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Production of intangible investment and growth: Methodology in INNODRIVE

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ABSTRACT

We develop a methodology for evaluating companies' investment in intangible assets using linked employer-employee data. Firms produce goods of the types: (i) information and communications technology (ICT), (ii) research and development (R&D), and (iii) organizational capital (OC). If the use of these goods is not in the current year they can be classified as intangible capital formation, which is typically ignored in conventional calculations of capital stocks and depreciation. In order to produce intangible capital goods, firms apply resources supplied by different factors of production: labor, intermediate, and capital services. We compare an expenditures-based approach to measuring firms' intangible investments, where investment is proportional to the salary costs of workers in particular occupations, to a performance-based approach, where investment is proportional to the productivity of these workers. The former approach is similar to the method commonly adopted in constructing national measures of intangible capital formation.

JEL classification: M40, J30, O30, M12, J62

KEYWORDS: Intangible capital, R&D, market valuation, management, linked employer-employee data

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1. INTRODUCTION

An increasing number of researchers suggest that many analytical problems in growth analysis arise due to the fact that certain expenditures made in the expectation of future returns are not properly classified as investment. Recent research focuses on the possible impact of intangible investment. Neglecting intangible assets affects not only the capital accounts but also a number of other elements in the bookkeeping system of a company or an economy. According to the standard accounting rules for the European economies given by ESA95, value added is calculated as the sum of

- Sales less intermediate consumption,
- Inventory changes, and
- Own account production of assets.

Purchased intangibles that are incorrectly classified as intermediate consumption underestimate the first item. If expenditures for labor, intermediates, and capital usage combine to create intangible capital goods, then we have own account production. If this is neglected, the last item is underestimated. In both cases value added is underestimated. Depending on the depreciation of intangible capital, operating surplus may also be underestimated.

These accountancy based changes are independent of any possible causal influence of intangible capital on productivity and growth. Of the two types of expenditures discussed, the focus of this paper is on the own account production of intangibles including the costs of labor, intermediates, and capital needed to produce these assets. In the piloting study of Corrado, Hulten and Sichel (2005), hereafter CHS, different approaches to estimating own account production are applied. They range from applying multiples or fractions of certain purchased goods, assuming complementarity between the purchase and own account production of intangibles, to using shares of working time or wages and salaries of certain employees. At the macro level, CHS were able to underpin their estimates of the purchased part[1] of intangible investment with a number of additional empirical surveys. For the own account part they had to make broad assumptions, since it was not possible for them to refer to firm-level information. This study helps to substantiate the own account part of intangible investment based on firm-level data. However, while own account production of intangibles is the focus of this paper, we believe that on average these are positively associated with and, as we argue below, may in some instances proxy for purchased intangibles.

While standard balance sheet data tend to ignore most types of intangibles, information on these types of expenditures is collected in some business surveys. However, business surveys do not tend to cover the broad range of intangibles considered in recent research and do not necessarily include information on other variables used in growth analysis. This paper sets out a framework for assessing the possible magnitude of firms' production of intangible assets, using information on the occupational distribution of the labor input combined with the cost structure of an assumed production function for intangibles. We use linked employer–employee data, which have been extensively utilized in the study of human capital formation beginning with Abowd, Kramarz, and Margolis (1999). These data are convenient for use in an analysis relying on the valuation of different tasks and occupations. Production of intangible capital goods is capitalized, applying the standard methodology developed in EU KLEMS. The firm-level data developed in INNODRIVE provides another perspective on the importance of intangible capital formation, otherwise evaluated at the national level.

[1] It has to be acknowledged, that also in the case of purchased intangibles the margins of uncertainty in the estimates are very wide. In particular, it is very difficult to separate purchased intangible capital services from purchased intangible investment provided for instance by producers of consulting products. While the first item has to be treated similar to leasing activities as in the case of tangibles, only the second item can be treated as an investment rather than intermediate consumption and thus capitalized by the purchasing firm.

2. OWN ACCOUNT PRODUCTION

Following CHS, we classify intangible capital into three broad categories: computerized information, innovative property, and economic competencies. Specifically, we assume that in addition to any traded goods and services each firm produces goods of the types

- Information and communications technology (ICT),
- Research and development (R&D), and
- Organizational capital (OC).

The production of these types of goods is exclusively directed towards own uses by the firm. If the uses are not in the current year, these types of goods can be classified as intangible capital formation, which is not counted as investment in conventional calculations of capital stocks and depreciation, as for instance in the National Accounts. In order to produce these types of capital goods, firms apply resources supplied by different factors of production: labor, intermediate, and capital services. To assess labor services that go towards the production of intangibles, we distinguish three types of labor input: ICT-, R&D-, and OC-related personnel (ISCO88 classification shown in appendix table A1).

- *ICT* personnel includes information and communication technology experts.
- *R&D* personnel includes technicians, engineers, and similar occupations.
- *OC* personnel includes management and marketing employees

We assume that only a fraction of workers in these occupations are engaged in the production of intangible capital goods; with the remainder of these workers engaged in current production (i.e. production of goods and services with a service life less than a year).

Substantial parts of intangible ICT investment are software and databases on which there is typically only limited information at the firm level. Lequiller and Blades (2006) argue that ICT intensive firms like Microsoft record all ICT investment as intermediate expenditures for two reasons. First, this is in line with the precautionary accounting approach applied by private firms, since only a limited share of ICT investment turns out to be productive, and firms are obliged by law not to overvalue their capital stocks. Second, in this way the expenditures can be immediately deducted from taxable profits. Intangible ICT capital is also concentrated in specific industries: financial intermediation, transport, storage and communication. We assume that half of the expenditures on ICT personnel are dedicated to the maintenance of ICT operation and half to the production of own account intangible capital goods.

We apply a very broad definition of R&D personnel including all employees that have a technical education. Accordingly, we assume only 70% of R&D personnel as defined above are engaged in creating R&D capital goods for future uses by the firm. Organizational workers include management and marketing personnel. As in the National Accounts, we include only activities which result in an outcome with an expected service life well above one year. CHS refer to expenditure on organizational structure as managers' time spent on developing business models and corporate cultures. Their central estimates are based on the assumption that 20% of management time is spent on organizational innovation. Acknowledging the uncertainty surrounding this assumption, they provide figures where this parameter ranges from 10% to 30%. Based on their central estimate, CHS (2005) suggest that over the period 1998-2000, businesses in the US devoted more than $200 billion per year to improving the effectiveness of their organizations on their own account. The purchased component in the CHS approach is represented by management consultant fees, and these are equivalent to 40% of own account investment in organizational structures. CHS assume that spending on brand development is represented by expenditures on advertising and market research. This encompasses the costs of launching new products, developing customer lists, and maintaining brand equity. Investment in brand equity is assumed to equal 40% of advertizing expenditures. Together with expenditures on market research, US investment in brand equity amounted to $235 billion per year in 1998–2000. This is not very different from investment in organizational structures, but unlike these is mostly accounted for by the purchased component.

In the six European countries in INNODRIVE the marketing and management worker shares (for the non-farm business sector) are as illustrated in figures 1 and 2. Overall the share of management and marketing workers from all employees hoovers around 6% in Slovenia to 12% in UK and Germany. We find that the share of workers in marketing occupations is typically half the share of workers employed in management occupations (with the exception of Finland). This suggests that the own account component of investment in brand equity may be substantially higher than assumed in CHS. Similar to CHS we assume 20% of management work goes towards the production of intangible capital.[2] We also assume that 20% of marketing work goes towards the production of intangible capital.

[2] In the case of Finland the assumption that 20% of wage costs are allocated to investment leads to the lower bound of figures obtained by Hulten and Hao (2008) when evaluating against selling, general and administration expenditures.

