

### Sources of Country-Industry Productivity Growth: Total factor Productivity, Intangible Capital and Inputs Reallocation in the EU15 and the US

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### Abstract

Empirical evidence shows that intangible capital accounts for one-fifth to one-third of labor productivity growth in the market sector of the US and EU economies and that it provides a similar contribution both in manufacturing and services. Total factor productivity (TFP) instead provides a large negative contribution to labor productivity in the slow growing economies as opposed to a positive contribution in the fast growing countries (Corrado, Haskel, Jona-Lasinio, 2015). This paper develops a sources of growth analysis for the total economy with a complete accounting for intangible capital inputs focusing on the growth contributions of both market and nonmarket sectors in the EU15 and the US. We also look at the role of factor inputs reallocation as drivers of TFP growth (Jorgenson and Schreyer, 2013).

To investigate these issues, we merge newly created SPINTAN measures of public and nonmarket intangible investment with newly updated (1) INTAN-Invest industry-level measures of intangible investment for 15 EU and US economies in 1995-2013 and (2) EUKLEMS and National Account industry data on output, and labor and tangible inputs.

JEL: O47, E22, E01

Keywords: productivity growth, economic growth, intangible capital, intangible assets.

### 1. Introduction

Empirical evidence shows that intangible capital accounts for one-fifth to one-third of labor productivity growth in the market sector of the US and EU economies<sup>1</sup> and that it provides a similar contribution both in manufacturing and services (Corrado, Haskel, Jona-Lasinio, 2015). These authors found that total factor productivity (TFP) in contrast provides a large negative contribution to labor productivity in slow growing economies as opposed to a positive contribution in fast growing countries. This paper presents a theoretical and empirical investigation of the transmission mechanisms through which intangible capital affects total economy productivity growth. We analyze this issue looking at both the direct and indirect channels through which intangibles foster productivity growth across countries and between/within industries. In particular we investigate capital reallocation in a framework that includes intangible capital, drawing on the framework of Jorgenson and Schreyer (2013).

To investigate these issues, we merge newly created SPINTAN measures of public and nonmarket intangible investment with newly updated (1) INTAN-Invest industry-level measures of intangible investment for 15 EU and US economies in 1995-2013 and (2) EUKLEMS and National Account industry data on output, and labor and tangible inputs.

We conduct a sources-of-growth analysis to evaluate the contribution of TFP, tangible and intangible capital to labor productivity growth at the industry level. The focus is on the role of intangible capital and the measurement bias resulting from its exclusion. We also look at the role of capital reallocation as a driver of TFP growth before and after the financial crisis. Specifically we investigate the main factors that influenced capital reallocation over the financial crisis in a framework accounting for national accounts (NA) and non-NA intangible capital. A central allegation leveled at the financial system since the financial crisis is that it is no longer functioning in a manner that allocates capital such that productivity can grow. Whilst this suspicion is widespread, it has proved difficult to gather evidence to examine its validity.

<sup>&</sup>lt;sup>1</sup> The most recent report of this accounting is in Corrado, Haskel, Jona-Lasinio, and Iommi (2013). Corrado, Hulten, and Sichel (2009) and Marrano, Haskel, and Wallis (2009) first reported results of about one-fourth for the US and UK, respectively. The contribution in Japan and many EU countries is lower (Fukao, Miyagawa, Mukai, Shinoda, and Tonogi, 2009 and van Ark, Hao, Corrado, and Hulten, 2009).

The paper is organized as follows. Section 2 briefly describes the sources of growth calculation and the methods and data used in its estimation. Section 3 presents and discusses the sources of growth results. Section 4 outlines the capital reallocation calculations and section 5 concludes.

### 2. Sources of growth for the total economy, methods and data

### Sources of growth

We conduct a sources-of-growth analysis using a Divisia index approach to computing TFP (Caves, Christensen, and Diewert, 1982) and evaluate the contribution of TFP, tangible and intangible capital to labor productivity growth at the industry level. This enables us to quantify the measurement bias of the exclusion of intangible capital from sources of growth analyses and to estimate the industry contributions to labor and TFP growth to assess to what extent productivity growth differentials across countries can be attributed to different industry structures or to different industry performance.

The basic sources of growth equation is given by:

$$\Delta \ln Q_{c,i,t}^{(a)} = s_{c,i,m,t}^{L(a)} \Delta \ln L_{c,i,m,t} + s_{c,i,m,t}^{K(a)} \Delta \ln K_{c,i,m,t} + s_{c,i,m,t}^{R(a)} \Delta \ln R_{c,i,m,t} + \Delta \ln A_{c,i,m,t}$$
(1)  
where:

where:

c=country, i=industry, m=market-nonmarket sector, t=time;

s = (PxX/PqQ) are the shares of inputs in the value of output, and (a) denotes that these are consistent with capitalized intangible assets;

L is labor input, K is tangible capital, R is intangible capital and TFP is a residual.

