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UK Economic Performance: How Far Do Intangibles Count?

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ABSTRACT

This paper is concerned with the link between productivity growth and the increasing importance of intangible assets. A growing literature suggests that the standard production function, consisting of capital and labour, is inadequate in accounting for modern changes in productivity. Knowledge intensive intermediate inputs and own-account production, often netted out or ignored in earlier studies, have an increasingly important role to play. Existing work on intangibles is typically performed at the national level. Here, we discuss the definition and construction of occupational measures of intangibles for UK firms. Specifically, we argue that the human capital component of intangibles is substantial and thus construct occupationally defined measures of R&D, ICT and organisational capital based on the earnings of workers engaged in the production of these goods. Using a variety of micro datasets for Great Britain, we estimate firms' intangible assets and include these in a growth accounting exercise for 1998-2006. Our findings point to a strong association between a firm's performance and a firm's investments in intangible capital. We find that firms investing in one type of intangible asset tend to invest in other types of intangible assets too. Our findings indicate that overall, intangibles account for around 0.4 per cent per annum of the growth in labour productivity in the industries considered. Our results reveal aggregate properties consistent with previous UK studies but offer an alternative, disaggregated means of measurement.

JEL classification: M40, J30, O30, O40, M12, J24

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

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1. INTRODUCTION

It has become increasingly clear in recent years that traditional productivity measurement, focusing on labour and capital inputs has been missing something. Specifically, research is turning to the significant expenditure on knowledge assets (such as R&D, software and marketing) which under the traditional national accounting framework is excluded from value added calculations, and as such is excluded from estimates of national income. Corrado, Hulten and Sichel (2009) (hereafter CHS) estimated that the exclusion of intangible investments from measured GDP from measures of capital stock in the US resulted in an underestimation of US capital stock of around $3 trillion (2003 data). Indeed, comparisons of UK and US estimates for the ratio of adjusted to unadjusted GVA figures reveal considerable similarities, particularly over the 1995-2003 period (Table 5, Giorgio-Marrano, et al, 2009) with a much smaller proportion of the growth for the US is attributable to tangible capital deepening, which experiences a bigger contribution from intangibles, compared to the UK.

Intangible assets by their very nature are difficult to identify. However, there is a general acceptance that they include a strong knowledge component which is difficult to measure in a market context. Hulten (1979) argued that such assets ought to be treated as investments rather than current expenditures. Moreover, whilst considerable research has focused on the aggregate importance of intangibles, it is evident that they are, to a large extent, firm specific inputs.

Much of the micro-analysis of intangibles in the UK and elsewhere has so far been relatively ad hoc; focusing on one or two aspects of intangible assets, such as R&D expenditure, innovation or management practices. Generally in these micro studies, investment in intangible assets is not capitalized. A second body of literature stems from the work of CHS, by Giorgio-Marrano et al (2009) which focuses on the macroeconomic impact of intangible assets. Thus, given the firm specific nature of intangibles and the importance of capitalization of these assets, there exists a gap in current evidence for the UK.

The purpose in this paper is therefore threefold. Firstly, we provide new estimates of intangibles for UK firms. Our analysis is part of a wider European research effort and thus our approach is harmonised with others (e.g. Görzig et al, 2011; Piekkola, 2010). Secondly, we construct our intangible assets using both an expenditure based and a performance based measure. Thus, we can compare our findings from both approaches which offers a robustness check on the plausibility of our assumptions. Finally, our estimates of intangible capital are aggregated to be broadly nationally representative and incorporated into a growth accounting exercise to provide estimates of the effect this intangible capital mis-measurement has on productivity growth estimates for the UK. We compare our results with findings from other UK studies that have carried out similar exercises at an aggregate level, putting our firm level estimates into context. The period covered in our analysis is 1998-2006. This is dictated by data availability but covers the longest period possible.

The paper is organised as follows, we begin with a discussion of the definition of intangible assets and provide an overview of existing estimates of the magnitude and impact of intangibles that are currently available. In section 3, we present a detailed discussion of data sources we use to construct occupationally defined intangible assets. Section 4 provides a more information on the construction of intangibles for UK firms. In section 5 we illustrate the properties of firm level intangibles and include these within a growth accounting framework. In section 6 we include our measure of intangible assets within a growth accounting framework, providing estimates of how big an impact intangibles have on measures of growth for the UK and compare our findings to existing aggregate estimates. Section 7 contains our initial conclusions and directions for further research.

2. INTANGIBLES: DEFINITION AND EVIDENCE

It is hard to be precise about the definition of intangible assets, which by their very nature are difficult to identify, trade and indeed see. The academic literature offers a variety of broad and more narrow definitions of what should and should not be included, however, following the seminal work of CHS(2006) the literature tends to agree broadly on three main sources of intangible capital (CHS, 2006; Giorgio Marrano, Haskel and Wallis, 2009; Haskel et al, 2011; Jona-Lasinio, 2011). These are (CHS,2006):

1. Digitized information

This is often measured as ICT capital, composed of software as well as databases.

2. Innovative Property

This includes both scientific R&D and non-scientific R&D. By which we mean R&D into social sciences and humanities, mineral exploration, new motion picture films and other forms of entertainment, new architectural and engineering design and new product development in financial industries.

3. Economic Competences

Such as brand equity, including advertising and marketing expenditures; market research. This category also includes firm specific resources, including human capital (investments in training) and organizational structure (management).

Intangibles, some have argued are not easily verifiable, are not always visible, ma by non-rival in consumption (and thus display elements of public good) and (as with R&D) it is not always easy to fully appropriate the returns. Despite these problems, fundamentally, any input that reduces current consumption so that future consumption increases, qualifies as an investment and should be treated as such (CHS, 2009). Corrado, Hulten and Sichel are largely credited with developing the current 'best practice' methodology on incorporating a wider definition of intangibles into the national accounts methodology. However, it is clear that with such asset, the approach to measurement is crucial.

In their macro analysis of the US, CHS make a number of assumptions in order to measure and capitalize intangibles, some of which we discuss in our methodology below. Their analysis highlights that by ignoring intangibles labour productivity growth is almost certainly mismeasured. Intangibles are estimated to account for around 26 per cent of the growth changes, on a par with the size of the tangible capital component. They also find that the unexplained multi factor productivity (MFP) component falls as the explanation of growth improves. Inclusion of intermediates as a new capital input does not alter the acceleration in labour productivity that the US experienced in the mid 1990s. Giorgio Marrano et al (2009) adopt a largely similar approach for the UK, constructing a measure of intangibles for the

UK over the period 1990-2004. They find that, similarly to the US, nominal business investment in intangible assets has grown over the period, increasing from around 6% in 1970 to around 15% in 2004. Intangible investments are estimated to be roughly equivalent in value to tangible investments. Broadly, their findings mirror those in the US (albeit, to a lesser extent) except in the fact that the slowdown in labour productivity growth in the mid 1990s is largely accounted for by the exclusion of intangibles from national accounts. Both papers, note that their measure of economic competences is far from perfect but nonetheless, their research contributes significantly to the debate.

Despite the fact that most of the economic studies so far have constructed aggregate, macroeconomic data, intangibles are embedded in the **firm** and in all these sources, perhaps the most constant source of intangible assets is knowledge. There have been a number of firm level estimates of intangibles however these stem from the accounting literature rather than economics. Lev et al (2009) highlight the contribution that accurate measurement of organisation capital can make to explain the discrepancy between market and book values of firms and to the generation of abnormal profits. They identify 4 types of firm level intangibles; learning (R&D), customer related (brands), human resources (training) and organisation (business processes). Developments in the latter, they argue, are still in their infancy. Hulten et al (2009) have recently attempted to relate macro measures of intangibles to micro estimates for the US and Germany focussing on a small samples of multinationals. They find German firms to be more R&D intensive than their US counterparts, but in terms of overall intangibles were less intangible intensive because of high US organisation capital intensity particularly.

In this paper, we follow the lead of Piekkola (2010) in the measurement of firm specific intangible capital. Corresponding to the three main 'assets' discussed above, we identify three groups of workers that are instrumental in determining intangible assets within a firm and thus these form the basis of our asset types in the construction of intangible capital. Organisation capital incorporates highly skilled management and marketing workers but in which we would also include social scientists. Research and development is our second category of workers which would incorporate all science based research, including architects. Our final occupational category of worker is ICT personnel. Whilst previous growth studies have looked to incorporate a measure of ICT and R&D into their production function, the measure of economic competences, captured by organization workers is a relatively new addition to the literature.

