regard to intangible assets in Europe. Therefore, assessing investment in intangibles is an important element of the 'Third Pillar' of the Investment Plan for Europe (EFSI).

Looking at the drivers of and possible barriers to investment in intangibles, a key question addressed by the note is whether the factors that tend to hold back investments in Europe are the same for tangible and intangible assets and, consequently, whether there is a need for specific policy measures to tackle barriers to investment in intangible assets. While this issue has been addressed in the economic literature in relation to R&D investments, the note goes beyond R&D to look also at other types of intangible assets.

Investment in intangible assets can be associated with:

(i) competition forces that may lead to economies of scale, monopolistic rents and rent seeking behaviour which, however, might be offset e.g. by spill-overs due to knowledge diffusion;

(ii) systematic risks with regard to knowledge (capital) creation combined with significant sunk costs and large uncertainty concerning investment returns, that may altogether lead to (socially desirable) investment decisions not being undertaken; and

(iii) evidence of synergies and complementarities among individual asset types.

Drawing on these characteristics, relevant drivers of and barriers to investments in intangible assets can be grouped into five categories: (i) regulatory framework; (ii) financial conditions; (iii) human capital; (iv) public intervention; (v) and macro-economic framework.

[1] The Economic Policy Committee provides advice and to contributes to the work of the ECOFIN Council and the Commission, around economic analyses on structural policies for improving growth and employment in the EU.

The note presents an empirical analysis that relates investments in intangible assets to a series of variables under the broad categories of drivers and barriers distinguished above. Results suggest that such investments are indeed significantly affected by public investments in R&D, science-business linkages, human capital, regulatory frameworks (product and labour), and financial conditions. Moreover, drivers and barriers differ between tangible and intangible investments. Human capital, public investment in R&D and business-friendly regulation matter more for intangible investment. By contrast, financial conditions tend to have a stronger effect on tangible investment.

From the conceptual considerations and the empirical findings, the note draws some lessons to inspire policy intervention:

- In general, to unlock investment in intangible assets, regulation enabling flexible re-allocation of resources, in particular well-functioning product, labour and capital markets, is pivotal.
- At the same time there is a need for an appropriate mix between modern/effective intellectual property rights systems to ensure sufficient returns to investment and competition policy (and its effective enforcement) addressing monopoly power and rent seeking.
- Access to finance for intangibles can also be improved by amending financing schemes i.e. increasing venture capital or using the European Fund for Strategic Investments (EFSI) and by improving systematic reporting of investments i.e. suggesting new standards for accounting and corporate disclosure.
- In case of market failures, public intervention can play an important role by providing direct or indirect support, in particular for assets with high social returns such as R&D and training, or by ensuring sufficient investment in infrastructure such as e.g. universities and knowledge hubs. Indeed, the rise in importance of intangible assets also calls for getting human capital policies right.
- Finally, there is a need to adopt an enlarged concept of knowledge creation, including R&D but also other forms of intangible capital, which implies improved measurement of intangible capital – both in terms of National Accounts but also at the firm level.

The data used to measure intangible investment stems from the "INTAN-Invest" harmonised (open access) database on macro-economic intangibles across a selection of countries, that builds on work funded by the "INNODRIVE" and "COINVEST" projects under the EU's Seventh Framework Programme for Research and Innovation.

EUROPEAN COMMISSION
DIRECTORATE GENERAL
ECONOMIC AND FINANCIAL AFFAIRS

EUROPEAN COMMISSION
DIRECTORATE GENERAL
RESEARCH & INNOVATION

Brussels, 22/10/2007

UNLOCKING INVESTMENT IN INTANGIBLE ASSETS

Note for the Economic Policy Committee

This note has been jointly elaborated by the European Commissions' Directorates Economic and Finance (ECFIN) and Research & Innovation (RTD)

EXECUTIVE SUMMARY

Intangible assets are at the core of what makes firms competitive and thus vital for productivity and economic growth. However, due to specific characteristics of intangible assets, there are reasons to believe that overall investments tend to remain systematically below their corresponding social optimum. This holds for all market economies alike, but as the EU is lagging behind the US in terms of investments in intangibles, the gap between EU and US may mask a much higher under-investment with regard to intangible assets in Europe. Therefore, assessing investment in intangibles is an important element of the '*Third Pillar*' of the Investment Plan for Europe.