The database employed in this paper has multiple dimensions: country, industry, institutional sector and time. It includes data on both tangible and intangible capital inputs as well as standard growth accounting variables such as output and labour input. The main database for variables other than intangible capital is the EU KLEMS database<sup>2</sup> (see O'Mahony and Timmer, 2009, for details). These data were updated to 2013 using national accounts sources. For the market sector, intangible capital is taken from the INTAN-invest database<sup>3</sup> as outlined in Corrado et al. (2016). This divides intangible assets into three broad groups - computerised information, innovative property and economic competencies. Computerised information basically

<sup>&</sup>lt;sup>2</sup> http://www.euklems.net

<sup>&</sup>lt;sup>3</sup> http://www.intan-invest.net

coincides with computer software and databases. Innovative property refers to the innovative activity built on a scientific base of knowledge as well as to innovation and new product/process R&D more broadly defined. Economic competencies include spending on strategic planning, worker training, redesigning or reconfiguring existing products in existing markets, investment to retain or gain market share and investment in brand names. The measurement of intangible assets has been extended as part of the SPINTAN project to include the non-market industries (public administration, education and health) and to include a division into private and public sectors.

### Measuring Intangible Investments

The INTAN-Invest estimates reported in this paper (INTAN-Invest 2016) are the result of a complete revision and update of previous INTAN-Invest data. SPINTAN is a project funded by the European Union's Seventh Framework Programme that aims at discovering the theoretical and empirical underpinning of public intangible policies and that has among its objectives to build a public intangible database for a wide set of EU countries and some other big non-EU countries.

The two sets of intangible estimates, although generated from two different and independent projects, share the same measurement approach and refer to two non-overlapping cross-classifications of sectors and industries. INTAN-Invest and SPINTAN estimates, taken together, provide harmonized measures of investment in intangible assets for the total economy cross classified by 21 industries (corresponding to the sections of the Nace rev. 2 classification) and two institutional sectors (market and non-market) - see Bacchini et al. (2016) for an overview of the estimation methods.

The main pillar of SPINTAN and INTAN-Invest estimation strategy is the adoption of the expenditure-based approach to measure the value of investment in intangible assets (i.e., expenditure data are used to develop direct measures of intangible investment). Moreover, both projects have the goal of generating measures of harmonized intangible investment satisfying (as much as possible) the following criteria: exhaustiveness, reproducibility, comparability across countries and over time, and consistency with official national accounts data. The above characteristics are assured by the adoption of official data sources homogeneous across countries. An implication of the adopted estimation strategy is that our estimation methods can be applied only for the years when national accounts data are available. For EU countries, the starting date of national accounts data from Eurostat database usually ranges from 1995 (for almost all countries) to 2000 (and even more recent years for detailed data on GFCF by industry in a few countries).

SPINTAN provides estimates of intangible investment performed by the nonmarket sector in a set of industries of interest. More precisely, the SPINTAN Non-market sector consists of the non-market producers classified in the following industries: (1) Scientific research and development (Nace divison M72); (2) Public administration and defence; compulsory social security (Nace section O); (3) Education (Nace section P); (4) Human health and social work activities (Nace section Q), and (5) Arts, entertainment and recreation (Nace divisons R90-92) – see Corrado, Haskel, Jona-Lasinio, 2015.

Non-market producers are defined consistently with National Accounts definitions (i.e. establishments that supply goods or services free, or at prices that are not economically significant and that are classified in the Government Sector (S.13) or in the Non Profit Institutions Serving Households (NPISH) Sector (S.15)).

In the System of National Accounts, units are classified by industry according to the activity they carry out, being market or nonmarket producers. Therefore, each industry can (potentially) consist of a mix of market and nonmarket producers. In particular, this is true for all the industries covered by SPINTAN estimates, with the exception of the industry "Public administration and defence; compulsory social security" (Nace Section O), that include only units belonging to sector S13. We refer to these industries as SPINTAN mixed industries. Note that the SPINTAN nonmarket sector is differsfrom the total of sectors S13 and S15 from National Accounts (because it does not cover non-market producers that are not classified in the industries of interest) and it is different to the total of industries of interest (because it does not include market producers that are classified in the mixed industries).

The INTAN-Invest 2016 estimates cover total investment in industries from Nace sections from A to M (excluding M72) and section S plus the market sector component of Nace M72, P, Q and R. In other words, they cover the part of the economy that is not included in the SPINTAN estimates. For the sake of simplicity, we refer to the INTAN-Invest estimates as covering the market sector, but actually, they also include the non-market sector component not covered by SPINTAN. The industry and sector coverage in INTAN-Invest 2016 has changed with respect to the previous INTAN-Invest estimates that did not cover industries P and Q and covered all industry R. Details of the calculations and assumptions required to calculate

investments in intangible assets are given in the Appendix.

The main analysis developed in this paper covers the period 1995-2013 and includes a breakdown into 20 industries and for 12 countries. The latter include the US, large Northern European economies (Germany (DE), France (FR) and the UK), three Scandinavian countries (Denmark (DK), Finland (FI) and Sweden (SE)), Mediterranean economies (Spain (ES) and Italy (IT) and three smaller European economies (Austria (AT), the Czech Republic (CZ) and the Netherlands (NL)). Intangible Capital is calculated from real investment using the perpetual inventory method and geometric depreciation. Real value added and the input shares are adjusted to take account of the capitalization of these assets (see Corrado et al. (2016) for details.