In related microeconomic literature, Bloom et al (2010) review the existing evidence of the role that organizational factors play in accounting for productivity dispersion within sectors and between countries. Again, they perceive there to be a measurement error in the production function where organizational factors are not adequately accounted for. Their review concentrates on management quality and decentralization within the firm. Whilst citing the lack of usable data for such analysis, they do draw some conclusions from recent empirical analysis. They note that larger, more skilled and more globally engaged firms are better managed and more decentralized and it is implied that these factors are correlated with higher productivity. The more competitive the market in which firms operate also affects management quality and the extent of decentralization. The propensity to engage in IT use and in heterogeneous sectors are found also to be more decentralized (p.34, Bloom et al, 2010). Thus, we see that it is not only within the growth accounts literature that the production function is perceived as mis-measuring inputs. We hope to offer further insight with our firm level measures of organizational capital derived from estimates of occupational structures within firms.

It is important to be clear about what we are trying to capture with respect to firm level intangibles. In this paper we focus on own account production of intangibles and not those purchased by firms. Görzig et al (2011) highlight a number of reasons why this component is likely to be substantial and generally poorly measured, not least with respect to ICT assets because of accounting practices that make it more sensible to record ICT investment as an intermediate expenditure (c.f. Lequiller and Blades, 2006).

3. UK DATA SOURCES

Measures of UK firms' expenditures on intangible capital goods may be derived from a number of data sources.[1] For the purposes of developing and analyzing occupationally based measures of these expenditures we require information on the occupational distribution of the firm's workforce in addition to standard financial information on the operations of the firm.[2] Details of UK firms' employees, their occupations, earnings and hours worked are available from the Annual Survey of Hours and Earnings (ASHE). These employee data can be linked via the ONS's Inter-Departmental Business Register (IDBR) to firms in the Annual Business Inquiry (ABI), which holds information on firms' labour costs, output, capital investment, intermediate expenditures, and employment. However, because the ASHE is but a 1% sample of employees in UK businesses, we are only able to construct adequate occupational measures for the small sample of (very large) UK businesses that have sufficient employees included in the ASHE. For this reason we match the employee data to firms by detailed industry and size group, rather than by firm identifier. Here we outline the two business surveys we use, the properties of the linked and matched samples, coverage, limitations and other issues.

3.1 Business surveys

The ASHE is a 1% random sample of employee jobs on the PAYE register held by the UK tax authorities, and contains detailed information on approximately 160,000 employees every year. Sample selection occurs on the basis of National Insurance numbers and is maintained over time, thus the ASHE contains longitudinal information on UK employees. The survey

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[1] For example, the Community Innovation Surveys (CIS) include information on firms' expenditures on R&D (intra- and extra-mural), knowledge acquisition (purchases external to the firm), personnel training, as well as expenditures on design, market research and advertising associated with the development of new or significantly improved goods and services. The Business and Enterprise Research & Development Inquiry contains information on scientific R&D. Limitations of these surveys are small sample sizes and relatively narrow focus (e.g. focus on scientific R&D and lack of information on expenditures on organizational structures). Where the CIS is concerned a further constraint is intermittent availability and non-response bias in earlier surveys (see Criscuolo and Haskel, 2002).

[2] Linked employer-employee data (LEED) of this kind have been used elsewhere in the labour economics literature to explore the nature of human capital formation (cf. Abowd *et al.*, 1999).

covers all sectors of the UK economy. Detailed information on pay and hours worked are collected from employers, as well as detailed occupation and industry category. It contains no information on employees' qualifications. Low-paid workers are under-recorded in the ASHE; weighting procedures allow this to be taken into account.

The ABI is a census of UK businesses with more than 250 employees and a stratified (by industry, region and employment size) sample of smaller tax-registered businesses.[3] On average response rates are 82%.[4] Sector coverage is almost complete; however there are a number of omissions and also a number of sectors where inputs are not thought to be directly comparable to the measured outputs. Typically, the latter consist of public sectors, such as education and health. Sectors that are not covered include certain industries within agriculture, public administration and defence, and, particularly pertinent to this paper, the financial services sector is omitted completely. Together, industries included in the ABI account for approximately two thirds of the UK economy.[5] The ABI contains employment and financial information on approximately 50 thousand UK enterprises every year since 1998. Although the information in the ABI yields annual longitudinal information for larger firms, there are large gaps in the data for smaller firms because of the rotating sampling strategy (smaller firms cannot be included in the sample in consecutive years). This means that when we capitalize investment flows we need to interpolate data for smaller firms.

Data in the ABI are collected at the level of the Reporting Unit. This is an administrative unit within a firm, decided upon entirely by the firm for the sake of convenience. One problem with using reporting unit data as the unit of analysis is that the firm does not necessarily use a consistent definition over time (Harris, 2002). An alternative is to disaggregate the data back down to the plant level, but this involves the assumption that all plants within a Report-

[3] For a full description of the ABI see Barnes & Martin (2002) and Criscuolo *et al.* (2003).

[4] http://www.statistics.gov.uk/abi/2007-archive/quality_measures.asp

[5] http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=15360

ing Unit are identical. We use ABI information aggregated to the Enterprise reference (the smallest legally distinguished production unit). This is because it is at this level that we can link the ABI to the ASHE, although postcodes can be used to extend the link to more disaggregated units in some instances, and the enterprise is perhaps most akin to the concept of a firm.[6]

Information on firms' stocks of plant, machinery and equipment can be constructed from the ABI information on investment.[7] We ignore expenditure on land and buildings. These are quite volatile over time, and one might argue these fluctuations have little to do with the productive capacity of a plant. The capital stock items that can be constructed are less reliable for Utilities and Construction firms and for the public sectors, and hence we exclude these sectors from our sample.

3.2 Linked and matched samples

We link the information on the occupational distribution of labour costs, hours worked and employment from the ASHE to the financial information of firms in the ABI via the Enterprise reference available in both datasets.[8] In this way we generate estimates of firms' expenditures and use of workers in particular occupation categories. Firm employment and

[6] The vast majority of Enterprise references are associated with a single Reporting Unit (and single plant). We exclude Enterprises references for which we do not have full financial information on all Reporting Units. We allocate enterprise industry and City Region on the basis of the industry and City Region of the majority of employees within the enterprise. In the few cases where we observe ties these characteristics are allocated randomly.

[7] We use plant, machinery and equipment capital stock data provided by Richard Harris augmented with firms' leasing of these assets. These were constructed using starting stocks at the 3-digit level of industry disaggregation provided by NIESR/Mary O'Mahony. For manufacturing, these starting stocks run from 1969 and are subsequently built-up using the Perpetual Inventory Method of calculation, using real net capital expenditures year on year. The methodology underlying the construction of these data is fully described in Harris & Drinkwater (2002).

[8] Enterprise references are not available in the ASHE before 2002 and need to be linked in via the PAYE reference. We thank Richard Upward (personal correspondence, 2007) for his advice in using 1997 and 2004 look-up tables for ENTREF-PAYEREF in order to add in Enterprise references in the ASHE 1998-2001. Where there is conflict between the ENTREF in the 1997 and 2004 tables we allocate the ENTREF that corresponds to the same 4/5 digit industry.

labour cost totals are constrained to be as in the ABI. However, this procedure is only meaningful for firms where we have a sufficient number of ASHE employees. Because of the restrictive ASHE sample of firms' employees, our firm-sample becomes very limited in coverage, highly skewed towards very large firms. For instance, focusing on linked firms where we have at least 10 ASHE employees and for which we have full financial information, we achieve a sample of approximately 400 firms per annum. For these reasons we match in the occupational information via 3-digit SIC category and 4 employment size bands by year. Where this leads to cell sizes smaller than 30 ASHE employees we merge employment size groups, and, in some cases, move to the 2-digit SIC category. This procedure leaves us with on average 270 linking cells per year, distinguished by 163 industry categories (see Table 1).