In October 2016, the EPC had a preliminary discussion on investment in intangibles, based on a note presented by the Commission which focussed on conceptual issues, trend patterns in intangible investments as well as their role in fostering productivity and economic growth. The analysis suggested that official statistics tend to under-estimate the total investments in intangible assets and that the contribution of all intangibles to output growth is in most of the observed countries between one and three times that of tangible assets. Moreover, intangibles were found to be robust drivers of TFP growth, i.e. looking at intangibles can improve our understanding of TFP differentials among countries.

This follow-up note complements the earlier discussions by looking at the drivers of and possible barriers to investments in intangibles. A key question is whether the factors that tend to hold back investments in Europe are the same for tangible and intangible assets and, consequently, whether there is a need for specific policy measures to tackle barriers to investments to intangible assets. While this issue has been addressed in the economic literature mainly for investment in R&D, the present note aims at going beyond R&D by looking also at other types of intangible assets.

Intangibles are defined by specific features and their relevant characteristics can be grouped according to their effects on investment (incentives). Accordingly, investing in intangibles can be associated with (i) competition forces that may lead to economies of scale, monopolistic rents and rent seeking behaviour which, however, might be offset e.g. by spill-overs due to knowledge diffusion; (ii) systematic risks with regard to knowledge (capital) creation combined with significant sunk costs and large uncertainty concerning investment returns, that may altogether lead to (socially desirable) investment decisions not being undertaken; and (iii) evidence of synergies and complementarities among individual asset types.

Drawing on these characteristics, relevant drivers of and barriers to investments in intangible assets can be grouped into (i) regulatory framework, (ii) financial conditions, (iii) human capital, (iv) public intervention, (v) and macro-economic framework. An empirical analysis is performed, relating investments in intangible assets to a series of variables under the broad categories of drivers and barriers distinguished above.

Results from an accelerator model suggest that investments in intangibles are indeed significantly affected by human capital, public investments in R&D, science-business linkages, regulatory frameworks (product and labour) and financial conditions. Moreover, drivers and barriers differ between tangible and intangible investment. Human capital, public investments in R&D and business-friendly regulation matter more for intangible investment. By contrast, financial conditions tend to have a stronger effect on tangible investment.

From the conceptual considerations and the empirical findings, some lessons can be derived that could contribute to guide policy intervention.

In general, to unlock investment in intangible assets, regulation enabling flexible re-allocation of resources, in particular well-functioning product, labour and capital markets, is pivotal. But at the same time there is need for an appropriate mix between modern/effective intellectual property rights systems to ensure sufficient returns to investment and a competition policy (and its effective enforcement) addressing monopoly power and rent seeking. Access to finance for intangibles could also be improved by amending financing schemes i.e. increasing venture capital or using the European Fund for Strategic Investments (EFSI) and by improving systematic reporting of investments i.e. suggesting new standards for accounting and corporate disclosure. In case of market failures, public intervention can play an important role by providing direct or indirect support, in particular for assets with high social returns such as R&D and training, or by ensuring sufficient investment in infrastructure such as e.g. universities and knowledge hubs. Indeed, the rise in importance of intangible assets also calls for getting human capital policies right. Finally, there is a need to adopt an enlarged concept of knowledge creation, including R&D but also other forms of intangible capital, which implies improved measurement of intangible capital – both in terms of National Accounts but also at the firm level.