# **3.** Sources of growth in the EU15 and the US (empirical results by institutional sectors)

This section describes sources of growth across time, country and industry, focusing especially on the role of intangible capital. Figure 1 shows the shares of intangible investments in total GDP in 2013 by country. Overall (market and nonmarket) intangible investments account for from nearly 14% (Sweden) to just under 6% (Spain) of value added. The market sectors accounts for the main component of intangible investment as a share of value added - averaged across countries, the market sector shares of value added are 8% compared to 1.5% for the non-market sectors.



Figure 1 - Market and nonmarket intangible investment: adjusted value added shares (2013)

Source: INTAN-Invest and SPINTAN estimates

In those countries with the highest shares of intangibles (Sweden, the US and the UK), intangibles investments now account for a larger value added share than tangibles capital investments (Figure 2). Less advanced countries such as Spain and Italy have a much lower share of intangibles than tangibles. The differences in intangible intensity across countries also mirror the industrial structure of the economies, with countries such as Germany that are heavily concentrated in manufacturing having a higher share of tangible than intangible investments.



Figure 2 - Tangible and intangible investment: adjusted value added shares (2013)

Source: INTAN-Invest and National Accounts

Over time there have been shifts in the relative investment shares of the two types of assets as illustrated in Figure 3. This shows that after the crisis, tangible investment experienced a prolonged slowdown while intangible investment only showed a small downturn and went back quickly to pre-crisis levels. In the earlier period investments in the two assets showed similar trends, although with a slightly higher growth in intangible investments. It is also apparent that the speed of recovery varied between the EU and the US as shown in Figure 4. In both regions Intangibles were relatively resilient during the crisis but intangibles recovered faster in the US and tangibles lagged behind in the EU.



Figure 3 – Tangible and intangible investment trends, EU+US

Figure 4 – Tangible and intangible investment trends, EU+US



Source: INTAN-Invest and National accounts

Table 1 uses equation (1) to estimate the sources of growth, averaged from 1999 to 2013, for the non-farm Business sector (excluding Agriculture, Public Administration, Education and Health). This shows that in Finland, the UK and the US, intangible capital provided a relatively higher growth contribution than tangible capital. The Czech Republic, Germany, Spain and Italy have much lower contributions of intangible relative to tangible capital with other countries showing more equal contributions. All countries but the UK show smaller growth contributions of intangible capital than the US, even if at a different pace, as shown in Figure 5.

Country	DlnQ	DlnL	DInK	DlnK ICT DlnK		DInTFP	
			NonICT		intan		
AT	2.01%	0.28%	0.33%	0.24%	0.49%	0.68%	
CZ	3.07%	-0.16%	1.17%	0.42%	0.28%	1.41%	
DE	1.28%	-0.07%	0.43%	0.19%	0.24%	0.50%	
DK	1.05%	-0.04%	0.29%	0.25%	0.36%	0.19%	
ES	1.18%	0.34%	0.97%	0.23%	0.31%	-0.68%	
FI	1.90%	0.22%	0.05%	0.13%	0.40%	1.10%	
FR	1.71%	0.24%	0.30%	0.12%	0.51%	0.56%	
IT	0.25%	-0.04%	0.26%	0.18%	0.13%	-0.27%	
NL	1.59%	0.04%	0.35%	0.12%	0.40%	0.70%	
SE	2.96%	0.26%	0.52%	0.37%	0.56%	1.30%	
UK	1.74%	0.02%	0.28%	0.15%	0.36%	0.92%	
US	2.01%	-0.18%	0.27%	0.32%	0.70%	0.90%	

Table 1. Sources of Growth, Non farm business sector, 1999-2013,

(% Contributions)

Note: Contributions of inputs are estimated by multiplying their growth by their shares in output.



Figure 5 - Sources of growth (1999-2013): deviations from the US

We now consider the non-market sectors (Public Administration, Education and Health) and see that only in the UK and US are the contribution of intangible capital more relevant than contributions of tangible capital (Table 2). In most other countries the contribution of tangible capital is significantly higher than intangible capital.

	DlnQ	DInL	DInK	DInK ICT	DlnK intan	DInTFP		
			Nonici					
AT	1.06%	0.64%	0.14%	0.28%	0.14%	-0.14%		
CZ	0.32%	-0.10%	0.71%	0.17%	0.05%	-1.18%		
DE	1.07%	0.21%	0.47%	0.13%	0.19%	0.08%		
DK	0.44%	0.42%	0.29%	0.12%	0.10%	-0.38%		
ES	2.77%	1.47%	0.96%	0.25%	0.23%	-0.13%		
FI	0.42%	0.72%	0.43%	0.05%	0.03%	-0.80%		
FR	1.14%	0.24%	0.32%	0.04%	0.08%	0.45%		
IT	0.11%	-0.08%	0.24%	0.08%	0.11%	-0.23%		
NL	1.83%	1.08%	0.21%	0.14%	0.21%	0.18%		
SE	0.64%	0.55%	0.33%	0.21%	0.07%	-0.52%		
UK	1.96%	1.25%	0.68%	0.02%	0.40%	-0.19%		
US	1.64%	1.19%	0.15%	0.04%	0.54%	-0.28%		

Table 2. Sources of Growth, Non-market sectors, 1999-2013, (% contributions)

Note: Contributions of inputs are estimated by multiplying their growth by their shares in output.