For the small sample of large firms for which it makes sense to link the ASHE occupational information by the enterprise identifier we check the coherence of the occupational distribution between the two measures (note that both are only approximations of the true data). Table 2 shows the correlation across firm-years of the share of employees (hours, or labour costs) in a particular occupation group as measured by the 1% sample of the firm's workforce and as measured by the 1% sample of employees in the same industry/firm-size category. The correlations for the three occupation groups that define our intangibles are positive and highly statistically significant. For R&D and ICT workers these correlations are higher (73% for labour cost shares) than for organizational workers (50% for labour cost shares); R&D and ICT tend to be more concentrated in particular industries.

3.3 Coverage and other issues

As our approach is harmonsied with a number of other European countries we make a number of restrictions on the data. We exclude firms with turnover less than €2million (averaged at 2000 prices) and/or employing less than 30 employees. In addition, we exclude firms in the agricultural and public sectors. We have already alluded to further constraints on the basis of the British data specifically. There is poor or incomplete coverage of the following sectors: mining and quarrying of energy producing materials; manufacturing of coke; refined petroleum products and nuclear fuel; electricity, gas and water supply; construction; financial intermediation; health and social work. In total, this leaves us with a sample of approximately 11,000 enterprises per annum 1998-2006.

Our data covers only Great Britain; i.e. the UK excluding Northern Ireland. However, when we weight up the firm-level data to be nationally representative of the industries in our sample, we weight to a published UK total. Sample coverage is indicated in Table 3, which shows, for the industries we consider, the share of UK total gross value added and employment accounted for by the firms in our sample. Coverage averages a third of GVA and is a bit higher measured on employment. The industries we consider account for approximately 55% of whole economy GVA (calculated using EU KLEMS).

In weighting up the firm-level data to be nationally representative (as we do in what follows) we aggregate to ABI broad industry totals published by the ONS (gross value added for financial items, employment for hours worked and employment items, labour costs for intangible items). We make an adjustment for differences in labour use between the smaller firms that are excluded from our sample and the larger firms included in the sample on the basis of the ASHE. We use the Business Structure Database, which holds information on turnover and employment for all UK tax registered businesses, in order to derive within industry weights by firm-size category.

The ABI financial information is published in current values. ONS input and output deflators are used to construct real values; these are typically available at the 2-digit sector level. Intangible investment is deflated using the average earnings index.

Our classification of workers into "intangible" producing occupations is constructed on the basis of detailed occupational classification and information on workers' qualifications. We base our grouping of occupations on ISCO88 as listed in Görzig *et al.* (2011), facilitating international harmonization. Look-up tables to the UK Standard Occupational Classification are available from the ONS. In the absence of information on workers' qualifications in the ASHE we evaluate the average skill content of individual occupations using the Labour Force Survey (LFS) and classify occupations accordingly. The change in UK occupational classifications between SOC90 and SOC2000 causes a discontinuity in our data between 2001 and 2002; given this, the data are not strictly comparable between the first 4 years and the latter 5 years of our sample. Using the LFS, which is coded to both SOC90 and SOC2000 in some years, we attempt to minimize this discontinuity.

4. MEASURING INTANGIBLE CAPITAL

We measure intangible investment and capital following the methodology adopted in INNODRIVE (European Commission FP7 project), which is described in full in Görzig *et al.* (2011). Here we outline briefly the methodology.

4.1 Basic approach

Crucially, a firm's investments in intangible assets are assumed to be proportional to the firm's labour costs associated with workers in intangible occupations (i.e. involved in the creation of intangible capital goods). The proportionality factor is a multiple of three separate parameters: the share of intangible workers' time that contributes to future production, h^{IC}, a scaling factor to account for other (non-labour) inputs associated with the production of intangible capital goods, m^{IC}, and the ratio of the marginal product of intangible workers to the wages they are paid, p^{IC}; *IC=R&D, ICT, ORG*. Thus, a firm's investment in intangible assets is derived as:

$$I_{it}^{IC} = h^{IC} m^{IC} p^{IC} w_{it}^{IC} L_{it}^{IC} \qquad (1)$$

where w_{it}^{IC} and L_{it}^{IC} are the wage and labour input of intangible workers type *IC* in firm *i* at time *t*. Figures 1 illustrates the share of workers in occupations that we classify as "intangible" occupations. On average, ICT workers account for around 3½% of employment, R&D workers 6% of employment, and organizational workers 14% of employment (which can be disaggregated as 10% management workers and 4% marketing workers). In other words, our occupational classification implies that almost 1 in 4 workers, in the industries we consider, spends some of their time producing intangible capital goods. Figure 2 illustrates the hourly labour costs of these workers and contrasts these to the costs of other workers. Clearly, workers in "intangible" producing occupations are expensive, costing nearly twice a worker in other occupations. Basically, workers in "intangible" occupations are highly skilled and highly paid. Of the three intangible categories, workers in organizational occupations tend to be the most costly. The break in figures 1 and 2 is to remind the reader of the discontinuity in SOC classifications between 2001 and 2002.

We capitalize these intangible investments for the firm according to the perpetual inventory method:

$$K_{it}^{IC} = I_{it}^{IC} + (1 - \delta^{IC})K_{it-1}^{IC} \qquad (2)$$

where K_{it}^{IC} denotes the end of year stock of intangible capital type *IC* and δ^{IC} denotes the depreciation rate. As described in Görzig *et al.* (2011), we assume starting stocks (for the year before we first observe a firm in the data) are proportional to the sample average of intangible investment (discounted appropriately), $\bar{I}_i^{IC}$, for the firm:

$$K_{i\,start}^{IC} = \bar{I}_i^{IC} \frac{1-(1-\delta^{IC}-g)^T}{1-(1-\delta^{IC}-g)} \qquad (3)$$

where *T* is set to 100 and *g* is set to 0.02. Inevitably, with a relatively short span of firm-level data, our intangible capital stocks are sensitive to these initial assumptions. Depreciation rates for intangible capital are usually set substantially higher than the equivalent for tangible capital, i.e. intangible asset lives are assumed to be shorter than tangible asset lives. Informed by the literature we use: $\delta^{R\&D} = 0.20$, $\delta^{ICT} = 0.33$, and $\delta^{ORG} = 0.25$ (Table 3, Görzig *et al.* (2011)).

4.2 Scaling parameters

We use two approaches to setting the three scaling parameters discussed above. The first of these, which we call the expenditure approach, is akin to the methodology typically adopted in deriving national estimates of intangible capital items that are based on the wages and salaries of particular workers. The second of these, the performance based approach, provides a robustness check on our main approach to estimating organizational capital.

To assess labour services that go towards the production of intangibles, we distinguish three types of labour input: R&D, ICT, and ORG-related personnel. 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). Specifically, in the expenditure approach we assume that 70% of R&D workers' time, 50% of ICT workers' time, and 20% of organizational workers' time is spent on the production of intangible capital goods (i.e. $h^{R\&D} = 0.7$, $h^{ICT} = 0.5$, and $h^{ORG} = 0.2$).[9] To account for the capital services and materials that complement this labour in the production of intangible assets we scale the relevant labour expenditures with the cross-country[10] average ratio of total production to labour costs in the ICT, R&D and Business services sectors; SIC 72, 73 and 74 respectively. These are: $m^{R\&D} = 1.48$, $m^{ICT} = 1.55$, and $m^{ORG} = 1.76$ (Table 5, Görzig *et al.* (2011)). Finally we assume that the productivity-wage gap of intangible type workers is zero so that $p^{IC} = 1$ for all types of intangibles.

As in much of the literature on intangibles these scaling parameters are based on simplifying assumptions and the evidence in support of some of these is as yet relatively scarce. The performance approach in INNODRIVE goes some of the way in gauging the robustness of these assumptions. Here we outline the basic estimating equation in the performance approach. The framework is discussed in more detail in Görzig *et al.* (2011). We assume a simple framework where firms produce intangible capital goods (own-account) in addition to final output. In producing these goods firms use tangible and intangible capital, as well as labour services. We can write a stylized production function for the firm as:

$$\tilde{y}_{it} = \exp(e_{it})\, b_0 {K_{it}^{IC}}^{b_{IC}} {K_{it}^{TC}}^{b_{TC}} (q_{it} L_{it})^{(1-b_{IC}-b_{TC})} \qquad (4)$$

[9] Considerations leading to these assumptions are set out in Görzig *et al.* (2011).