Questions for discussion with the Member States

Do you see the need to address investments in intangible assets by additional policy action (beyond existing initiatives)? Do you see the need to address these issues explicitly, i.e. possibly launching dedicated initiatives going beyond those that seek to stimulate investments in general or, for instance, R&I activities in particular?

If your country has made particularly good progress with implementing reforms / creating a business environment that stimulates investments in intangible assets, what were the key elements enabling this progress that could also be applied elsewhere?

What bottlenecks specific to investments in intangible assets do companies encounter in your country? How do you address them?

Do you agree that further efforts – at technical level – need to be undertaken to improve statistical coverage of the spending on intangibles? Would you urge your national statistical offices to collect corresponding data (for instance in satellite accounts as currently done as pilot projects in UK, NL, and US)?

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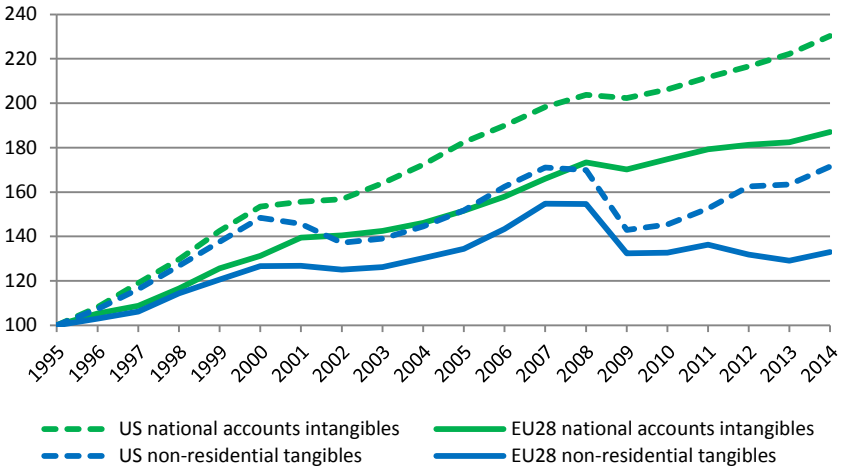
1. INTRODUCTION

This note looks at drivers of and barriers to investment in knowledge capital (notably: 'intangible assets'[1]) and is thus contributing to the ongoing thematic work on the 3rd pillar of the 'Investment Plan for Europe'. It builds upon an earlier note on 'Investment in Intangible Assets' (presented to EPC on 24/10/2016), which discussed conceptual aspects, empirical trends and economic impact of intangible assets. The earlier note i) outlined that the current System of National Accounts falls short in capturing investments in intangibles[2] while intangibles become ever more important in light of the emergence of the knowledge economy; ii) illustrated the order of magnitude and trend patterns of investments of intangibles; and iii) provided empirical evidence on the positive link between intangible assets, productivity and economic growth.

A distinguished picture emerges when considering investments in tangible and intangible assets in detail: investments in intangibles evolve more dynamically than those in tangible assets and the EU is lagging behind the US especially in terms of investments in intangibles (see Graph 1). Accordingly, there is reason to believe in weaknesses in terms of investment in intangibles in the EU, which needs to be better understood and possibly addressed by policy. Moreover, beside some barriers to investments which tend to affect tangible and intangible assets alike, there are some specific characteristics of intangible assets that give rise to the assumption that the observed investments may remain below the social optimum. Since this holds for the US as well, the observed current gap between EU and US eventually may mask a much higher underinvestment with regard to intangible assets.

Graph 1: Non-residential intangible and tangible investments in EU-28 vs. the U.S*



*Total economy according to SNA, chain linked volumes, index 1995 = 100
Sources: Eurostat national accounts for EU-28, BEA for U.S.

This follow-up note aims at complementing the former contribution by focussing on determinants of investments in intangible assets with a view to identifying the elements that hold back productive intangible investment as well as assessing the extent to which there are intangible-specific barriers. This is important in view of the need to design the most effective and most efficient policy response.