## 4. TFP and inputs reallocation (The Jorgenson-Schreyer (2013) accounting framework)

### The JS model

We follow Jorgenson and Schreyer (2013) and use their accounting framework, that directly links the reallocation of capital between industries and (total factor) productivity growth. We do this using data from 11 countries, 1997-2013, so we can try to provide both cross-country evidence and data before and after the financial crisis. The main concern is that capital is somehow not being allocated to the "right" sectors and this is impeding productivity growth.

The basic idea is that in evaluating the degree of misallocation, a "benchmark" for productivity growth has to be identified (one where capital were being allocated efficiently) and compared to the current capital allocation. The JS method calculates the contribution of capital services to productivity under these different scenarios. The JS model can be described as follows: Assume that there are *b* labour types and *a* capital asset types. Then we can write capital and labour aggregates as:

$$\Delta lnK = \sum s_{K}^{Ka} \Delta lnK_{t,a} \tag{2}$$

and

$$\Delta lnL = \sum s_{L}^{Lb} \Delta lnH_{b,t} \tag{3}$$

where  $H_b$  are the person-hours worked by type *b* workers and the shares are shares of total capital and labour payments. They can be defined as:

$$s_{L}^{Lb} = \frac{1}{2} \left( \left( \frac{P_{Lb} L_b}{P_L L} \right)_t + \left( \frac{P_{Lb} L_b}{P_L L} \right)_{t-1} \right)$$
(4)

and

$$s_{K}^{Ka} \equiv \frac{1}{2} \left( \left( \frac{P_{Ka}K_{a}}{P_{K}K} \right)_{t} + \left( \frac{P_{Ka}K_{a}}{P_{K}K} \right)_{t-1} \right)$$

Labour is in natural units, hours, while capital stocks for each type a is built from

nominal capital investment in asset type a and a price index for investment goods, by a perpetual inventory model. For Ka we have:

$$K_{a,t} = \frac{P_{Ia}^* I_a}{P_{Ia}} - \delta^{Ka} K_{a,t-1}$$
(5)

The input side of the model is completed by the user-cost relation between  $P_I$  and  $P_K$ 

$$P_{Ka} = \tau_a P_{Ia} \left( \rho + \delta^{Ka} + (\Delta P_{Ia} / P_{Ia}) \right) \quad (6)$$

And so industry i TFP at time t can be written as:

$$\Delta \ln TFP_{it} = \Delta \ln Q_{it} - \left(\sum_{b=1}^{B} \left(s_Q^{Lb}\right)_{it} \Delta lnH_{bit} + \sum_{a=1}^{A} \left(s_Q^{Ka}\right)_{it} \Delta lnK_{ait}\right)$$
(7)

Where we sum over b=1,..,B labour types and a=1,..A asset types.

We do not observe  $\rho$ , the rate of return, directly, and so use the ex-post method to infer it. We may estimate an industry specific or economy wide  $\rho$ , in which case the sum of the payments to capital in the industry sum to observed industry profits, or the sum of payments to capital in the economy sum to observed economy profits.

That is, for industry level  $\rho$ 

$$P_{Qi}Q_i - \sum_{b=1}^{B} P_{Lb,i}L_{b,i} = \sum_{a=1}^{A} P_{Ka,i}K_{ai} = \sum_{a=1}^{A} \tau_{a,i}P_{Ia,i}(\rho_i + d_a)K_{a,i}$$
(8)

And for economy-wide  $\boldsymbol{\rho}$ 

$$\sum_{i=1}^{I} P_{Qi} Q_i - \sum_{i=1}^{I} \sum_{b=1}^{B} P_{Lb,i} L_{b,i} = \sum_{i=1}^{I} \sum_{a=1}^{A} P_{Ka} K_{ai} = \sum_{i=1}^{I} \sum_{a=1}^{A} \tau_{a,i} P_{Ia,i} (\rho + d_a) K_{a,i}$$
(9)

Where  $d = d = \rho \Delta P / P$ .