[10] Cross country average for Germany, UK, Finland, Czech Republic, Slovenia.

where $\tilde{y}_{it} = y_{it} + I_{it}^{IC}$ is value added adjusted to include intangible investment, $q_{it}L_{it}$ is quality adjusted labour, K_{it}^{IC} and K_{it}^{TC} are intangible and tangible capital respectively. The rest are production function parameters. I_{it}^{IC} and K_{it}^{IC} are as defined in the previous section 4.1. Note that in practice we have three types of intangible capital, rather than just the one in this illustration. This stylized production function can be likened to the production function underlying the standard growth-accounting framework used in macroeconomic studies that evaluate the contribution of intangible capital to productivity growth.

Labour is adjusted for the quality of intangible workers and is given by $q_{it}L_{it} \equiv L_{it}^{NIC} + aL_{it}^{IC}$, where L_{it}^{NIC} denotes labour in all other occupations than "intangible" occupations, and a is the ratio of the marginal product of intangible workers to the marginal product of other workers. Note that this can be rearranged so that $lnq_{it} \cong (a-1)z_{it}^{IC}$, where z_{it}^{IC} is the share of intangible workers in the firm's labour force. This specification allows us to evaluate the relative marginal products of workers in intangible occupations (following Hellerstein *et al.*, 1999).[11] Also, note that in our basic approach to measuring intangible investment we can write: $I_{it}^{IC} = h^{IC}m^{IC}(\frac{a}{w})w_{it}^{IC}L_{it}^{IC}$, where w is the ratio of the average (across firms) wage of intangible workers to the average wage of other workers, so that we have simply replaced $p^{IC} = a/w$ in the expression for intangible investment, assuming that other workers are paid their marginal product. Finally, note that we can rewrite the expression for $\tilde{y}_{it}$ so that $ln\tilde{y}_{it} \cong lny_{it} + \frac{I_{it}^{IC}}{y_{it}}$. With these manipulations we can rearrange the production function above to formulate the following estimating equation[12]:

[11] Although we essentially assume two production functions, one for the production of intangibles and one for the production of final output, it seems reasonable to evaluate the marginal product of intangible workers within a single production function setting as we do here because it is likely that workers' time would be distributed between activities to equate their marginal products between the two. The single production framework can also be justified if we assume that the two outputs can be exchanged at zero cost within the firm.

[12] The specified estimating equation makes no *ex-ante* assumptions about the scaling parameters. Note that the coefficient on intangible capital in this equation is independent of the scaling parameters because it is specified

$$lny_{it} = cons + c_0\left(\frac{w_{it}^{IC}L_{it}^{IC}}{y_{it}} \cdot \frac{1}{w}\right) + c_1 z_{it}^{IC} + b_L lnL_{it} + b_{IC} lnK_{it}^{IC} + b_{TC} lnK_{it}^{TC} + e_{it} \quad (5)$$

Using the estimated coefficients from this equation we can produce estimates of some of our scaling parameters. We derive the relative productivity of intangible workers to other workers as $a = \frac{c_1}{b_L} + 1$, so that our estimate of the ratio of the marginal product of intangible workers to the wages they are paid becomes $p^{IC} = \frac{1}{w}\left(\frac{c_1}{b_L} + 1\right)$. We are also able to derive an estimate of the product of the two scaling parameters h^{IC} and m^{IC} (these cannot be identified separately): $h^{IC}m^{IC} = -c_0/\left(\frac{c_1}{b_L} + 1\right)$.

Table 4 reiterates the scaling factors used in the expenditure approach for all three types of intangible assets, alongside estimates of these from the performance approach for R&D and ORG investment. The total scaling factors derived from a simple pooled OLS regression of the equation above do not differ substantially from the scaling parameters in the expenditure approach. The performance approach does suggest that the marginal products of R&D and ORG workers exceed their wages. For ORG workers, where there are good reasons to consider such a productivity-wage gap (Görzig *et al.*, 2011), we explore this in more detail below.

5. INTANGIBLE CAPITAL IN UK FIRMS

Using the expenditure approach above we report our main estimates of intangible capital in UK firms. Next we provide some additional analysis of organizational capital constructed using a performance based approach.

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in logs and we can write: $K_{it}^{IC} = h^{IC}m^{IC}p^{IC}\widetilde{K}_{it}^{IC}$, where $\widetilde{K}_{it}^{IC}$ is the intangible that would result if we set all scaling parameters to one.

5.1 Expenditure-based estimates of intangible capital in UK firms

Table 5 provides a summary of the UK intangibles data characteristics, unweighted. In all cases, we divide through by sales to give an intensity measure comparable across firms. With respect to our organisation measures we see that the average value of compensation over the period is around 8 per cent of sales. In investment terms, this figure is much smaller – around 3 per cent of sales, however organisation capital represents around 10 per cent of sales. Note also that the median values are not dissimilar to the means, suggesting a relatively even distribution. R&D measures reveal around a 2 per cent mean for both compensation and investment for the period, thus on average compensation is relatively lower than for organisation workers. R&D capital is larger at 8.5 per cent of sales, reflecting its lower depreciation rate. Exploring the median values shows that there is much more variation in these data over time and sector, as we would expect. In the case of IT workers, as a proportion of sales, compensation, investment and capital are relatively small in comparison with the other intangibles, with ICT capital accounting for only 2 per cent of sales. Median values are significantly lower.

Overall, the table shows that on average across firms intangible investments account for around 6 per cent and intangible capital is approximately 21 per cent of sales, compared with 26 per cent for tangible capital. These are unweighted results, a mean across firms in the sample. Thus, the two forms of capital are comparable in magnitude. Our findings can be considered in the light of other UK studies however it is important to note that there are some marked differences in what the measures are designed to capture and construction. Haskel et al (2011), incorporate both purchased and own account intangibles in their measure. Recent international analysis by Jona-Lasinio et al (2011) finds that in Anglo-Saxon countries (Ireland and the UK), intangible shares of GDP are around 8.9 per cent in 2005 which is noticeably larger than our 6 per cent, however ours is an unweighted mean and relates to own account intangibles only which are a sub-component of what these other studies capture.

In Figure 3 we present the intangible intensity of value added using the expenditure based approach to constructing intangible capital. Here data are weighted to be broadly nationally representative. Intensities here are constructed as a proportion of the newly revised GVA, incorporating intangible investment. We see a slight increase in IT and organisation investment over the period. R&D investment over time is relatively sable, and both R&D and organisation investments are of similar magnitude. IT on the other hand is lowest, with an intensity of around 2 per cent of the new value added. Combined, intangible investments account for around 10 per cent of new value added, increasing their share very gradually over the 9 year period.

Table 6 provides correlations across firms of the capital measures with each other, including tangible capital (K). Whilst all are statistically significant and positively correlated, the greatest correlation is between IT and organisation capital (0.43). Given the nature of production, we would expect a positive and significant correlation and overall, the level of correlation is observed, but we feel that joint inclusion in econometric estimation is perfectly possible.

Figure 4 presents intangible capital intensity by broad sector. These data are averaged over the full 1998-2006 period. We see that Business Services (K) and Office Machinery and Precision equipment (DL) have the highest levels of intangibles. Composition of intangibles varies, R&D is more sector specific than organisation capital and IT capital tends to make the smallest contribution of the three assets. In Hotels and Restaurants (H), almost all intangible investment is organisation capital.

Figure 5 compares the UK under two different industrial structure scenarios – the existing one, and the EU average. Thus, the blue bars (to the right) indicate how the UK would look in terms of capital intensities were it to have an industrial structure of employment to the EU average. If the UK industrial structure looked more like the EU average manufacturing employment would be around a third higher. In terms of organisation and IT intensity, there would be very little difference although the UK is slightly more service intensive, which leads us to conclude that for these forms of capital, industrial structure is less influential. In the case of R&D, there is a small but clear difference between the UK as it is and the EU industrial structure. Were the UK to look more like the EU average, it is likely to have a higher R&D intensity. The biggest difference is in tangible capital intensity, although it is worth noting that in terms of tangible capital we are only able to capture plant, machinery and equipment, not property. This may affect our findings in relation to tangible capital.