Figure 1. Management worker share in INNODRIVE

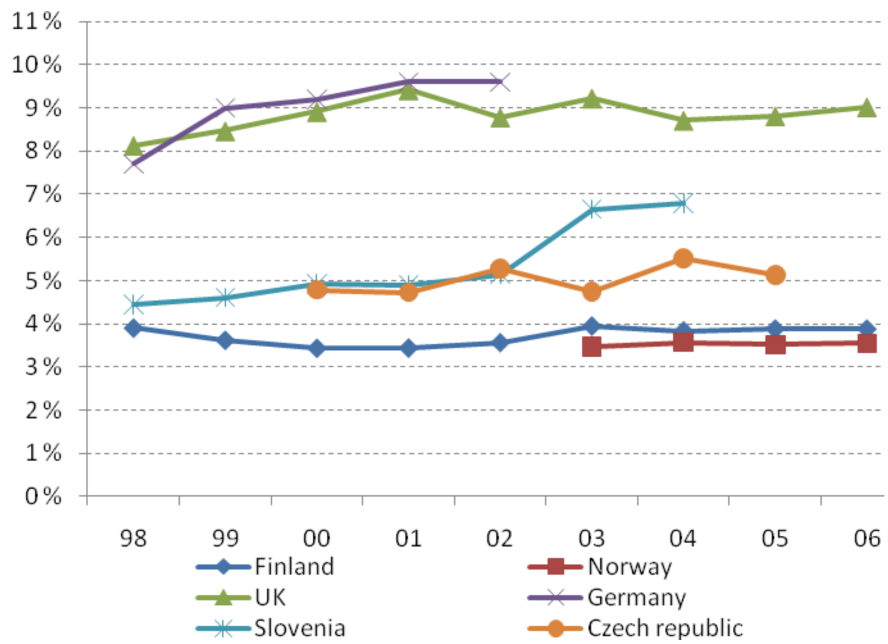
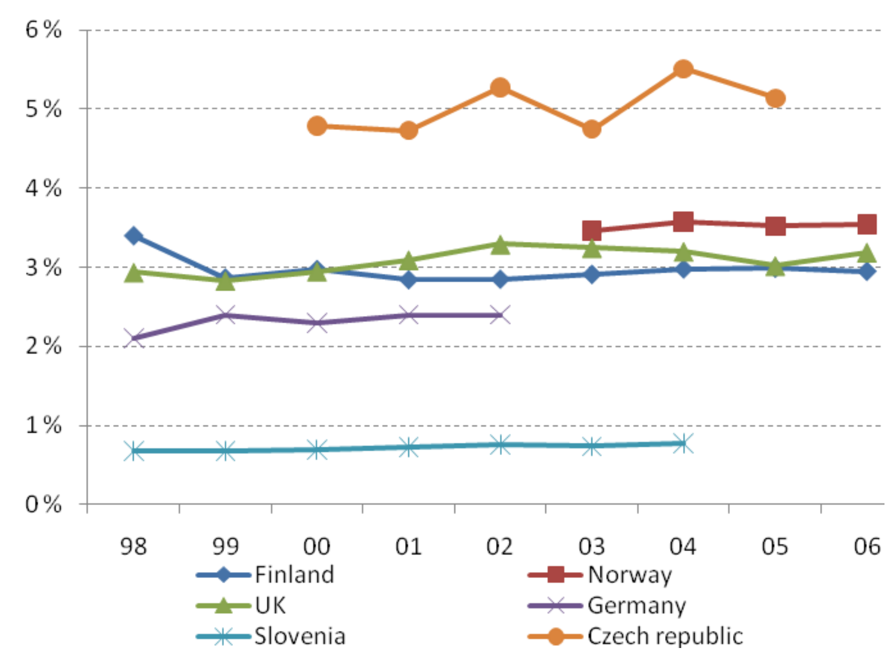


Figure 2. Marketing worker share in INNODRIVE



A priori, it is an open question, how purchased intangibles goods relate to own account production of intangibles. Given commonly applied theories on the division of labor and on specialization, one might assume that outsourced production (purchased goods) are suitable substitutes for in-house (own account) production such that cost driven outsourcing might also be applied to intangibles. In this case, one would expect a negative relationship between own account and purchased intangible investment. However, studies on industry-level tangible investment, for instance for Germany (DIW 1988), do not find a negative relationship between own account and purchased tangible investment. The degree of own account production of versus purchased tangibles appears to be specific to the type of industry and hence the product that is finally produced with the help of the investment.

Analysis of UK businesses included in the Annual Business Inquiry provides some evidence that firms' purchases of intangible goods are complementary to firms' own-account production. For instance, measured relative to sales, a firm's purchase of advertising services is positively correlated with its expenditures on employees engaged in marketing[3]. Similarly, a firm's purchase of telecommunications and computer services are positively correlated with their expenditures on IT workers. While there are differences across industries, these relationships (illustrated in appendix table A2) hold across firms within all industries considered, and are statistically highly significant. Theses findings suggest that the firm-level data we construct provide reasonable indicators of the variation in total (purchased and own account production) intangible investment across firms.

A possible explanation for these results is that own account production can be better customized to the needs of the firm, such that the competitive advantage for the firm increases. In addition, external competitors are prevented from acquiring firm specific information. Thus, own account production induces an increase in competitiveness by

[3] The occupational distribution of firms is derived from the Annual Survey of Hours and Earnings and is linked to firms in the Annual Business Inquiry by detailed industry sector and firm size.

strengthening the monopolistic power of a firm. In the case of tangibles this strategy is limited to firms, which are also able to produce tangible assets, mainly in the manufacturing sector. Looking at intangible investment, which mostly concerns the production of services, we can expect a much broader application of this strategy across all types of industries.

INNODRIVE assumptions discussed in this section are listed in Table 1.

Table 1. INNODRIVE share of labor cost dedicated to the production of intangible goods

	ICT	R&D	OC
Share of labor input with expected life over 1 year (h_{IC}, where IC=ICT, R&D, OC)	0.50	0.70	0.20

3. THE USE OF CAPITAL AND DEPRECIATION

Economically, the depreciation rate measures the loss of value of an asset. In the theoretical model, the loss of value is the reduction of future returns. Many factors can influence future returns, but most commonly time is assumed the most important factor. The reduction of the remaining service life of an asset reduces the expectations of future returns. However, service life is defined by economic criteria. An asset ceases to exist as an economic good if the returns it generates fall below the costs of operating the asset.

Given this background, it is not surprising that the UNECE survey (UNECE, 2004) shows that in measuring depreciation very different methodologies are applied across countries. Tangible fixed capital estimates usually rely on national estimates. For countries in the EU area, based on National Accounts, Görzig (2007) reports that the implicit depreciation rates of conventional capital stock estimates in the National Accounts of EU countries vary considerably, depending on the methodology applied, including the basic assumptions on service lives, and the economic structure of a country (Table 2).

In these calculations Germany has an average depreciation rate of 4.6% per annum. At 5.6% per annum, the average depreciation rate for Finland is more than 20% higher. The UK ends up with an average depreciation rate of 6.1% per annum. Contrary to the case of tangibles, the convention adopted in constructing national level estimates of intangible capital is to assume common investment shares of expenditures and depreciation rates across countries. For example, in CHS, 20% of management expenditures are considered as investment in economic competence. Databases and software are assumed to depreciate at a rate of 33% in all countries in this project.

Surveys are common sources of information on the expected service life of intangibles other than R&D. In the case of physical capital, e.g. cars, the expectation is that firms' survey responses yield shorter service lives than the scrapping statistics. Tax service lives (UNECE, 2004) and additional surveys on how these relate to economic service lives are another source of information on depreciation rates. Generally speaking, economic service lives turn out to be higher than tax service lives.