[1] There are generally three major forms of intangibles: (i) those created primarily through innovation and discovery, (ii) those that underlie organization practices (including also investments in customer satisfaction, product quality and brand reputation), and (iii) those related to human capital (see Hand and Lev, 2003).

[2] Accordingly, about half of the corresponding spending is not accounted. See EPC Note 24/10/2016 (EC, 2016b).

The note is organised as follows. Based on the findings emerging from the empirical and theoretical literature, section 2 discusses specific characteristics of intangibles assets. By looking at the individual types of intangible asset types, emphasis is thus on possible market failures. Section 3 discusses corresponding drivers of and barriers to investments in intangible assets and aims at developing preliminary lessons that could contribute to guide policy. Section 4 reports on a series of empirical analyses set to test the arguments put forward in section 2 and 3. Finally, section 5 summarises the main empirical findings and the corresponding key policy messages. Section 6 provides some possible elements for future thematic research.

2. ECONOMIC CHARACTERISTICS OF INTANGIBLES

Intangible assets comprise investment in R&D, innovation and technology development, training and education of workers, internal organization structures, customer and institutional networks, market exploration and development (marketing), and software and information technology. Different types of intangibles commonly share some specific features which, however, distinguish them from tangible assets[3]. These *defining characteristics* are decisive for identifying barriers to investment and may justify policy intervention

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).[4] However, it is important to bear in mind that intangibles are indeed quite heterogeneous. Table 1 illustrates this by assessing how these main characteristics apply to various types of intangibles.

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 characterized by limited appropriability and partial excludability[5]. 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-

[3] 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 A6 in the Appendix for details. Note that some of these investments are already included in the National Accounts measure of Gross Fixed Capital Formation (GFCF), especially computerized 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).

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

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

ensuring[6] may be needed to increase the appropriability of the returns to innovation before knowledge diffuses.[7]

Separability[8] and transferability[9] 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,[10] 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*[11]) without engendering scarcity or diminishing their basic usefulness (e.g. software or designs). With a view at 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*)[12] and ultimately to monopolistic competition. Positive *network externalities* can reinforce this tendency.[13]

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*.[14] 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.

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

[7] Note however that some intangible assets can be generated internally by firms and remain inherently non-marketable. Its 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.

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

[9] 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.

[10] 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.

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

[12] 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).

[13] 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.

[14] 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.

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, ex ante non-verifiability of intangibles implies financial constraints. This applies to all intangibles.

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 1 provides an *ad hoc* assessment of the main characteristics of intangible assets along the categories of intangibles already used in the previous note on intangibles (grouped according to Corrado, *et al*. 2005). The table is largely illustrative, based on work by the OECD, complemented by DG ECFIN's own assessment.

Table 1: *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*		
Computerized information	Computer software	partly excludable, transferable	fully non-rival, scalable, network-external.	high (codified)	high	potentially high
	Computerized 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
	Organizational capital	partly excludable, non-separable, transfer	largely non-rival, scalable	partly	high	potentially high
	Market research[15]	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).

[15] 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 (2015). 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.

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.

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.

***Box 1:** Economic characteristics specific to Research and Innovation*

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, 2016) 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[16] 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[17], 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[18].

[16] 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

[17] 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

[18] 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/)

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.[19]

3. DRIVERS AND BARRIERS TO INVESTMENT IN INTANGIBLES

The economic characteristics identified in the previous section suggest a range of drivers of and barriers to investment in intangibles. In this section a non-exhaustive list of altogether five drivers and barriers is presented, drawing on the relevant literature[20] 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) availability of public support 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 3.6.

3.1. Regulatory framework conditions and a pivotal role for re-allocation

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 the higher uncertainty of intangible assets due to their often exploratory nature increase the importance of an efficient mobilisation of resources. Indeed, compared to tangibles, intangible investment 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[21] and a large internal market can also effectively help channel resources towards the most productive investments and facilitate the scale-up of companies.