In the constructed measures of intangibles here we focus exclusively on own account intangibles, embodied in the wages of the occupational groups identified here. We therefore do not include those that are purchased such as advertising, software or copyright/licence costs. Macro studies, for instance Haskel et al (2011) and Jona-Lasinio et al (2011) use as far as possible official data sources that are harmonized across countries to construct national measures of intangibles. For own account production they use Structure of Earnings Surveys (SES) from Eurostat and LFS data. Estimates of purchased intangibles are constructed from a variety of sources including Eurostat's Structural Business Statistics (SBS) and for R&D they use BERD data. Their core national accounts data are derived from EUKLEMS.

5.2 Performance-based estimates of organizational capital in UK firms

The above expenditure approach can be criticised because, in reality, wages can at best be only a proxy for marginal product of workers. The returns to successful management, for example, may well be reflected in the value of the firm over and above the amount that managers are paid in terms of salary. Under such conditions, we need to consider how good our proxy of the relative productivity of intangible workers is. Following Hellerstein, Neumark and Troske (1999), who focused on the gender pay gap, we adopt a means of testing expenditure based measures of marginal product with the construction of a performance based measure of organisation capital.

We begin with a standard Cobb Douglas function, where output is a function of labour (adjusted for quality/characteristics - QL), R&D expenditure (RD), capital (K), and intermediate inputs (M). In the case of our analysis, organisational capital workers are included, weighted by their wagebill share (equation 1; ORG).

Table 7 contains the results for the pooled random effects estimation of the production functions in order to construct the alternative, performance based measure of organisational capital. We estimate both with and without the organisational investment term and the GVA used for the dependent variable in both estimations is adjusted for the intangible assets. The first set of results we look at the productivity wage gap of organisational workers using the approach adopted in INNODRIVE, ignoring the suggest a relatively high marginal product for organisation workers, however, this approach ignores consistency in the treatment of organisational investment within the equation. In the second estimation which includes the organisational investment term to avoid double counting, ORG is removed from adjusted GVA. Relative marginal products still exceed wages but by less than the first column. The combined multiplier can be derived directly through this methodology and is 0.280, compared with the assumed 0.35 in the expenditure based model. Whilst this is a little lower, it broadly supports the initial estimate (an EU approximation rather than UK specific) and acts as a useful check on the plausibility of one of the assumptions made in the expenditure based approach. Combined with the estimate of relative marginal product, this yields a total multiplier of 0.33 as shown in Table 4. This is very similar the multiplier used in the expenditure based approach.

As well as a pooled regression, we estimate the production function within a panel framework, across time and broad industry groups. Table 8 contains the mean values of the estimated coefficients. These are generally consistent with the coefficients reported in Table 7 (first column) with the exception of ORG Asset, which is halved and tangible capital, which is almost doubled compared the pooled results. In table 9 results are presented separately by broad sector. We note that the marginal product of IT capital is largest with respect to business services and lowest in manufacturing. R&D capital has its lowest coefficient in other sectors (construction; utilities) and is highest in business services. With respect to organisation capital, the return appears to be lower in retail than in all other sectors. The relative productivity of organisational workers is highest in manufacturing and business services.

The performance based measure has a number of advantages, not least that the time profile appears more consistent with other studies. We compare the findings from both approaches – expenditure and performance based organisation capital in Figure 6. The performance based measure is more volatile than the expenditure based, peaking at 6 per cent of new value added in 2001, consistent with others findings. This compares with a share of only 4 per cent in the expenditure based measurement. Here we have measured only the organisation capital using this method, were we to estimate R&D this way, it is likely that R&D ratios would be lower and therefore more consistent with existing studies. However, the performance based measure is perhaps also more all encompassing in the sense that it may also capture purchased intangibles as well as own account measures. In the pooled regression (table 7) we estimate the equation with and without the organisation investment term. When the investment term is excluded we see a much higher relative productivity, consistent with the findings in other innodrive countries. A caveat to our findings is the probability that our findings are likely to be affected by multicolinearity.

6. INTANGIBLE CAPITAL AND PERFORMANCE

Given the results we observe in the construction of the performance based measure of organisation capital, we would expect to find a positive association between firm performance and all forms of intangible capital. In order to evaluate the contribution to sector level performance of our measure of intangible capital, we aggregate our firm level data to an aggregate sectoral level and perform a simple growth accounting exercise. This enables us to compare our findings with other UK studies (Giorgio-Marrano et al, 2009; Haskel et al, 2011) which apply a similar methodology to more aggregate data. In our growth accounting approach we follow a translog production function, and following Diewert (1976), in applying tornqvist index as an approximation of the Divisia index (Jorgenson et al, 1987), decomposing growth into its various components:

$$\Delta \ln Q_{jt} = \Delta \ln A_{jt} + \alpha_{jt} \Delta \ln L_{jt} + (1 - \alpha_{jt}) \Delta \ln K_{jt} \qquad (6)$$

Where α_{jt} is the share of labour in value added (labour costs divided by value added) averaged over period t and t-1. In studies relating to the impact of ICT on productivity, this has involved quality adjustment of capital, accounting for substitution between new technology and traditional capital. Details of the derivation of intangible capital shares are presented in Görzig et al (2011)

The growth accounting results are presented in tables 10 to 12. In the first panel, standard growth accounting results are presented, where intangible capital is not included. This is our base-line check. Over the period, we see average annual growth rates in labour productivity of around 3.6 per cent per annum, consistent with other studies. MFP is estimated to be growing at around 2.3 per cent over the period and tangible capital at 1.4 per cent per annum. Incorporating intangibles using the expenditure based measures sees a slight average decline in annual labour productivity, which is concentrated in the second half of the period (2003-2006). MFP also falls relatively to the baseline, and we see a very small decline in tangible capital too. Intangible assets each contributes around 0.1 per cent average annual labour productivity growth over the full period, for R&D and organisation capital, this is a slightly larger contribution in the earlier period. In any case, the magnitude of intangible capital is as much as one third of tangible capitals contribution to labour productivity growth. If we consider the performance based measure of organisation capital we see more variation, with organisation capital having a negative effect on labour productivity growth in the later 2003-2006 period. Overall, however, there is little difference between the contribution made in the expenditure and performance based approaches. What is noticeable is the differential impact it has on labour productivity growth across the two periods.

Our findings bear some similarities to existing measures of intangible capital, particularly in terms of time profiles. However, we note again that our data capture own account intangibles and not purchased intangibles. In addition, ours is a measure of firm specific intangible capital whereas other estimates for the UK have been constructed at the aggregate level.

There are reasons also to suppose that our estimates would benefit from further refinement. The growth accounting exercise here makes no adjustment for labour quality; therefore there is a distinct possibility that human capital (individual rather than firm specific knowledge) is conflating our intangible capital measures. Even if these two terms are not highly correlated, at the very least, by omitting this control, the unexplained residual, the MFP component, is likely to be overestimated.

7. CONCLUSIONS

In this paper, we present the method of construction used to create firm level intangible capital stock measures for the UK. We have followed the emerging macroeconomic literature with regards to a number of assumptions, subject to UK data limitations and idiosyncrasies. Specifically, our measure captures own account intangible assets and not those purchased directly from the market. This component is crucially important given the firm specific nature of intangibles, which leads us to believe that much of it is untraded and therefore difficult to measure. Having constructed the data, we explore the plausibility of our data and test alternative construction methods. Using the growth account methodology and by aggregating our firm level data to national estimates, we find that intangibles contribute 0.4 per cent to average annual labour productivity growth (tables 11 and 12). The time profiles differ depending on the method of organisation capital calculation; when the expenditure approach is used, the contribution is more even across the two periods, the performance based approach suggests that in the earlier period, labour productivity growth benefitted more from intangibles, with less of a contribution in the second half of the period under consideration.

Our data reveal a number of insights. Firstly, we observe a positive association between intangible assets and productivity at the firm level. Whilst expected, this helps us to explain sources of firm level heterogeneity more robustly than previously possible. We also note a tendency for firms to bundle intangible assets, particularly ICT and organisation capital. This is consistent with the findings of Bloom et al (2007) which found complementarity between organisational assets and IT investment. Thus we indirectly observe evidence of complementarities between these intangible assets. Moreover, there appears to be complementarities between intangible and tangible capital, consistent with the idea of capital-skill complementarity (Goldin and Katz, 1998).