Table 2: Evaluation of Implicit Depreciation Rates for Published Depreciation Values in the National Accounts

Country	Average service life	Average depreciation rate
	years	%
Luxembourg	18	9.3
Portugal	20	8.7
Denmark	20	8.4
Belgium	24	6.9
UK	27	6.1
Ireland	29	5.1
Netherlands	29	5.6
Finland	30	5.6
Spain	33	4.8
France	33	4.8
Germany	35	4.6
Sweden	36	4.4
Italy	38	4.2
Austria	38	4.3
Greece	59	2.1
Source: DIW Calculations. -		

CHS (2005) apply the following depreciation rates

- Firms Specific Resources (Firm specific human capital and OC): 40%
- Brand Equity (Advertising and Marked Research): 60%

As part of the COINVEST[4] project, Awano et al. (2010) have surveyed firms about life length by asset category, obtaining a figure of 2.7 years in training, reputation and branding equivalent to a geometric depreciation[5] rate of 37%.

[4] COINVEST - Competitiveness, Innovation and Intangible Investments in Europe European. Commission Framework 7 project funded under the Socioeconomic Sciences and Humanities them. ..http://www.coinvest.org.uk/bin/view/CoInvest.

[5] We apply simple geometric depreciation and do not refer to the BEA declining balance model, where a 5 years service live assumption could result in a .33 depreciation rate, if the balance rate is set to 1.65.

In Germany, the value of a purchased company can be depreciated linearly over five years if it exceeds its book value. Similar tax regulations exist in several other countries (OECD 2006). The average capital stock that results from this depreciation schedule would also be generated by a geometric depreciation rate of about 25% over the same period of time. Company value can be seen as a catch all variable for all assets not accounted for in the capital accounts of a firm. Given the standard model assumptions of a perfect economic world and if full coverage can be assumed, the average depreciation rate of the company value should be the same as the weighted averages of the individual depreciation rates of all types of intangible and other capital goods. For R&D and ICT investment we follow CHS in assuming depreciation rates of 20% and 33% respectively (see Table 3). Given an average depreciation rate for company value of around 25%, economic depreciation of OC is expected to be 25% at least.

Table 3: INNODRIVE depreciation rates

	ICT	R&D	OC
Depreciation rate	0.33	0.20	0.25

4. INTANGIBLE CAPITAL: CENTRAL SETTING AND EXPENDITURE-BASED APPROACH

While CHS (2005, 2006) also consider purchased intangible assets that are traditionally classified as intermediate consumption, we concentrate on the assessment of own account production of intangibles. The core idea is that there exists a production function, which describes the combination of labor, intermediate, and capital necessary to produce intangible assets. Intermediate and capital inputs in this production function are different from purchased intangibles (wrongly classified or not), since they consist of conventional inputs needed to produce service products like energy or office space, either rented or invested. But intermediate inputs may also include elements of purchased intangibles and the capital used might also include intangible capital, for instance R&D capital in the production of R&D investment. The combination of the factors of production creates the intangible asset. To quantify the production function, we refer to those industries, which are engaged in market production of comparable types of goods. The following industries have been chosen:

- Computer and related activities (Nace 72) as a proxy for ICT goods,
- Research and development (Nace 73) as a proxy for R&D goods, and
- Other business activities (Nace 74) as a proxy for OC goods.

The amount of intermediate and capital expenditures needed in combination with one unit of labor expenditures to produce an intangible good are evaluated separately for each industry. These two factors show the magnitude by which labor expenditures have to be multiplied to account for the additional intermediate or capital cost needed to produce intangible capital goods. Together these factors result in a total factor multiplier, which can be applied at the firm level to generate total production costs for the different types of intangible capital goods.

In applying this multiplier, we assume an implicit production function of the CD-type with constant returns to scale in perfect economic surroundings. Apart from the fact that these assumptions certainly do not hold exactly for existing economies, we note that the additional input of intermediates and capital cannot be recovered completely by applying conventional cost shares, since an important input is neglected, namely the existing stock of accumulated intangible capital. It is not available in conventional analysis. However, it has to be assumed for instance that the stock of R&D is an important input in the production of new R&D assets. It is noteworthy that the calculated multiplier may or may not represent a lower bound depending on how well the applied intermediate input shares in NACE 72-74 can also capture the purchase of intangibles from other industries. In the performance-based approach, discussed later in this paper, we use production function estimation applying proxies for intangible capital to capture the 'pure' productivity effect of intangible type work. We also discuss an approach to estimating a combined multiplier that implicitly takes into account this missing intangible capital stock

Our approach to accounting for additional factor input differs from the CHS type approach where gross output of entire industries are classified as intangible good production (purchased intangible goods). For example, in constructing national measures of intangible investment (including the macro approach in INNODRIVE), purchased organizational capital goods (structure) are evaluated using the nominal gross output of industry "7414 – Business and management consultancy activities"[6]. We treat investment in intangibles in a similar manner to investment in tangible goods. The purchases of these goods are recorded across industries. However, in accounting for additional factor input associated with labor costs for these goods, we rely on the cost structure in particular industries. For example, in calculating organizational investment, we consider the use of intermediate consumption (and capital) in *other business activities (Nace 74)* to be representative of purchased goods from other industries, including purchased intangibles. Overall, we concentrate on own account production of intangibles but cannot exclude the possibility that intermediates also include an important part of the purchased component of intangibles.

Data for the assessment of the factor multiplier are taken from the EU KLEMS database for Finland, UK, Germany, Czech Republic, and Slovenia in NACE industries 72, 73, and 74 within NACE category 7. We assume that the relationship in these industries between the production factors labor, intermediates, and capital indicates the cost structure in production of these types of goods in the firms in our analysis.

Compensation for labor services is defined in line with ESA95 definitions for the National Accounts including all labor cost accruing to the firm, including also social security contributions. Similarly, intermediates are defined in line with ESA95 definitions for the National Accounts. However, the composition of intermediate input in NACE 72 to 74 differs considerably from the one used in the own account production of intangible products. Supply and use tables (e. g. Destatis, 2006) make transparent that more than half of the intermediate input in these NACE industries comes from intra-industry supply of the same industry and possibly very often the same firm. To avoid overestimating the impact of intermediate input in the production of intangibles and to capture also better some of the purchased component of intermediates (including

[6] NACE 2002 version.

intangibles) in the production of intangible capital, we only consider those intermediates, which are supplied by other industries. Accordingly, the ratio of intermediate- to labor costs has been set to 35% of the industry specific value for ICT- and R&D-products and to 45% for OC-products. The ratio of intermediate to labor costs varies quite substantially across countries. In particular, in R&D production this ratio is 0.55 in Germany[7] and, at 0.28, only half this in the UK (see Table 4).

The concept of capital user costs (OECD 2001, Jorgensen 1963) has been applied to quantify the expenditures needed to use capital in the production of intangible capital goods. The main components of the capital user costs are depreciation and the return on capital[8]. According to ESA95, in the case of own account production, only the production costs can be used in the valuation of the capital goods. This means that profits are excluded from the calculations of the capital user costs[9]. We apply an external rate of return (representing the market interest rate) of 4%. Multiplied with the net capital stock this yields the interest part of the user costs in NACE industries 72 to 74. Again, we assume that only 40% of capital- relative to labor costs in these NACE industries is used for the own account production of ICT, R&D, and OC products. Unfortunately, the industry breakdown for the capital accounts in EU KLEMS is less detailed than for labor and intermediates. Only one factor for all three types of intangibles can be calculated here. Calculations that are more precise can be made for Germany, referring to the Eukleed (2010) database, which show that capital cost in the production of ICT

[7] The comparative high value in Germany for intermediates in the case of R&D might have to do with the fact that R&D activities in many cases have been transferred to special research companies in the ownership of manufacturing firms. This could imply that in Germany, the part of purchased R&D (from own affiliates) might have a bigger impact compared with own account production. However, it is likely that purchased OC activities from own affiliates are also important in international firms. The lack of persistent figures across the countries may also explain the large differences in intermediate use.