### Capital reallocation and finance

To see how the financial system affects productivity, we write down the industry-by-

industry accounts for, three sectors, D, E and F (finance itself say). We write the contributions of capital services to productivity in each sector as:

$$s_{D}^{K} \Delta \ln K_{D} = \sum_{a=1}^{A} \left( \frac{\tau_{a,D} P_{Ia,D} (\rho_{D} + d_{a}) K_{a,D}}{P_{Q,D} Q_{D}} \right) \Delta ln K_{aD}$$

$$s_{E}^{K} \Delta \ln K_{E} = \sum_{a=1}^{A} \left( \frac{\tau_{a,E} P_{Ia,E} (\rho_{E} + d_{a}) K_{a,E}}{P_{Q,E} Q_{E}} \right) \Delta ln K_{aE}$$
(10)
$$s_{F}^{K} \Delta \ln K_{F} = \sum_{a=1}^{A} \left( \frac{\tau_{a,F} P_{Ia,F} (\rho_{F} + d_{a}) K_{a,F}}{P_{Q,F} Q_{F}} \right) \Delta ln K_{aF}$$

The JS method is to compare equation (10) with a model in which the industry level  $\rho_i$  is equal to the economy-wide  $\rho$ , that is  $\rho_i = \rho$ . Let us write this as

$$s_{D}^{K}\Delta\ln K_{D} = \sum_{a=1}^{A} \left( \frac{\tau_{a,D}P_{Ia,D}(\rho + d_{a})K_{a,D}}{P_{Q,D}Q_{D}} \right) \Delta lnK_{aD}$$

$$s_{E}^{K}\Delta\ln K_{E} = \sum_{a=1}^{A} \left( \frac{\tau_{a,E}P_{Ia,E}(\rho + d_{a})K_{a,E}}{P_{Q,E}Q_{E}} \right) \Delta lnK_{aE}$$
(11)
$$s_{F}^{K}\Delta\ln K_{F} = \sum_{a=1}^{A} \left( \frac{\tau_{a,F}P_{Ia,F}(\rho + d_{a})K_{a,F}}{P_{Q,F}Q_{F}} \right) \Delta lnK_{aF}$$

Suppose that sector D has a high rate of return and sector E a low one so that  $\rho_D > \rho > \rho_E$ . Then assume that the financial system is working "well" in the sense that capital is flowing to the high return sector. Thus  $\Delta lnK_D > \Delta lnK_E$  and so measured capital services are high in D and low in E.

Compare this with the case under a uniform  $\rho$ . Sector D, under a uniform  $\rho$ , values its capital services too low and sector E values them too high. Thus the true contribution of capital in D will be higher relative to the uniform  $\rho$  assumption and that of E will be lower. Hence a "well functioning" system should be measured by the contributions of capital under industry-specific  $\rho$  being higher than the contributions under economy-wide  $\rho$ . Thus we expect the following sum to be positive:

$$REALL_{K} \equiv \sum_{i=1}^{I} (s_{i}^{K} \Delta \ln K)^{\rho = \rho_{i}} - \sum_{i=1}^{I} (s_{i}^{K} \Delta \ln K)^{\rho = \rho}$$
  
$$= \sum_{i=1}^{I} \sum_{a=1}^{A} \left( \frac{\tau_{a,i} P_{la,i}(\rho_{i} + d_{a}) K_{a,i}}{P_{Q,i} Q_{i}} \right) \Delta ln K_{ai} - \sum_{i=1}^{I} \sum_{a=1}^{A} \left( \frac{\tau_{a,i} P_{la,i}(\rho + d_{a}) K_{a,i}}{P_{Q,i} Q_{i}} \right) \Delta ln K_{ai}$$
  
$$= \sum_{i=1}^{I} \sum_{a=1}^{A} \left( \frac{\tau_{a,i} P_{la,i} K_{a,i}}{P_{Q,i} Q_{i}} \right) \Delta ln K_{ai} (\rho_{i} - \rho)$$

(12)

By contrast, suppose the financial sector is working "badly". Then there is a negative covariance between  $\rho_i$  and  $\Delta ln K_i$ . This causes measured, industry specific, contributions to be low relative to when  $\rho$  is measured economy-wide. Thus REALL<sub>K</sub><0.

### Results

Figures 6 and 7 provide an overview of measured capital reallocation by country over time and show the differential impact of the capitalization of intangible assets on the reallocation term. More specifically, Figure 6 refers to capital reallocation when only national accounts intangibles are capitalized while Figure 7 shows the reallocation term when all intangible assets are capitalized. The dynamics of capital reallocation looks a bit slower when all intangibles are capitalized.

As for the impact of the financial crisis, both charts suggest that  $REALL_K$  becomes negative in all countries in the immediate Great Recession years. It continues negative in, for example, Spain but recovers in, for example, the US. So  $REALL_K$  varies substantially across countries showing a certain degree of heterogeneity especially after the crisis.



Figure 6 – Capital reallocation (only national accounts intangibles are capitalized)





### Empirical investigation of factors influencing capital reallocation

We investigate possible drivers of capital reallocation estimating the following specification:

$$REALL_{K} = \alpha_{1} \Delta lnr_{c,t} + \alpha_{2} Crisis + \alpha_{3} Exp_{c,t}^{j} + \alpha_{4} Z_{c,t}^{i} + \gamma_{c} + \varepsilon_{c,t}$$
(13)

where r is the long term interest rate, Crisis is a dummy variable for 2008,  $\text{Exp}^{j}$  are indicators of economic sentiment, with j=ESI, Factors influencing investments (demand (Dem) and financial (Fin), Z<sup>i</sup> are other controls for government support to investment and  $\gamma_{c}$  are country dummies. The results are shown in Table 3.