We find that whilst our growth accounting results broadly correspond to other UK figures, there are discrepancies which are driven in part by different data sources and subsequent sectoral coverage. In addition, we need to emphasise that our study focuses on own account intangible assets and not purchased intangibles. It is also worth noting that the UK results differ from those of other EU countries, in part the result of different industrial structure since the UK is more heavily involved in the service sector compared to the EU average. .

The main purpose of this paper has been to chart the construction of these data and illustrate some of its key properties. Whilst aggregate sector data have been constructed elsewhere, this is the first time that firm level data have been constructed to explore the role that own account intangible assets play in the production process. In this way, the data have considerable potential to provide further insight, not only in terms of the direct associations between intangibles and productivity (Riley and Robinson, forthcoming) and how different inputs in the production process interact but also with respect to indirect associations with productivity through regional or industrial spillovers. These are areas of on-going research but depend heavily on the plausibility of the data constructed here.

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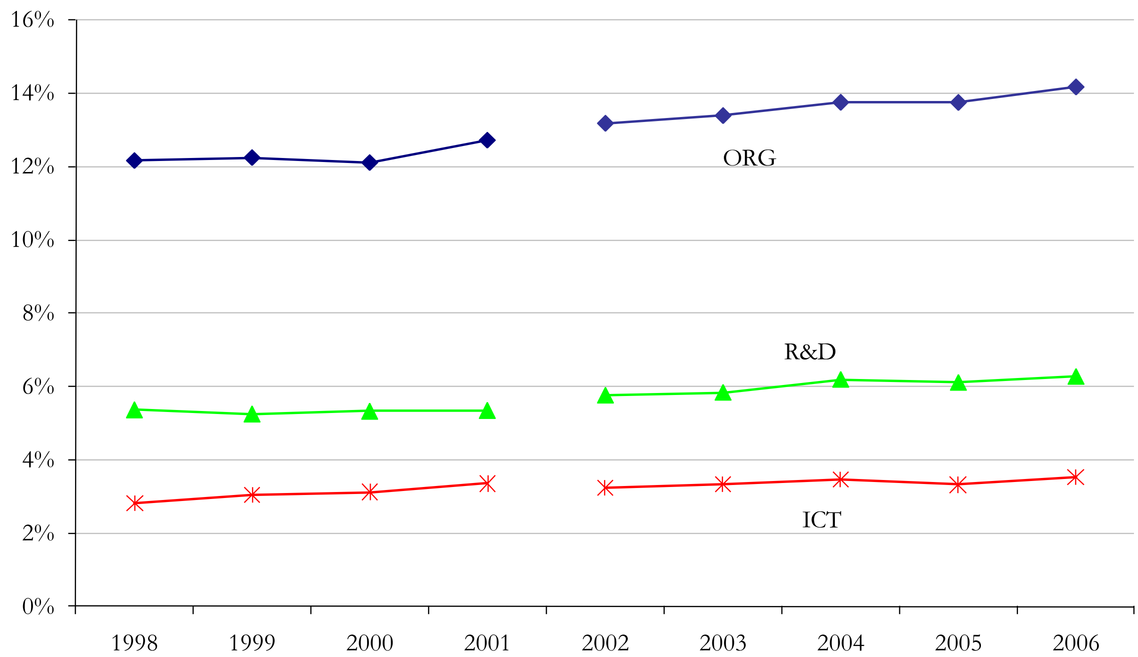
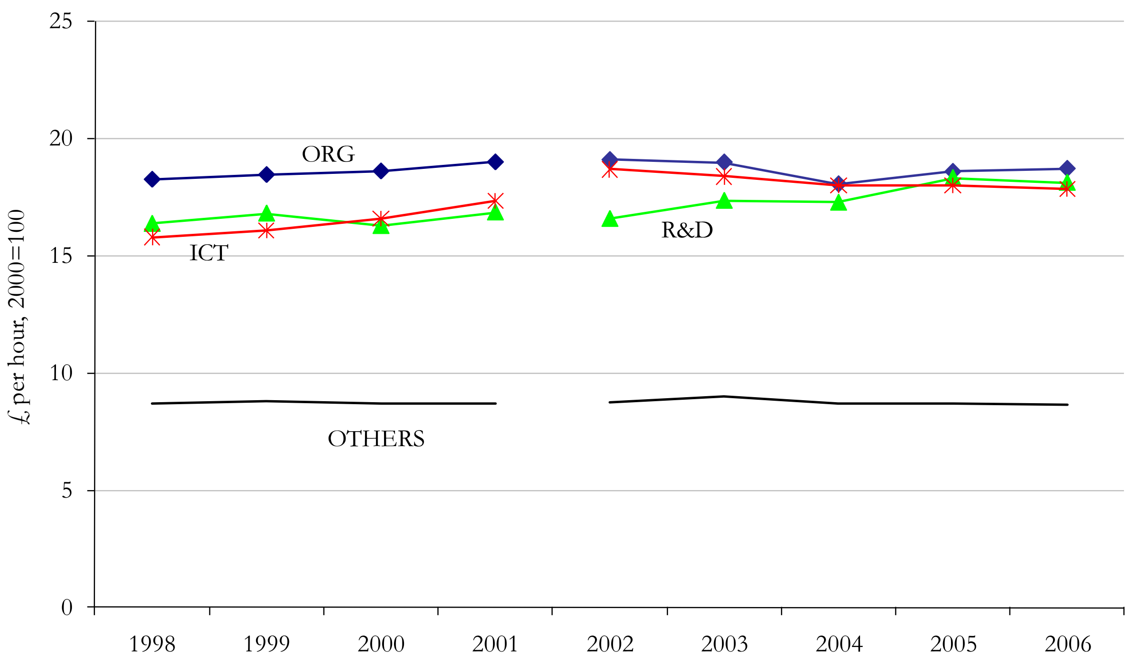
Figure 1. Employment Shares of Workers in Intangible Producing Occupations



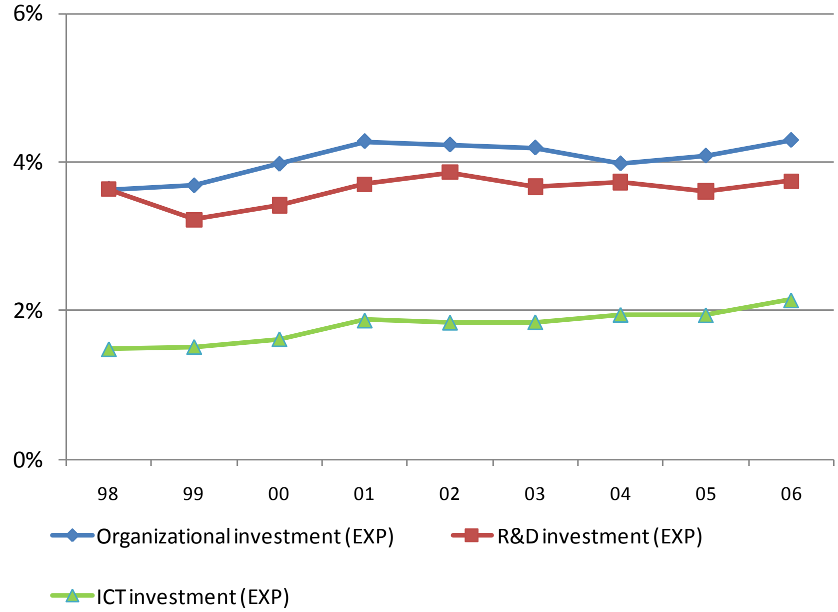
Notes: Non-Farm private business sector excl. CA, E, F, J
Source: Annual Survey of Hours and Earnings, Labour Force Survey

Figure 2. Hourly Labour Costs of Workers in Intangible Producing Occupations



Notes: Non-Farm private business sector excl. CA, E, F, J; Deflated by average earnings index (2000=100).
Source: Annual Survey of Hours and Earnings, Labour Force Survey