[8] We do not include changes in the prices for investment goods, because of the lack of data there is no firm level variation in this variable.

[9] This is different in the performance based approach discussed later in this paper.

and OC seem to be negligible. One reason for this is that small firms with low capital input have a strong influence on the unweighted average across firms.

There are several reasons why the average structure of the selected business services may not adequately represent actual cost shares for firms' own account production of capital goods. The calculations contain a number of uncertainties:

- The sampling rate in business services is likely to vary from one country to another.
- The ratio of factor to labor costs may change depending on the business cycle.
- The results for the selected industries depend heavily on the different degree of outsourcing across countries. Capital services, for instance office space, might be bought (rented) or supplied by own investment.
- The cost structure may vary depending on whether the produced goods in the chosen industries are capital goods or other types of goods.
- Industry cost ratios are weighted averages across all firms of the industry in question.

To emphasise the fact that the total factor multiplier we calculate is a very rough indicator of the cost structure underlying a firm's production of intangible capital goods, we apply a common set of factor multipliers for each intangible type (ICT, R&D, and OC) for all countries. Multiplied with the share of labor costs considered as investment in intangibles and the wage expenditures of a firm, these factors yield an assessment of firms' own account investment in intangible capital. The common factor multiplier is calculated as a weighted average of country specific outcomes (Table 4).[10]

[10] Data for the assessment of the intermediate input and capital cost share are taken as a weighted average using the EU KLEMS database for Germany (40% weight), UK (30% weight), Finland (15% weight), Czech Republic and Slovenia (7.5% weights) in the NACE industries 74, 73, and 72 within NACE category 7 shown in Table 4.

Weights are chosen so that the sample countries (60% of EU27 GDP in 2000) roughly represent the whole EU area. Germany accounts for 22.5% and the UK for 17.5% of EU27 GDP in 2000, which after aggregation (multiplying by 1/0.6) gives respective weights 40% and 30%. Finland is representative of the Nordic countries and Austria that account for 10% of EU27 GDP resulting in a weight of 15%. The remaining weight of 15% is divided between Slovenia and the Czech Republic. Thus these two countries are assumed to represent both new EU member countries (Slovenia, Czech Republic, Poland, Estonia, Lithuania, Latvia, Croatia, Hungary, Macedonia, Malta, Romania), which account for 4% of EU27 GDP, and to some extent Southern and Central Europe.

Table 4: Factor multiplier for calculating total production costs of intangible assets - EU KLEMS averages (1999 - 2003)

Type of intangible	ICT	R&D	OC
industry proxy	Nace 72	Nace 73	Nace 74
Related intermediate costs[1] - Labor costs = 1			
Germany	0.25	0.55	0.51
UK	0.36	0.28	0.53
Finland	0.31	0.25	0.50
Czech Republic	0.54	0.36	1.47
Slovenia	0.41	0.24	0.74
Related capital costs[2] - Labor costs = 1			
Germany		0.25	
UK		0.11	
Finland		0.06	
Czech Republic		0.21	
Slovenia		0.00	
Factor multiplier m_{IC}[3]			
Germany	1.50	1.80	1.76
UK	1.47	1.40	1.64
Finland	1.37	1.31	1.56
Czech Republic	1.75	1.57	2.68
Slovenia	1.41	0.24	1.74
Weighted average[4]	1.48	1.55	1.76

[1] 35% (45%) of the relation applied in the production of Nace 72, 73, (and 74).

[2] Depreciation + net capital*0.04 (external rate of return).

[3] **Total production cost (excluding profits and including labor costs) related to labor costs.**
[4] **GER 0.40, UK 0.30, FIN 0.15, CZ 0.075, SL 0.075**

We use the weighted average relationship between labor, intermediates, and capital in NACE 72-74 as a proxy for the cost structure of own account production of intangible goods in the firms in our analysis. Combined with the figures in Table 1 (replicated in Table 5) on the share of labor costs dedicated to the production of intangible capital, we arrive at a combined multiplier of 0.35 for OC, 1.10 for R&D, and 0.70 for ICT. The central settings in INNODRIVE are thus shown in Table 5.

Table 5: Central settings in INNODRIVE

	ICT	R&D	OC
Investment share of labor h_{IC}	0.5	0.7	0.2
point estimate range	(0.4-0.6)	(0.6-0.8)	(0.15-0.25)
Factor multiplier m_{IC}	1.48	1.55	1.76
Combined multiplier $M_{IC} = h_{IC} \cdot m_{IC}$	0.7	1.1	0.35
point estimate range	(0.6-0.8)	(0.9-1.2)	(0.26-0.43)
Depreciation rate	0.33	0.20	0.25

Similar to CHS, we consider the share of organizational work producing intangible capital to be most imprecisely valued. The share of organizational work producing intangible goods is assumed to range from 15% to 25%. In the literature usually some 70-80% of R&D investment is considered to be wage costs. Here the 10%-point variation is shown in terms of the investment share. ICT investment is the smallest category of expenditure in all countries. The relatively broad range of the combined multiplier (in comparison to R&D) does not influence much the figures on overall investment in intangibles.

In this expenditure-based approach to measuring intangibles, investment in intangibles is proportional to the labor costs associated with workers in particular occupations. These are adjusted with the share of labor costs considered as investment, h_{IC}. Expenditures for intermediate consumption and capital needed to produce intangible assets are accounted for by applying the factor multiplier, m_{IC}. The calculations have been made for every type of intangible expenditure. We calculate the expenditure-based measure of intangible investment as:

$$I_{ICit} \equiv M_{IC} w_{ICit} L_{ICit} \tag{1}$$

where $IC = OC,\ R\&D, ICT$, $M_{IC} = h_{IC} \cdot m_{IC}$ is the combined multiplier (shown in Table 5), w_{ICit} is the wage cost for workers engaged in the production of intangible assets in firm *i* (deflated by the earnings index, which is assumed to represent the deflator for intangible assets) and L_{ICit} is the respective labor input of these workers.

Having assessed capital formation for the types of intangibles in question, we can now calculate the intangible capital stock. Each type of capital accumulates according to the perpetual inventory model, as in EU KLEMS:

$$K_{ICit} = I_{ICit} + (1-\delta_{IC})K_{ICit-1} \tag{2}$$

with depreciation rate δ_{IC}, which differs according to the type of asset IC=OC, R&D, ICT, and gross capital formation in the current year I_{ICit}. K_{ICit} denotes the closing stock (at the end of the year). The opening stock, K_{ICit-1}, is the stock a firm starts with (usually the closing stock of the year before, if no revaluation takes place). To apply these stock values in a production function, it has to be made comparable with other variables such as employment, which in most cases is the average (stock) of the number of persons employed over the year, and production, which is the flow or output over the year. If the production function is not based on the flow of capital services, a common procedure to achieve comparability is to calculate the average stock over the course of a year.

Depending on the assumed depreciation rate, the conventional EU KLEMS methodology affords long time series of investment data. Micro data do not allow for a long history of intangible capital accumulation. The available data range from 5 years in Germany to 13 years in Finland. Let θ be the first observation for a firm. Capital stocks are based on observed figures and an estimate of the initial closing capital stock $K_{\theta-1}$ in the year before we observe a firm in the data. We assume a constant rate of growth in investment, g, before the first year of observation. Back extrapolating yields:

$$I_{\theta-1} = I_{\theta}(1-g) \tag{3}$$

with I_t for capital formation of the current year. Given the general cumulative definition of the closing stock in (2) we can apply the following equation to calculate the initial stock:

$$K_{\theta-1} = I_{\theta-1} \sum_{0}^{\infty} (1-\delta-g)^t \; . \tag{4}$$

δ is the (constant) depreciation rate and g is the growth of investment in the years preceding the initial year. Applying the sum formula for a geometric row leads to

$$K_{\theta-1} = \hat{I} \; \frac{1-(1-\delta-g)^T}{1-(1-\delta-g)} \; . \tag{5}$$

where $\hat{I}$ is an estimate of the starting value $I_{\theta-1}$. In theory T should be infinite; for practical purposes it can be set to 100. Growth rate g is set at 2%, which follows the sample average growth rate of intangible capital in the observation period. This implies that we assume that the past and current average growth rates are similar. $\hat{I}$ is derived as the average investment in the five-year period following the first observation year θ. The average is used to assess the average investment over the business cycle. It is corrected by a discount factor to reflect the growth of investment in the observation period.