[19] 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.

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

[21] 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).

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.

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 organizational 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[22]). 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.

3.2. 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 verifiability and transferability of intangibles compared to tangibles.

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. 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[23] 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 Commission's Investment Plan[24] could be useful policy tools in that respect.

[22] Aghion et al (2005) also provide evidence for an inverted U-shaped relationship between competition and innovation.

[23] 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.

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

3.3. Availability of 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[25] 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.

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. Empirically, 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, 2014).

3.4. Other forms of 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 by supporting firms in getting access to finance for R&D activities (e.g. by direct loans, loans guarantees, state backed venture capital or public procurement). Recent evidence supports this positive impact[26], although in some cases, the results are divergent. The ambiguity of these results is partly attributable to the large array of policy instruments used[27] 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 computerized information). Direct public support also includes investment in infrastructure, public R&D or the public education system (see also Section 3.3).

[25] See e.g. Caballero and Jaffe (1993): New R&D investments can benefit from an existing stock of R&D investments.

[26] Becker (2014)

[27] 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.

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[28], 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 2 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 2: *Tax incentives as driver or barrier to investment in intangible assets*

Given that returns on R&D and training investment 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 (CPB 2014) and another one carried out by the European Commission (2016) to support the effective design of R&D tax schemes[29] 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[30], although the quantitative effects vary widely, ranging from partial crowding out of private investment[31] (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 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[32]. An ongoing study conducted by the OECD and the European Commission will help provide better evidence in this respect[33]. 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 approximately 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 expenditure, 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).

[28] 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.

[29] This report is part of the work undertaken to support mutual learning exercises across EU governments for better research and innovation policies under the Horizon 2020 Policy Support Facility (https://rio.jrc.ec.europa.eu/en/policy-support-facility/mle-administration-and-monitoring-rd-tax-incentives)

[30] Becker (2014). Public R&D Policies and Private R&D Investment: A Survey of the Empirical Evidence." Journal of Economic Surveys 29 (5): 917–42.

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

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

[33] 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.

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).

3.5. 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.

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[34].

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.

3.6. The role of barriers and drivers by types of intangible assets

The drivers and barriers discussed above may affect the respective types of intangible assets differently. Therefore, Table 2 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 characterized 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.

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 computerized 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 subsidized 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 collaterize but may be more important for those assets which are not easily transferable or verifiable such as organizational 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 computerized information and innovative property, while

[34] 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.

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.

Table 2: *Drivers and barriers to intangible investment by asset type (emerging from 3.1-3.5)*

		Public support		Financial conditions[35]	Regulatory framework	Availability of human capital	Macro-economic conditions
		Should public support step in?		Do these drivers and barriers affect the respective asset types?			
		Direct (grants)	Indirect e.g. tax incentives				
Computerized information	Computer software	potentially*	potentially	yes, as difficult to collateralize 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
	Computerized databases	potentially	potentially	yes, as difficult to collateralize 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 collateralize, 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 collaterize 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 collaterize 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 collaterize; 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 collaterize; 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
	Organizational capital	no	no	yes, as difficult to collaterize and not easily transferable	yes, as competition can act as a driver to innovate management techniques	yes, mainly interpersonal skills	yes
	Market research[36]	no	no	yes, as difficult to collaterize; transferable via firm ownership	yes, as competition can act as a driver	yes, mainly analytical skills	yes

Source: own illustration, adapted and extended from Andrews and de Serres (2012).
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 subsidized when using new technology but these subsidies could lead to lock-in effects as they do not give firms the incentive to grow.

[35] The assignment of the degree of transferability in this column is taken from Andrews and de Serres (2012).
[36] 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 (2015). 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.

4. EMPIRICAL ANALYSIS

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 3 - namely *regulatory framework (flexible markets), availability of human capital, other forms of public intervention* and *financial conditions*[37]. Box 3 describes the methodology used for the analysis[38]. The macro analysis presented below is complemented with some further empirical evidence on R&D (see Box 4).