Figure 3. UK Intangible capital intensity per new value added



Notes: Non-Farm private business sector excl. CA, E, F, J; Own account production of intangible assets.
Source: Annual Survey of Hours and Earnings, Labour Force Survey

Figure 4. UK Intangible capital intensity per new value added (by industry, mean 1998-2006)

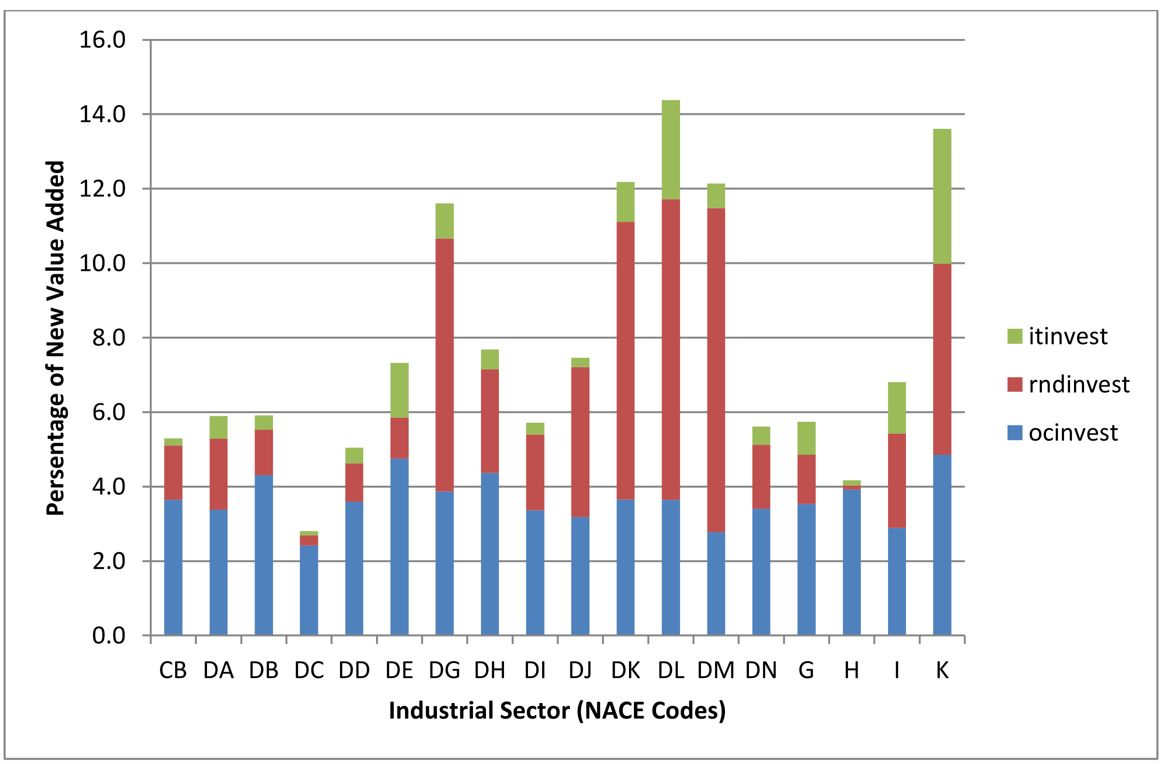
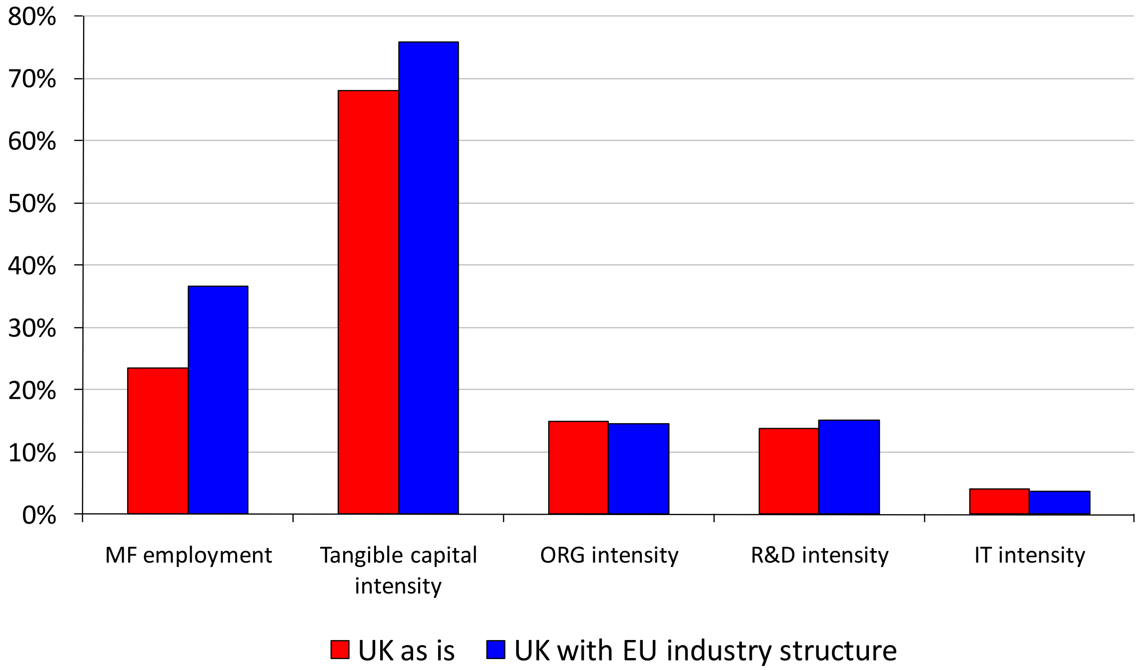
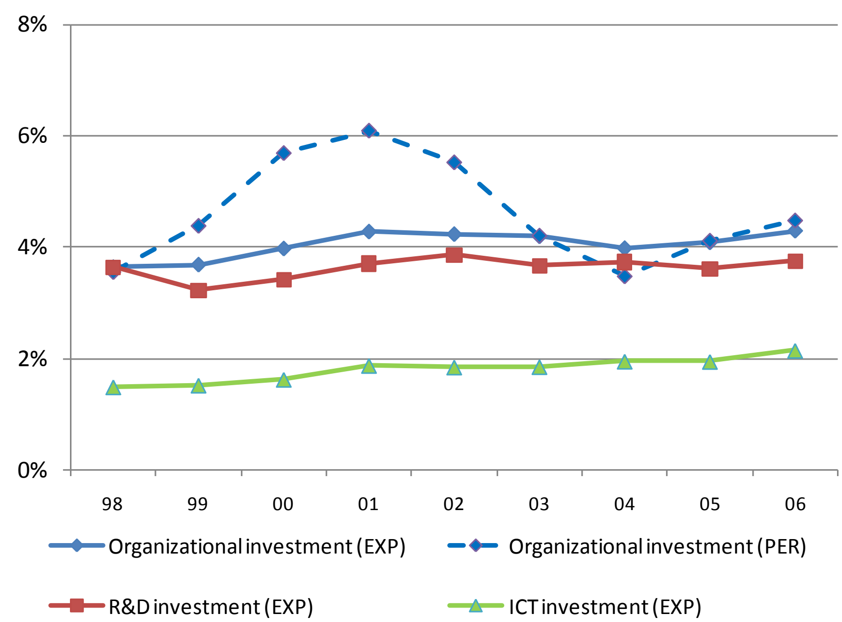


Figure 5. UK Intangible capital intensity with EU industry structure of employment



Notes: Figures calculated for the non-farm business sector excl. agriculture, finance, utilities and construction; Capital intensities refer to capital intensity of GVA; Tangible capital includes plant, machinery and equipment capital.

Figure 6. UK Intangible capital intensity per new value added (two approaches)



Notes: Non-Farm private business sector excl. CA, E, F, J; Own account production of intangible assets.
Source: Annual Survey of Hours and Earnings, Labour Force Survey

Table 1. Number of different linking cells between ASHE and ABI

	Linking cells	Nace3 cats
1998	271	163
1999	273	164
2000	269	165
2001	272	163
2002	266	161
2003	268	162
2004	272	163
2005	268	163
2006	270	162

Notes: Linking cells distinguished by firm size and industry; Linking cells for non-farm non-financial business sector.