5. A PERFORMANCE-BASED APPROACH TO MEASURING ORGANIZATIONAL INVESTMENT

The expenditure-based approach to evaluating firms' own account production of intangible assets assumes a separate production for each type of intangible good, where inputs are intermediates, capital and labor. The production function was chosen to be of the type found in industries that produce these respective intangibles as final products. In the expenditure-based approach investment in organizational capital is proportional to the product of the wage rate and hours worked of employees in particular occupations:

$$I_{OCit}{}^{EXP} \equiv M_{OC} w_{OCit} L_{OCit} \qquad (6a)$$

where the proportionality factor M_{OC} is the combined multiplier reported in Table 5. Here we outline a performance-based approach, in which investment in intangibles is assumed to be proportional to the product of marginal productivity and hours worked in these same occupations:

$$I_{OCit}{}^{PERF} \equiv M_{OC} \hat{w}_{OCit} L_{OCit} \qquad (6b)$$

where M_{OC} is the total multiplier as in (6a) and $\hat{w}_{OCit}$ is the estimated productivity of OC-labor. The difference from the expenditure based approach is that we allow productivity to deviate from the wage rate. Using the expenditure-based estimates as a starting point we re-estimate the productivity of organizational workers using their contribution to value added in the production of traded products and intangible capital goods. We consider a further extension that allows us to estimate directly the combined multiplier, as well as the marginal productivity of organizational workers:

$$I_{OCit}{}^{PERFM} \equiv \hat{M}_{OC} \hat{w}_{OCit} L_{OCit} \qquad (6c)$$

where $\hat{M}_{OC}$ is the estimated combined multiplier and $\hat{w}_{OCit}$ is the estimated productivity of OC-labor. This approach provides a robustness check on the assumptions we make concerning the combined multiplier.

There are good reasons for questioning whether the wage rate provides an adequate representation of the productivity of organizational workers and hence of expenditure on organizational capital. Therefore the performance-based measures of organizational investment provide important robustness checks on the expenditure-based approach that is commonly adopted in constructing national measures of intangibles. Hellerstein et al. (1999) find some evidence that marginal products exceed the wage rate of workers in managerial and professional occupations, but remark that labor market theory has no clear explanation for this. Ilmakunnas and Piekkola (2010) show clear evidence that in Finland both organizational and R&D type workers increase profitability, so that their productivity exceeds their wage costs. We suggest that organizational capital is an important missing input in production, which may partly explain the finding of a positive productivity-wage gap for workers in managerial positions. Thus, omitting organizational capital in the production function, estimated marginal products become a mix of compensation for quality adjusted labor and the return to organizational capital. Other reasons we might find a productivity-wage gap for organizational workers are associated with the difficulty of assessing and monitoring their productivity. First, there are likely to exist complementarities between management/marketing work and other unobserved inputs, or inputs not properly controlled for in estimation. For example, due to the complementarities between ICT capital and organizational workers their individual contributions to productivity may be difficult to measure (Bloom, Sadun, and Van Reenen, 2007). Also, as discussed above, there are complementarities between firms' expenditures on organizational workers and purchases of intangible goods. Second, although all workers may benefit from some form of rent-sharing with the owners of the firm, management workers are more likely to be paid in shares or other non-wage benefits than other workers. This practice arises in part to align the incentives of managers with the ultimate owners of the company, but may also reflect the potentially large rewards to the firm associated with organizational work. Third, and related to the arguments above, the output of management/marketing work may be difficult to observe, since we do not have an appropriate market valuation.

Here we estimate the productivity of organizational workers relative to other workers and compare this to the relative wage rate following the approach to estimating productivity-wage gaps set out in Hellerstein, Neumark and Troske (1999), hereafter HNT. It is convenient to model the production function following Mankiw, Romer and Weil (1992), hereafter MRW, replacing human capital with organizational capital. Organizational capital is thus considered to be proportional to the labor input[11]:

[11] In MRW the human capital investment decision (per head) is made by individuals as part of their long-term investment (the alternative is investment in physical capital through savings). Organizational

$$K_{OCit} = k_{OC} z_{OCit} L_{it} \tag{7}$$

where $z_{OCit} \equiv L_{OCit} / L_{it}$; k_{OC} is the ratio of organizational capital to organizational workers, which is predetermined.[12] We use a constant returns-to-scale production function. In addition to traded goods firms produce intangible investment for their own use. Thus, the explanatory variable is sales plus investment in all type of intangibles, i.e. $y_{it} = SALES_{it} + \sum_{IC} I_{ICit}$, where *IC*=*OC*, *R&D*, *ICT*, for firm *i* in year *t*, and the production function can be written as:

$$y_{it} = \exp(e_{it}) b_0 (q_{it} L_{it})^{(1-b_{OC}-\sum\limits_{IC\neq OC} b_{IC}-b_M-b_{TAN})} (k_{OC} z_{OCit} L_{it})^{b_{OC}} \prod_{IC\neq OC} K_{ICit}{}^{b_{IC}} M_{it}{}^{b_M} K_{TANit}{}^{b_{TAN}} \tag{8}$$

where K_{TAN} is tangible capital (plant, property and equipment), *M* is intermediate consumption, the K_{IC} refer to capital stocks of intangible types *IC*, and e_{it} is an error term.[13] The labor input is quality adjusted with factor q_{it}. As in MRW we essentially assume different production functions for intangible assets and traded goods/services, but assume these can be exchanged at zero cost.

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capital per worker can be similarly provided by training institutes. The amount of organizational capital still depends on the labor input.

[12] An alternative, following MRW more closely, is to assume that organizational capital is proportional to quality adjusted labor. In this case organizational capital is factored out of the estimation equation, which is specified in logs. Assuming instead, as we do, that organizational capital is proportional to the organizational labor input allows us to control for organizational capital in estimating the marginal productivity of organizational workers. Yet an option that is more consistent with the way in which we derive intangible investment is to assume here that organizational capital is proportional to organizational labor costs. In practice this matters less, because of the high correlation across firms between the input and total cost of organizational labor.

[13] The specification imposes decreasing marginal returns to investment in all types of intangible capital. It is therefore appropriate to use a wide definition of occupations that are engaged in the production of intangible capital.

In this simple framework workers are divided into two categories, organizational workers (OC) and others (NOC). Quality adjusted labor is given by $q_{it}L_{it} \equiv L_{NOCit} + aL_{OCit}$, where $a \equiv MP_{OC} / MP_{NOC}$ denotes mean marginal productivity of organizational workers relative to that of other workers. We assume that on average the wage rate for other workers reflects their marginal productivity and hence $a = MP_{OC} / w_{NOC}$. Reorganising the expression for quality adjusted labor we can write:

$$q_{it}L_{it} = (1 + (a-1)z_{OCit})L_{it}. \tag{9}$$

Following HNT we have $\ln q_{it} = \ln(1 + (a-1)z_{OCit}) \cong (a-1)z_{OCit}$, because organizational workers account for around 10% of all workers and because a denotes relative productivity (so that the second term in brackets does not deviate very significantly from zero).