Box 3: *Panel fixed-effects regression analysis of investment in intangible assets*

To test the potential drivers of intangible investment empirically, we estimate an investment equation based on an accelerator model[39] 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 δ_i (see Oliner *et al* 1995)[40]:

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

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:

$$\Delta K_{it}^{*} = c\Delta Y_{it} \quad (2)$$

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

$$\frac{I_{it}}{K_{it-1}} = \gamma_i + \sum_{j=1}^{N} \beta_{1j} \frac{\Delta GVA_{it-j}}{K_{it-1}} + \varepsilon_{it} \quad (3)$$

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):

$$\frac{I_{it}}{K_{it-1}} = \gamma_i + \sum_{j=1}^{N} \beta_{1j} \frac{\Delta GVA_{it-j}}{K_{it-1}} + \beta_2 DRI_{it-1} + \varepsilon_{it} \quad (4)$$

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[41] 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[42]. Data for the accelerator term and drivers of intangible investment are taken from various databases[43].

[37] 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.

[38] Further details are provided in the Note to the LIME group "Investment in intangible assets: barriers and policy lessons" (21/11/2016).

[39] 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 people's demand for consumer goods increases. Consequently, investment must increase to raise the productive capacity to meet the increased demand.

[40] 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.

[41] 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.

[42] The INTAN-Invest.net database 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.

[43] Further details are provided in the Note to the LIME group "Investment in intangible assets: barriers and policy lessons" (21/11/2016).

Table 3 below presents results from the regression model described in equation (4) in Box 3 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 computerized 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 A1-A4 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))[44]. Note that the estimated coefficients refer to country averages (EU-15), i.e. can hide some country heterogeneity.

Table 3: *Fixed effect regressions, introducing selected determinants per category (public support, availability of human capital, finance and regulation) by asset type*

VARIABLES	(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	0.000744***	0.000363**	0.000381***	0.000238
	(0.000200)	(0.000152)	(8.74e-05)	(0.000415)
Long-term interest rate	-0.000667**	-0.000502**	-0.000165*	-0.00200***
	(0.000274)	(0.000214)	(8.10e-05)	(0.000240)
EPL (strictness of selective dismissals)	-0.00643***	-0.000292	-0.00613***	0.00203
	(0.00160)	(0.00231)	(0.00165)	(0.00214)
Constant	0.0539***	0.0242**	0.0297***	0.0788***
	(0.00587)	(0.00796)	(0.00563)	(0.00552)
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 geo	13	13	13	13

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

Notes: (1) When controlling for additional variables the time trend becomes insignificant for all asset types apart from tangible capital which is characterised by a negative trend (see Note to LIME (21/11/2016)). For reasons of multi-collinearity we drop the trend from those regressions (i.e. we believe that the variables included in the model jointly explain more than the trend). Explanatory variables are added in lag-form as described in Box 3. (2) NA-intangibles refer to those intangible asset types that are included in the national accounts' measure of Gross Fixed Capital Formation (GFCF), namely computerized 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 (see also footnote 4).

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).

[44] 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.

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[45]. 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). Indeed, 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 A1-A4 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. In terms of comparing NA- with non-NA-intangibles, results suggest that EPL matters more for non-NA intangibles, which would indicate that allocation of resources is more important for those assets that are even less easily accountable than NA-intangibles.

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 A1-A4 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 qualification but the result captures more than this correlation as it applies to both NA and non-NA intangibles.

[45] 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.

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 (see also the Section 3). 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 A5 and A6). The regressions[46] 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. Further 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 2).

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[47] 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 routinized 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, as indicated in Box 1.

2. Financial conditions

[46] 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.

[47] Economic regulation encompasses regulations associated to competition policies, price regulations, market entry regulations, and the regulation of natural monopolies and public utilities.