Table 3. Factor	s affecting	the reallocation	of capital
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	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	1997-2013	1997-2007	1997-2013	1997-2007	7-2007 1997-2007			1997-2013		
VARIABLES	Includin	g the US	Excluding the US							
Interest rate	-0.0016***	0.0003	-0.0019***	-0.0036	-0.0018***	-0.0013**	-0.0008*	-0.0032***	-0.0025***	-0.0010
	(0.0005)	(0.0016)	(0.0005)	(0.0024)	(0.0005)	(0.0006)	(0.0005)	(0.0007)	(0.0007)	(0.0009)
ESI	0.0026***	0.0025	0.0032***	0.0034*	0.0032***	0.0036***	0.0037***	0.0063***	0.0075***	0.0052***
	(0.0009)	(0.0016)	(0.0009)	(0.0018)	(0.0009)	(0.0009)	(0.0009)	(0.0013)	(0.0012)	(0.0015)
GOS_GDP	-0.0058**	-0.0072**	-0.0078***	-0.0102***	-0.0069**	-0.0110***	-0.0127***	-0.0080*	-0.0158***	-0.0166***
	(0.0023)	(0.0030)	(0.0026)	(0.0035)	(0.0027)	(0.0024)	(0.0025)	(0.0042)	(0.0038)	(0.0039)
Crisis	-0.0007***		-0.0006***		-0.0006***	-0.0005***	-0.0005***			
	(0.0001)		(0.0002)		(0.0002)	(0.0002)	(0.0002)			
I grants_GDP					0.0003*	0.0003	0.0002	0.0008***	0.0004*	0.0002
					(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0004)
Demand conditions						0.0002*			0.0007***	
						(0.0001)			(0.0002)	
<b>Financial conditions</b>							0.0001*			0.0002*
							(0.0001)			(0.0001)
Observations	187	121	170	110	169	129	116	109	79	70
Standard errors in parentheses										
*** p<0.01, ** p<0.05, * p<0.1										

The results suggest that:

- High interest rate differentials are significantly and negatively correlated with capital reallocation;
- the 2008 shock (crisis) had a negative impact on REALL<sub>K</sub> as expected (cols 1,3,5,6,7)
- economic sentiment is significantly and positively related with capital reallocation; when expectations about future economic developments are favorable, capital reallocation increases, (robust across all the specifications).
- Low profit shares are related with high REALL<sub>K</sub> (gos\_gdp)

- Higher GDP share of investment grants stimulates  $\text{REALL}_K$  (col 8) especially over the crisis.
- Financial and demand conditions positively influence capital reallocation

### 5. Conclusions

The creation of a country-industry-sector database for productivity analysis allows for the first time to account for the role of tangible and intangible capital in the total economy (private and public). The data show that Intangible and tangible investment show different sensitivity to the business cycle and across countries: by 2011, intangible growth paths in both EU and US had returned to pre-crisis levels while tangible growth rates recovered more slowly in the US. In the EU, tangible gross fixed capital formation remained below pre-crisis levels by 2013. In most advanced economies intangible capital provides a large contribution both in the market and nonmarket sectors. It was a key variable for the recovery. The reallocation terms indicate differing effects of financial crisis across countries: positive reallocation suggests the presence of industries where capital grew relatively faster than the aggregate economy.

#### References

Bacchini, Fabio et al., (2016), "Estimates of Intangible Investment in the Public Sector: EU, US, CHINA AND BRAZIL", Spintan working paper series No. 11.

Corrado, Carol; Jonathan Haskel, Cecilia Jona-Lasinio and Massimiliano Iommi, (2014), " Intangibles and Industry Productivity Growth: Evidence from the EU " Working Paper, available at http://www.intan-invest.net.

Caves, D. W. Christensen, L.R. and Diewert, W.E. (1982), 'Multilateral Comparisons of Output, Input and Productivity using Superlative Index Numbers', *Journal of Econometrics*, 92, 73-86

Corrado, C., Hulten, C., and Sichel, D., (2009), 'Intangible Capital and US Economic Growth', *Review of Income and Wealth*, **55**(3), 661–685.

Corrado, C., Haskel, J., Jona-Lasinio, C. and Iommi, M. (2012), 'Intangible Capital

and Growth in Advanced Economies: Measurement Methods and Comparative Results'. Working Paper, June, available at http://www.intan-invest.net.

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

Jorgenson D.W, and Schreyer, P. (2013), 'Industry-level Productivity Measurement and the 2008 System of National Accounts', *Review of Income and Wealth*, 59(2), 185-211

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

O'Mahony, M. and Timmer, M. P. (2009), 'Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database', *Economic Journal* **119**(538), F374–F403.

van Ark, B., J. Hao, C. Corrado, and C. Hulten (2009). 'Measuring intangible capital and its contribution to economic growth in Europe'. *European Investment Bank Papers* 14(1), 62–93.