Rewriting the production function in equation (8) in log terms, using the approximation for $\ln q_{it}$ above, and suppressing the time subscript we have:

$$\ln y_i = cons + b_{OC}\ln L_{OCi} + b_L \ln L_i + cz_{OCi} + \sum_{IC \neq OC} b_{IC} \ln K_{OCi} + b_M \ln M_i + b_{TAN} \ln K_{TANi} + e_i \tag{10}$$

where $b_L = (1 - b_{OC} - \sum_{IC \neq OC} b_{IC} - b_M - b_{TAN})$ and $c = (1 - b_{OC} - \sum_{IC \neq OC} b_{IC} - b_M - b_{TAN})(a-1) = b_L(a-1)$. Thus the ratio of the marginal product of organizational workers to the marginal product of other workers can be derived from the coefficients in equation (10) as $a = c/b_L + 1$; the marginal productivity of management and marketing work differs from that of the rest of the workers by c/b_L per cent. Note that k_{OC} does not vary across firms and is absorbed in the constant term.

In practice we estimate equation (10) separately for each of 4 industry groups and year using OLS.[14] Industries are (i) *Manufacturing*, (ii) *Business service sector* (business services, telecommunication, finance, private health), (iii) *Trade and consumer services* (wholesale and retail trade, other service activities), and a residual category (iv) *Construction, hotels, utilities*. We do not impose constant returns in estimation. Because the number of organizational workers in the firm is correlated with $(a-1)z_{OCi}$ across firms we capture the organizational capital deepening effect on output using the average number of organizational workers by industry (24 categories) and firm-size (5 categories) and year, $\overline{L}_{OCi}$, as a proxy for L_{OCi} in equation (10). We use the expenditure-based estimates of intangible investment to construct the dependent variable, and the expenditure-based estimates of R&D and ICT capital stocks.

Our estimate of the marginal productivity of organizational workers in firm *i*, in industry group *j*, at time *t* is then given by

$$\hat{w}_{OCijt} = \hat{a}_{jt} \frac{w_{NOCjt}}{w_{OCjt}} w_{OCijt} \tag{11}$$

where $\hat{a}_{jt}$ is our estimate of relative marginal products between organizational and other workers in industry group *j* in year *t* from estimating equation (10) and w_{NOCjt} / w_{OCjt} denotes the inverse of mean relative wage rates of organizational to other workers in industry group *j* in year *t*. The product of these two terms equals the gap between productivity and the wage rate of organizational workers, because we assume that on average non-organizational workers are paid their marginal product. Inserting the expression in equation (11) into equation (6b) our performance-based measure of investment in organizational capital becomes:

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[14] We also estimate a pooled regression. In this case we include dummies for all year and industry group interactions.

$$I_{OCijt}^{PERF} = M_{OC}\hat{a}_{jt}\frac{w_{NOCjt}}{w_{OCjt}}w_{OCijt}L_{OCijt}. \tag{12}$$

Where possible we also consider a further extension of the performance-based approach in which we jointly estimate the marginal productivity of organizational workers and the combined multiplier. This involves a simple rewrite of equation (10). The dependent variable there can be expressed as $\ln y_i = \ln(y_i - I_{OCi}) + \ln(1+\frac{I_{OCi}}{y_i - I_{OCi}})$. Since investment in organizational capital relative to sales is not very different from zero we have $\ln y_i \cong \ln y_i^* + \frac{I_{OCi}}{y_i^*}$, where $y_i^* \equiv SALES_i + \sum_{IC \neq OC} I_{ICi}$. From the expression for the performance-based measure of intangible capital in equation (12) we have $I_{OCi} = M_{OC}a\frac{w_{NOC}}{w_{OC}}w_{OCi}L_{OCi}$. Substituting these expressions into equation (10) our estimating equation becomes:

$$\ln y_i^* = cons + b_I INV_i + b_{OC}\ln L_{OCi} + b_L \ln L_i + cz_{OCi}$$

$$+\sum_{IC\neq OC} b_{IC}\ln K_{OCi} + b_M \ln M_i + b_{TAN}\ln K_{TANi} + e_i \tag{13}$$

where $INV_i = \frac{w_{NOC}}{w_{OC}}\frac{w_{OCi}L_{OCi}}{y_i^*}$ and $b_I = -M_{OC}a$. As before, the ratio of the marginal product of organizational workers to the marginal product of other workers can be derived from the coefficients in equation (13) as $a = c/b_L + 1$. The estimate of the combined multiplier can be derived from the coefficients in equation (13) as $M_{OC} = -b_I/(c/b_L+1)$.

We estimate equation (13) pooling the coefficients across industry groups and time, but including dummies for all industry-year interactions. We then estimate this equation separately for each industry-year category, replacing b_I with $-\hat{M}_{OC}a$ and c with $b_L(a-1)$ in equation (13), where $\hat{M}_{OC}$ is the pooled estimate of the combined multiplier. In this approach we estimate the ratio of marginal products, a, using non-linear least squares. Because of the correlation across firms between the terms that involve organizational workers, in one shape or another, we proxy L_{OCi} and INV_i using industry/size/year averages. We use the expenditure-based estimates of R&D and ICT investment and capital.

In this extended performance-based approach investment in organizational capital is calculated as:

$$I_{OCijt}{}^{PERFM} = \hat{M}_{OC}\hat{a}_{jt}\frac{w_{NOCjt}}{w_{OCjt}}w_{OCijt}L_{OCijt}\,. \tag{14}$$

where $\hat{M}_{OC}$ is our pooled estimate of the combined multiplier, which was set to 0.35 (see Table 5) in deriving the performance-based estimate $I_{OCijt}{}^{PERF}$ in equation (12); $\hat{a}_{jt}$ is our non-linear least squares estimate of relative marginal products between organizational and other workers in industry group j in year t.

The benefit of this extended performance-based approach is two-fold. First, we provide a check on our assumption about the combined multiplier. Second, in estimating relative marginal products we are able to treat organizational investment consistently with its subsequent derivation.

6. GROWTH ACCOUNTING

We assume a Cobb-Douglas production function specification with constant share-parameters to assess factor contributions to growth in labor productivity, $\Delta \ln(Y_t / L_t)$, where Y_t is valued added at market prices and L_t is the total number of employees in the private sector. Intangible capital is decomposed into contributions from three types: organizational capital (OC), R&D capital (R&D) and information technology (ICT). Tangible capital is denoted by K_{TANt}. The residual term denotes growth in total factor productivity. We aggregate the firm-level data on all variables to be representative of the private sector in the respective industries. This is important as we are interested in long-term growth and not only year-to-year changes at the level of the firm. The expression for growth in labor productivity is given by

$$\Delta \ln\left(\frac{\hat{Y}_t}{L_t}\right) = \sum_{IC} \alpha_{IC} \Delta \ln\left(\frac{K_{ICt}}{L_t}\right) + (1 - \sum_{IC} \alpha_{IC} - \alpha_L) \Delta \ln\left(\frac{K_{TANt}}{L_t}\right) + \Delta TFP_t \ , \tag{15}$$

where *IC=OC, R&D, ICT*. The share-parameters α_{IC} and α_L are the costs for each type of intangible capital *IC* and total wage costs, respectively, measured relative to (nominal) value added (average of periods *t* and *t-1*). Value added $\hat{Y}_t$ is given by conventional value added plus investment in intangibles. Thus, value added including investment in intangibles is given by

$$\hat{Y}_t = Y_t + \sum\nolimits_{IC} I_{ICt} \ , \tag{16}$$

where *IC=OC, R&D, ICT* and organizational investment may refer to either the expenditure- or the performance-based estimate.

Derivation of labor and tangible capital cost shares is straightforward. In evaluating the share parameters for the intangible capital items we consider the associated user cost (Jorgensen, 1963). Following convention, own account production of capital goods is valued at production cost. The main components of capital costs are depreciation and the return on capital[15]. We apply an external rate of return of 4% (representing the market interest rate) in calculating these user costs, and apply the depreciation rates set out in Table 5. Thus we estimate:

$$\alpha_{IC} = (RR + \delta_{IC}) K_{IC} / \hat{Y} \tag{17}$$

[15] We do not include changes in the prices for investment goods, because of the lack of data there is no firm level variation in this variable.

where intangible capital and value added adjusted for intangible investment are measured in nominal terms, and *RR* is the external rate of return. Tangible capital shares are calculated by residual.