The econometric results presented in this note 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 been 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[48] 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. These findings support part of the empirical literature that highlights the positive impact that public R&D can on private R&D investment (David et al, 2000), even if some studies have found in some cases a negative effect. 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, 2014).

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 2. 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.

5. CONCLUDING REMARKS AND POLICY IMPLICATIONS

Several conclusions can be drawn from the conceptual and empirical considerations presented in this note and the EPC Note October 2016 the on intangible assets.

Investment in industrialised countries tends to be shifting away from traditional areas of physical assets towards more intangible / knowledge-based capital as

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

comparably high growth rates of investment in intangible assets show. However, the EU is lagging behind the US in terms of investments in intangibles.

Intangibles are 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[49]. 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[50].

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.

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.

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.

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:

- **Policy needs to strike an appropriate balance between promoting flexible and competitive markets on the one hand and the need to constantly modernise intellectual property rights (IPR) on the other hand.**[51]

  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.

[49] See the growth accounting exercise in the EPC Note October 2016.
[50] Ibidem.
[51] 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.

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 modernized 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 in order to adapt them to challenges commonly emerging when investing in intangibles** (higher uncertainty, significant sunk costs, lack of 'second-hand' markets for intangible assets).

  Efforts could be made to amend financing schemes. For example, effective measures could include stimulating e.g. early-stage equity finance, venture capital, crowd funding, and possibly also using EFSI 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.[52] 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[53] and promoting business-science linkages and knowledge transfer.

  In addition, investing and stimulating investment in tertiary education, skills and training is a crucial dimension of policies. 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.

- **Finally, 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 computerized

[52] 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).

[53] 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)

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).[54]

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

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APPENDIX

Table A1: 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	0.000906***										
	(0.000251)										
Overqualification		0.00145**									
		(0.000618)									
Underqualification			-0.000575*								
			(0.000286)								
Long-term interest rate				-0.00125**							
				(0.000459)							
Debt to equity ratio					-0.000704*						
					(0.000372)						
PMR						-0.00673*					
						(0.00331)					
Doing business: Construction permits							0.000556***				
							(6.34e-05)				
Doing business: trade across borders								0.000125*			
								(6.53e-05)			
EPL									-0.00698*		
									(0.00368)		
Public R&D intensity										0.0338***	
										(0.0106)	
Public-private copublications											0.000129***
											(2.90e-05)
Constant	0.0259***	0.0363***	0.0700***	0.0543***	0.0545***	0.0614***	0.0117**	0.0425***	0.0742***	0.0272***	0.0416***
	(0.00660)	(0.00588)	(0.00981)	(0.00126)	(0.00206)	(0.00521)	(0.00476)	(0.00567)	(0.0122)	(0.00713)	(0.00187)
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 geo	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 A1 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 as described in Box 3.

Table A2: 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	-5.35e-05											
	(0.000408)											
Overqualification		-0.000324										
		(0.000775)										
Underqualification			0.000385									
			(0.000371)									
Long-term interest rate				-0.00195***								
				(0.000276)								
Leverage of the banking sector					-0.000480**							
					(0.000215)							
Debt to equity ratio						-0.00170***						
						(0.000248)						
PMR							0.0110					
							(0.00619)					
Doing business: Construction permits								0.000519**				
								(0.000223)				
Doing business: trade across borders									0.000118			
									(0.000109)			
EPL (collective dismissals)										-0.00493		
										(0.00372)		
Public R&D intensity											-0.0375	
											(0.0271)	
Public-private copublications												7.65e-05
												(7.08e-05)
Constant	0.0781***	0.0799***	0.0617***	0.0894***	0.0838***	0.0860***	0.0549***	0.0535***	0.0814***	0.0958***	0.0987***	0.0766***
	(0.00739)	(0.00592)	(0.0158)	(0.00264)	(0.00475)	(0.00285)	(0.0136)	(0.0148)	(0.00891)	(0.0125)	(0.0149)	(0.00234)
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 geo	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 A2 includes a time trend as it turns out to be significant in Table 3, which implies that even when adding indicators jointly they do not explain the trend. Explanatory variables are added in lag-form as described in Box 3.