### Appendix: Estimation of Intangible Investments

The implementation of our estimation strategy leads to the adoption of two different approaches for intangible assets not currently included in the SNA2008/ESA2010 asset boundary (Design, Brand, Training, Organisational Capital and New financial products) and for the assets already included (Computer software and databases, Research and development, Mineral Explorations and evaluations and Entertainment, literary and artistic originals).

National Accounts Intangible Assets (NAIA) are based on official national accounts estimates of gross fixed capital formation by industry. National accounts data on GFCF in Intellectual property products ("IPP") by 21 industries and total GFCF (with no industry disaggregation) in Computer software and databases ("Soft") and in Research and development ("R&D") are available for all countries included in this paper. Moreover, for almost all countries also data on Soft and R&D by 21 industries are available. For these countries, we estimate overall GFCF in Mineral Explorations and Originals ("MinArt") by 21 industries as a residual. Instead, for countries where only total IPP by industry is available, we have adopted the following approach. First, we have produced preliminary estimates of the industry distribution of GFCF in Soft, R&D, and MinArt using the available indicators. Then we have rescaled preliminary estimates to make them consistent with total GFCF in IPP by industry and with aggregate GFCF in Soft, R&D and MinArt (using an iterative bi-proportional fitting procedure). The preliminary estimates have been derived from ESA95 national accounts data on GFCF by industry or from capital stocks estimates<sup>4</sup>, depending on data availability.

<sup>&</sup>lt;sup>4</sup> The country coverage of capital stocks data on Soft and R&D by industry is larger than the country coverage of GFCF data. Then, there are several countries for which capital stocks data by industry are available and GFCF is not. In this case, we have used capital stocks data as follows. Starting from capital stock estimates (chained values) for year t and t-1 (Kt and Kt-1) and making an assumption on the value of the depreciation rate (delta) we have computed the implied value of chained investment for year t (It), as

lt=Kt – Kt-1 + Kt-1\*delta.

If net capital stocks were estimated with the geometric model and if we knew the actual depreciation rate used to compute capital stocks the above calculation would provide the correct value for It. In the EU, national statistical institutes usually do not use the geometric method (with the exception of R&D), then the result of the calculation above can provide only an approximation of the real value of It. We use these approximated estimates as a preliminary estimate of investment by industry (i.e., as seeds for the iterative bi-proportional fitting). On the other hand, it is likely that the bias is quite similar across industries and therefore it should decrease when the initial estimates are re-scaled to make them consistent with total GFCF in IPP by industry and with aggregate GFCF in Soft, R&D and MinArt.

Once we have obtained total investment in the three asset types by industry, we have obtained the split between the market and the non-market component for each asset in each industry simply deducting from total GFCF by industry the estimates for the non-market component available from the SPINTAN project.

The estimates of the purchased component of Brand, Design and Organisational Capital in INTAN-Invest 2016 are based on completely different sources and methods with respect to the previous release of INTAN-Invest. Old estimates for the business sector were obtained from data on turnover of the corresponding industries and, as for Brand, also on private data sources (Zenith Optimedia and ESOMAR). Industry level estimates were obtained following a top-down approach<sup>5</sup>. New estimates, instead, are obtained directly at the industry level using expenditure data by industry provided by the Use Tables, expressed according to the NACE Rev2/CPA 2008 classifications. Use Tables consistent with ESA2010 national accounts are available for all countries included in this paper for 2010 and 2011 and for almost all countries for the year 2012, while Use Tables consistent with ESA95 national accounts are available from 2008 until 2010.

The Use Tables compiled according to NACE Rev.2/CPA 2008 report intermediate costs of each industry for the following products: Advertising and Market Research Services (CPA M73), Architectural and engineering services, technical testing and analysis services (CPA M71) and Legal and accounting services, services of head offices and management consulting services (CPA M69 and M70). We take the data on total intermediate costs for these products as a proxy for total expenditure, respectively, in Brand, Design and Organisational capital.

The general approach is quite similar for all three assets. The first step is to make the initial data a better proxy of expenditure in the corresponding asset. We deem that in the case of Advertising and Market Research Services (CPA M73) and Architectural and engineering services, technical testing and analysis services (CPA M71) the products identified in the USE Table are good proxies of the corresponding assets and no further adjustments are needed. In contrast, this is not the case for Legal and

<sup>&</sup>lt;sup>5</sup> Old INTAN-Invest estimates by industry were obtained as follows. We first produced a detailed benchmark estimate of intangible investment in 2008 based on the USE table and then we built time series for the period 1995 to 2007 applying the rate of change of gross output (National Accounts) by industry to the level of the estimated intangible gross fixed capital formation in 2008. Finally, since our benchmark was the INTAN-invest market sector estimate of

intangibles, we rescaled the estimated value for each industry, in each country, for every year, to the total provided by INTAN-invest (see Corrado et al (2014) for more details).

accounting services, services of head offices and management consulting services (CPA M69 and M70). In this case, we computed the share of turnover of NACE M701 in turnover of NACE M69 plus M70 for each country and we apply the share to intermediate consumption in CPA M69 and M70. The above correction is based on the assumption that, in each country the share of CPA M701 (consulting services) in total intermediate consumption for CPA M69 and M70 is the same across all industries.