This approach differs from the Jorgenson-Griliches procedure for estimating the rate of return cited by CHS (2005). This would imply a common rate of return to both tangibles and intangibles, assuming that businesses arbitrage their investments across all types of capital, investing in each type until the rate of return for all assets is equal. This would be the case if we apply the internal rate of return, as used in the EU KLEMS project. For better comparison between the expenditure and the performance approach we apply a unified rate of return for all intangibles, i.e. the external rate of return. In comparison to the Jorgenson-Griliches procedure, our approach may underestimate the contribution of intangible capital to labor productivity growth. This is because internal rates of return typically exceed external rates of return for the industries, countries and time periods we consider (see EU KLEMS data; Görzig and Gornig (2010) for Germany).

7. CONCLUSION AND EMPIRICAL EVIDENCE ON PARAMETERS

Empirical estimation is done using linked employer-employee data (LEED) in individual countries which is comparable from one country to another after aggregation of it to business sector level. In the analysis conducted by INNODRIVE in Finland, Norway, the UK, Germany, Czech Republic and Slovenia, the total shares of intangible capital type workers do not differ much from one country to another, and are typically around 18% of all workers. Organizational workers are the largest group with the UK at the top, where these workers account for 12% of employment. The share of managers is around 9% in the UK, 4% in Finland, 8% in the Czech Republic, 9% in Germany, 3.5% in Norway and 6.5% in Slovenia. We believe that micro data can be used to adjust the national figures. In Germany, the share of managers is much lower, 2-3% of all workers, using the Labour Force Survey by Eurostat.

R&D workers represent a notable share of employment of around 6%. The share of R&D workers is surprisingly low in Germany, being around 5%, although the manufacturing sector is large. Finland and Slovenia, where 9% and 7% of workers are engaged in R&D, respectively, stand out as the most R&D intensive countries. In recent years, the share of ICT workers has been 3% on average, and in this category the share is highest (4%) in Norway.

We suggest that the calculation of the share of organisational workers is more appropriate than management workers alone when evaluating organisational structures of the own-account type in the Corrado, Hulten, and Sichel (2006) approach. In fact, including all intangible-type workers in the analysis gives more harmonised figures than counting only the number of managers.

Here we study main results using LEED data in Finland, the UK and Germany.[16] LEED data from Finland in 1995-2008 has 2,933 firms with 400,000 workers covering nearly one fourth of the private sector employment.. The UK LEED data in 1998-2006 has 10,000 firms accounting for 20% of GVA in relevant industries. The match of company data is done at the 3-digit industry level to Labour Force Survey data on shares of workers with five skill categories. German LEED data in 1999-2003 has 1.5 million establishments about 20 million workers using Social Security Dataset (SSD). The following three graphs show the development of intangibles. These are measured per new value added that for consistency includes investment in intangibles. We have also aggregated the LEED data to be representative at the business sector level. This is achieved by adjusting the figures for the difference in the value added/employees and the number of firms in the LEED data and in the whole business sector in five firm-size and one-digit industry categories. Organisational investment calculated using the performance-based approach (PER) is also shown.

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[16] Data for all countries is described in greater detail in Innodrive web page www.innodrive.org, see working paper: Data and variable description and major outcomes in Innodrive company and country-level analysis).