Table A3: 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	0.000456***									
	(0.000129)									
Overqualification		0.000647**								
		(0.000216)								
Underqualification			-0.000233							
			(0.000136)							
Long-term interest rate				-0.000581**						
				(0.000249)						
PMR					-0.00391**					
					(0.00149)					
Doing business: Construction permits						0.000207***				
						(5.79e-05)				
Doing business: trade across borders							0.000126***			
							(2.55e-05)			
EPL								-0.00592		
								(0.00347)		
Public R&D intensity									0.0234***	
									(0.00639)	
Public-private copublications										7.24e-05***
										(1.79e-05)
Country dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Crisis control	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	0.00658*	0.0126***	0.0268***	0.0207***	0.0253***	0.00493	0.00950***	0.0389***	0.00288	0.0139***
	(0.00338)	(0.00201)	(0.00462)	(0.000731)	(0.00233)	(0.00434)	(0.00225)	(0.0115)	(0.00429)	(0.00115)
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 geo	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, public R&D intensity and PMR insignificant. Explanatory variables are added in lag-form as described in Box 3.

Table A4: 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	0.000450**										
	(0.000153)										
Overqualification		0.000804*									
		(0.000439)									
Underqualification			-0.000342*								
			(0.000179)								
Long-term interest rate				-0.000666**							
				(0.000256)							
Debt to equity ratio					-0.000372*						
					(0.000178)						
PMR						-0.00282					
						(0.00228)					
Doing business: Construction permits							0.000349***				
							(4.18e-05)				
Doing business: trade across borders								-8.36e-07			
								(4.34e-05)			
EPL (collective dismissals)									-0.00105		
									(0.00115)		
Public R&D intensity										0.0104	
										(0.00839)	
Public-private copublications											5.61e-05**
											(2.36e-05)
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
Constant	0.0193***	0.0237***	0.0432***	0.0336***	0.0336***	0.0361***	0.00677**	0.0330***	0.0352***	0.0244***	0.0276***
	(0.00406)	(0.00422)	(0.00615)	(0.000734)	(0.000989)	(0.00359)	(0.00309)	(0.00375)	(0.00384)	(0.00572)	(0.00159)
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 geo	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 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 as described in Box 3.

Table A5: Fixed-effect regressions; complementarities between different asset types – baseline model

VARIABLES	(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	0.0197***	0.00658*	0.0196***	0.0329***
	(0.00590)	(0.00328)	(0.00444)	(0.0101)
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 geo	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 as described in Box 3.

Table A6: Fixed-effect regressions; complementarities between different asset types – with controls

VARIABLES	(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	0.0356***	0.00732	0.0247***	0.0236
	(0.00831)	(0.0119)	(0.00804)	(0.0159)
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 geo	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 3 indicates that time trends are insignificant for the intangibles' models when including the control variables above. Explanatory variables are added in lag-form as described in Box 3.

Table A6: Types of intangible assets

Computerized 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.
Computerized 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. a. Mineral exploration, Census of Mineral Industries and NIPAs. 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: a. Development costs in the motion picture industry 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: a. New product development costs in the financial services industries, crudely estimated as 20 percent of intermediate purchases. b. New architectural and engineering designs, estimated as half of industry purchased services (revenues of the industry as reported in SAS). 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 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] a. Direct firm expenses (in-house trainers, outside trainers, tuition reimbursement, and outside training funds) b. Wage and salary costs of employee time in formal and informal training
Organizational structure (costs of organizational change and development; company formation expenses)	No broad statistical information and no clear consensus on scope. a. Purchased "organizational" or "structural" capital, estimated using SAS data on the revenues of the management consulting industry. 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).