Once expenditure for each asset is identified, the second step is to split total expenditure in each industry between the component due to the market sector and the component due to the non-market sector. This adjustment is applied only to the SPINTAN mixed industries (M72, P, Q and R90-92), while for all other industries we deem that the expenditure is entirely made up either by the non-market sector (industry O) or by the market sector (all remaining industries). The split is based on the share of non-market output over total market and non-market output in each industry.

Finally, in each industry the capitalization factor is applied to total expenditure by market producers to obtain the value of total expenditure that we deem should be treated as GFCF instead than intermediate consumption. Capitalisation factors are asset specific but not industry specific with the only exception of a special treatment for subcontracting. In fact, it is likely that part of Advertising and Market Research Services (CPA M73) bought by the Advertising and Market Research industry, that part of Design services (CPA M71) bought by the Architectural and engineering industry and that part of Legal, accounting and consulting services (CPA M69 and M70) bought by the Legal, accounting and consulting industry are due to subcontracting activity. For this reason, we assume that the capitalisation factors for CPA M73 in the Advertising and Market Research, for CPA M71 in the Architectural and engineering industry and for CPA M69 and M70 in the Legal, accounting and consulting industry are 50% lower than in the other industries.

The approach outlined above is used to obtain estimates from 2010 until 2012 (the years in which USE Tables consistent with ESA2010 national accounts are available). The same approach has been applied to the USE Tables consistent with ESA95 available from 2008 and 2010 and the resulting estimates have been used as indicators to back-cast the level of the estimated intangible gross fixed capital formation in 2010 until 2008. The back-casting procedure has been implemented at the industry level. For the years before 2008, we produced intangible investment time series using the

rate of change of the previous release of INTAN-Invest estimates of GFCF by industry as an indicator to back-cast the level of the estimated gross fixed capital formation from 1995 to 2008.

The estimates based on data available from the USE Tables guarantee the exhaustiveness of purchased GFCF in Brand (based on product CPA M73) and Organisational capital (based on product CPA M6970), but not that of Design (based on product CPA M71). In fact, in the CPA classification, part of design activity is also classified in the CPA M741 "Specialised design activities". The USE Tables currently available from Eurostat do not allow identifying expenditure in CPA M741 because they only report data for the CPA M74\_75 ("Other professional, scientific and technical services and veterinary services"). Instead, Structural Business Statistics report data on turnover of NACE M741. Then we have taken the turnover of NACE M741 as a proxy of total expenditure in CPA M741, we have assumed that only the market sector purchases "Specialised design activities" and, finally, we have obtained GFCF estimate applying the same capitalisation factor than CPA M71.

As for the own account component, its estimate requires detailed employment data by type of occupation and by industry (e.g., from the Structure of Earning survey or the Labour Force survey) or a special survey. Eurostat available occupational data allow identifying only those occupations related with organizational capital. This is why, at this stage, we measure only the own account component of Organizational capital, while for Design and Brand we only estimate the purchased component.

In order to estimate organisational capital produced on own account we need to estimate total compensation of managers and then apply a capitalisation factor. The estimate of total compensation of managers requires data on the number of managers and their average compensation. The main data sources for these variables is the Structure of Earnings Survey that is currently available for 2002, 2006 and 2010. From SES we are able to compute industry specific shares of gross earnings of managers in total earnings of all employees for the years 2006 and 2010 and the share for business sector in 2002. We have produced a time series of industry specific shares of gross earnings of managers from 1995 till 2013 as follows. For the years 2007-2009 we have (linearly) interpolated values from SES available for 2006 and 2010 onwards applying the dynamic of the share of the number of managers in total employees from Labour Force Surveys. For the year before 2006 no data at the industry level are available, then we back-casted 2006 shares using the same indicator for all industries

(namely, the change in the share of gross earnings of managers for total business sector between 2002 and 2006 from SESs and the change in the share of the number of managers in total employees from Labour Force Surveys for the previous years). Having produced a time series of the shares of gross earnings of managers at the industry level is a big improvement with respect to the previous INTAN-Invest release, that considered only the business sector with no industry detail and was based on the share obtained from SES 2002 updated using the change in the share of the number of managers in total employees from Labour Force Surveys.

We have then estimated total expenditure for management compensation consistent with national accounts data by applying the share of gross earnings of managers to national accounts measures of total compensation of employees in each industry. Finally, we have estimated the value of own-account investment in organisational capital by applying the capitalisation factor to the total managers' compensation.

As for Firm specific Human Capital, our estimates for the market sector are based on data from the Continuing Vocational Training Survey (CVTS) and Labour Cost Survey, that allow to produce industry level estimates of expenditure in training that include both the purchased and the own account component. For this asset the main improvement with respect to the old estimates is due to the availability of the CVTS for 2010 (while old estimates only used the 1999 and the 2005 survey). For training, we assume that all expenditures increase the value of the stock of FSHC and therefore should be considered as GFCF (i.e. we assume a capitalisation factor equal to one). The estimates of the non-market component are those available from the SPINTAN project.