Figure 3. Organisational, R&D and ICT investment per new value added in Finland

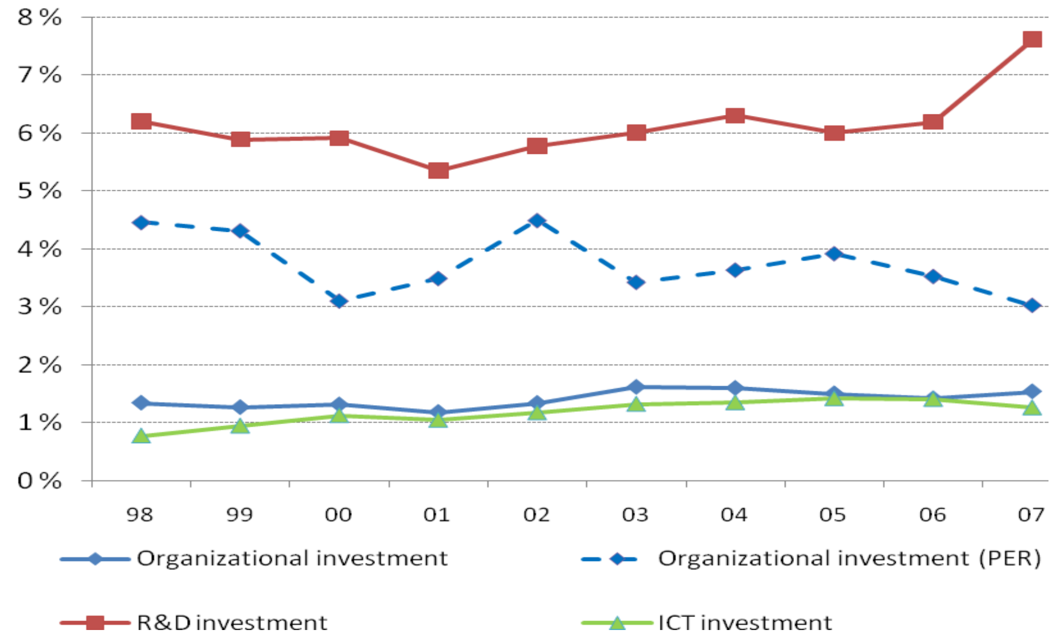


Figure 4. Organisational, R&D and ICT investment per new value added in the UK

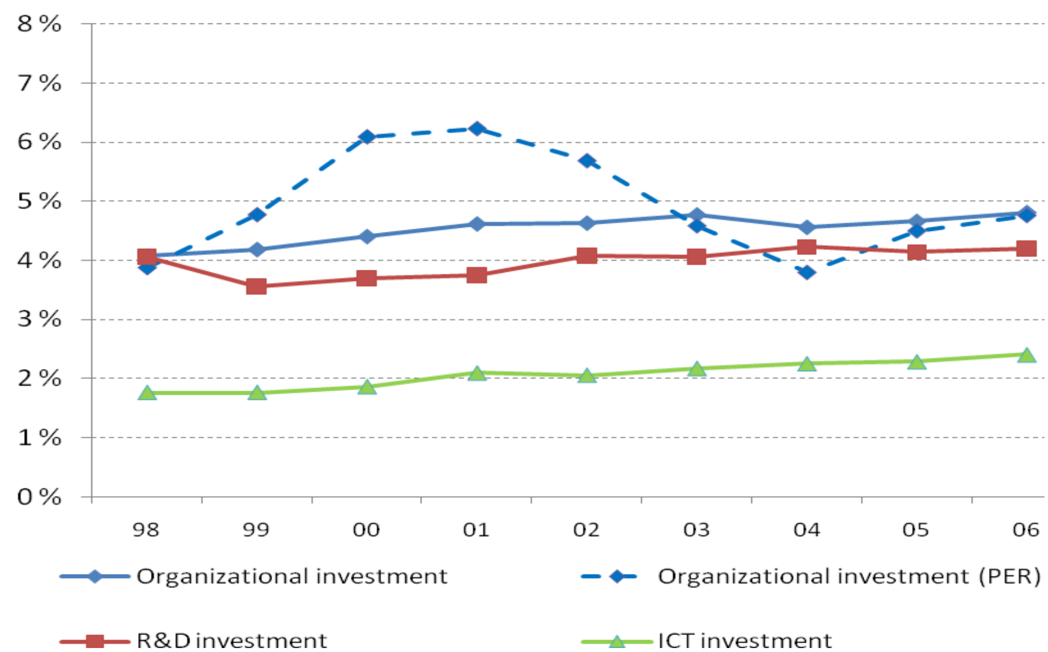
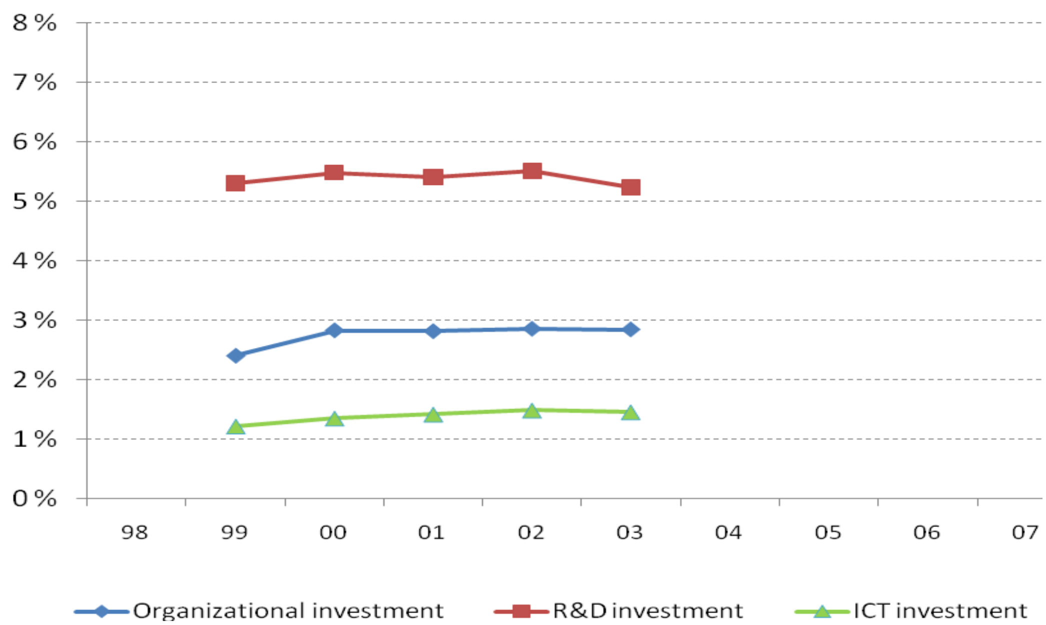


Figure 4. Organisational, R&D and ICT investment per new value added in the Germany



Finland provides an example of the Nordic countries, intensive in R&D capital and fairly poor in organisational capital (in management and marketing). In both large countries, the UK and Germany, investment in organisational capital is relatively high; in relative terms, investment in R&D capital is low. ICT investments are moderate at about 1.5% of value added in all the countries.

The expenditure-based approach gives only part of the picture regarding the value of intangibles when they are owned by the firm and employees are not fully compensated for the value of intangible production. On average our performance-based estimates of organizational capital are usually higher than our expenditure-based estimates. This is because in most industries and time periods we find evidence of a positive productivity-wage gap for organizational workers. Indeed, the performance-based approach increases the relative importance of organisational investment both in the

UK and in Germany. However productivity varies quite a lot from year to year, and in general imply that returns have decreased over time.

Of the countries considered, the UK is traditionally considered to have the most organizational investment in relation to value added. Organizational investment is around 4.5% of valued added using the expenditure-based approach and approximately 5% using the performance-based approach where we jointly estimate the combined multiplier and the relative productivity of organizational workers (using eq. (6c)). Assuming instead a combined multiplier of 0.35 (see Table 5), and applying the performance-based approach in eq. (6b), the performance-based estimates of organizational investment are significantly higher than the expenditure-based estimates, similar to the findings for other countries. Finland has less organizational capital: 2.1% of value added, but more than 5.5% of value added using the performance-based estimates, eq. (6b). These shares are almost the same in Norway (2.7% and 5.5%). Organizational investment has also increased markedly in more recent years in new EU member countries, reaching 6.2% of value added in Slovenia in 2004 and 5.8% of value added in the Czech Republic. The productivity returns to organizational type work are high and therefore the performance-based approach yields estimates that are approximately double the expenditure-based estimates.

Using the UK data we also evaluate the combined multiplier used in constructing these estimates. Based on the analysis in section 4 above we assume a combined multiplier of 0.35 (see Table 5). The UK data broadly supports this figure, although central estimates are somewhat lower.

Slovenia, Norway and Finland have the highest R&D intensity (9%, 6.5% 6% respectively), followed by Germany (4.6%), the Czech Republic and the UK (both 4.0%).

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Appendix Tables

A1. ISCO88 codes for INNODRIVE intangible occupations

Intangible	ISCO88		Additional criteria: Higher tertiary quals	Additional criteria: Sector
ICT	1236	Computing services department managers		
ICT	213	Computing professionals		
ICT	312	Computer associate professionals		
R&D	1237	Research and development managers		
R&D	211	Physicists, chemists and related professional		
R&D	212	Mathematicians, statisticians and related pro		
R&D	214	Architects, engineers and related professiona		
R&D	221	Life science professionals		
R&D	222	Health professionals (except nursing)		
R&D	223	Nursing and midwifery professionals		
R&D	311	Physical and engineering science technicians		
R&D	321	Life science technicians and related associate professionals		
OC	1221	Prod. operat. dep managers in agriculture, hunting, fores		
OC	1222	Prod. operat. dep managers in manufacturing		
OC	1223	Prod. operat. dep managers in construction		
OC	1227	General managers in manufacturing		
OC	1229	Prod. operat. dep managers not elsewhere classified		
OC	1233	Sales and marketing department managers		
OC	1234	Advertising and public relations department ma		
OC	1231	Finance and administration department managers	yes	
OC	2441	Economists	yes	
OC	3411	Securities and finance dealers and brokers	yes	
OC	342	Business services agents and trade brokers	yes	
OC	241	Business professionals	yes	
OC	242	Legal professionals	yes	
OC	343	Administrative associate professionals	yes	
OC	3416	Buyers		production
OC	347	Artistic, entertainment and sports associate		production
OC	3416	Buyers	yes	services
OC	347	Artistic, entertainment and sports associate	yes	services

A2. Association between intangible purchases and salary costs of workers in 'intangible' occupations

%point change in purchases associated with a 1 %point change in salary costs (relative to sales)

	All		Manufacturing		Business Services		Retail		Other	
Purchases of computer and telecommunications services versus salary costs of IT workers										
	coeff.	t-stat.	coeff.	t-stat.	coeff.	t-stat.	coeff.	t-stat.	coeff.	t-stat.
(1)	0.14	95.3	0.22	55.4	0.10	33.5	0.41	47.3	0.35	34.7
(2)	0.10	62.2	0.18	39.1	0.09	29.8	0.41	47.1	0.30	28.5
(3)	0.10	49.2	0.15	29.2	0.09	24.5	0.30	30.5	0.24	21.5
Purchases of advertising services versus salary costs of marketing workers										
	coeff.	t-stat.	coeff.	t-stat.	coeff.	t-stat.	coeff.	t-stat.	coeff.	t-stat.
(1)	0.08	22.4	0.08	12.5	0.05	9.6	0.22	19.0	0.13	8.4
(2)	0.09	23.8	0.06	8.5	0.05	9.8	0.22	19.0	0.20	12.4
(3)	0.09	24.1	0.06	9.1	0.06	11.6	0.21	17.3	0.16	10.5

Notes: 97890 enterprise-year observations; constant term included; regression (1) no other controls (2) industry and year dummies (3) industry and year dummies and enterprise random effects; Business services include telecommunications; Other industries include mining, hotels and utilities.
Source: Annual Business Inquiry and Annual Survey of Hours and Earnings, Authors' calculations.