Table 2. Correlation of occupational distributions of the firm

	Share of employees	Share of hours	Share of labour costs
Organisation	0.524	0.529	0.504
R&D	0.762	0.760	0.735
ICT	0.803	0.803	0.734

Notes: Correlations across 3633 firm-year observations; All statistically significant at the 1% level; Correlations are between measures derived from the 1% sample of employees in the firm and from the 1% sample of employees in the industry/firm-size catgeory.

Table 3. Sample coverage (% of total GVA and employment in included sectors)

	GVA	Employment
YEAR		
1998	32.1%	34.6%
1999	30.5%	35.9%
2000	35.6%	39.5%
2001	36.7%	40.6%
2002	37.0%	41.5%
2003	33.1%	37.9%
2004	35.5%	40.2%
2005	35.9%	41.4%
2006	33.4%	37.9%
NACE		
CB	14.3%	16.8%
DA	25.5%	27.9%
DB	31.8%	34.9%
DC	27.7%	35.6%
DD	25.3%	28.8%
DE	35.8%	34.2%
DG	27.3%	34.6%
DH	29.9%	31.9%
DI	27.5%	32.2%
DJ	24.3%	29.8%
DK	31.3%	34.9%
DL	31.8%	33.6%
DM	30.0%	34.0%
DN	31.8%	36.3%
G	31.4%	44.3%
H	50.4%	43.1%
I	44.0%	40.2%
K	36.6%	36.7%

Notes: 98788 firm-year observations; Total GVA and employment from ABI published totals published by ONS (vintage 29/07/2010) available at http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=15360.

Table 4: Scaling parameters for calculating intangible investment

	Expenditure approach			Performance	
	ICT	R&D	ORG	R&D	ORG
Investment share of labour, h^{IC}	0.5	0.7	0.2	~	~
Factor multiplier, m^{IC}	1.48	1.55	1.76	~	~
$h^{IC} * m^{IC}$	0.7	1.1	0.35	0.54	0.28
Ratio of productivity to wages, p^{IC}	1	1	1	1.66	1.17
$h^{IC} * m^{IC} * p^{IC}$	0.7	1.1	0.35	0.90	0.33

Table 5: Intangible capital in UK firms (unweighted characteristics, 1998-2006)

Variable	Mean	Standard Deviaton	Median Value
ORG Compensation / Sales	0.078	0.060	0.062
ORG Investment EXP / Sales	0.027	0.021	0.022
ORG Capital EXP / Sales	0.100	0.073	0.084
R&D Compensation / Sales	0.020	0.041	0.008
R&D Investment / Sales	0.022	0.045	0.008
R&D Capital / Sales	0.085	0.140	0.040
ICT Compensation / Sales	0.013	0.036	0.004
ICT Investment / Sales	0.009	0.025	0.003
ICT Capital / Sales	0.021	0.046	0.009
Intangible Investment EXP / Sales	0.058	0.065	0.038
Intangible Capital EXP / Sales	0.210	0.190	0.150
Tangible (plant, machinery & equipment) capital / Sales	0.260	0.290	0.170

Notes: 98788 observations; Minimum and maximum values not reported due to disclosure rules; Intangible capital includes Organization, R&D and IT capital.
Source: Annual Survey of Hours and Earnings, Labour Force Survey, Annual Business Inquiry

Table 6: Correlations of intangible capital (relative to sales) across firm-year observations

	ORG	R&D	ICT
R&D	0.28	1.00	
ICT	0.43	0.23	1.00
K	0.18	0.12	0.15

Notes: 98788 observations; All variables measured relative to sales; All statistically significant at the 1% level.

Table 7: Pooled production function estimates: ORG capital

	DPV = Adjusted GVA	DPV = Adjusted GVA less ORG investment
ORG worker share	0.921	0.660
	(25.53)	(16.86)
ORG Asset	0.200	0.197
	(30.13)	(28.78)
Employment	0.485	0.484
	(76.42)	(73.35)
IT Asset	0.107	0.108
	(56.48)	(54.33)
R&D Asset	0.128	0.128
	(56.60)	(53.50)
Tangible Capital	0.045	0.047
	(13.24)	(13.27)
ORG Investment Term		-0.661
		(6.44)
Observations	98788	98788
Firms	35890	35890
σ_u	0.499	0.517
σ_e	0.354	0.382
ϱ	0.665	0.646
Relative Marginal Products	2.898	2.362
	(39.37)	(29.68)
Combined Multiplier		0.280
		(6.64)

Notes: Random effects log estimates with robust t-statistics in parentheses; Dummy variables for industry*year interactions included; Adjusted GVA = Value added plus investment in intangibles.

Table 8: Average coefficients and t-statistics of yearly estimates (1998-2006)

Panel Mean Estimate		DPV = Adjusted GVA
Employment	coeff	0.561
	t-stat	(12.65)
	weighted coeff	0.550
IT Asset	coeff	0.125
	t-stat	(4.00)
	weighted coeff	0.094
R&D Asset	coeff	0.124
	t-stat	(6.20)
	weighted coeff	0.121
ORG Asset	coeff	0.106
	t-stat	(4.56)
	weighted coeff	0.119
Tangible Capital	coeff	0.077
	t-stat	(5.14)
	weighted coeff	0.075
Estimated Ratio of Marginal Products	coeff	2.287
	t-stat	(4.09)
	weighted coeff	2.857

Notes: The table shows the average coefficient, Fama and MacBeth's "t-statistics" and weighted average coefficients over industries and years with inverse of variance as weight; 98788 observations.

Table 9: Average coefficients by industry group (1998-2006)

Industry	Firms		L	IT	R&D	ORG	K	ORG workers versus non-ORG workers: **Estimated Ratio of Marginal Products**	ORG workers versus non-ORG workers: **Ratio of Hourly Wages**
Manufacturing	35,889	coeff	0.599	0.053	0.135	0.133	0.086	**3.05**	**2.05**
		t-stat	(16.7)	(15.7)	(28.6)	(4.4)	(28.5)	**(16.8)**	
		weighted coeff	0.580	0.053	0.136	0.149	0.085	**3.09**	
Business Service Sector (Finance not included)	24,897	coeff	0.449	0.199	0.155	0.111	0.088	**4.16**	**2.00**
		t-stat	(20.0)	(18.0)	(23.2)	(5.4)	(11.9)	**(13.8)**	
		weighted coeff	0.444	0.199	0.153	0.112	0.084	**3.99**	
Trade and Consumer Services	24,896	coeff	0.592	0.138	0.139	0.053	0.039	**-0.31**	**2.03**
		t-stat	(44.3)	(12.5)	(31.2)	(2.7)	(6.6)	**(0.3)**	
		weighted coeff	0.589	0.140	0.139	0.055	0.036	**0.50**	
Other (Construction, Hotels, Utilities)	13,106	coeff	0.606	0.110	0.067	0.128	0.093	**2.25**	**1.93**
		t-stat	(34.2)	(23.6)	(21.3)	(12.1)	(6.5)	**(7.0)**	
		weighted coeff	0.607	0.109	0.067	0.128	0.077	**2.15**	

Table 10: Growth accounting results (Standard)

Year	Labour productivity	MFP	Tangible capital	Organization capital	R&D capital	ICT capital	Total Intangibles
1999	5.0 %	3.7 %	1.4 %	0.0 %	0.0 %	0.0 %	0.0 %
2000	2.3 %	1.8 %	0.4 %	0.0 %	0.0 %	0.0 %	0.0 %
2001	1.4 %	0.7 %	0.7 %	0.0 %	0.0 %	0.0 %	0.0 %
2003	1.7 %	0.3 %	1.4 %	0.0 %	0.0 %	0.0 %	0.0 %
2004	7.1 %	4.9 %	2.2 %	0.0 %	0.0 %	0.0 %	0.0 %
2005	3.5 %	1.7 %	1.8 %	0.0 %	0.0 %	0.0 %	0.0 %
2006	4.4 %	2.7 %	1.6 %	0.0 %	0.0 %	0.0 %	0.0 %
Average 1999-2001	2.9 %	2.1 %	0.8 %	0.0 %	0.0 %	0.0 %	0.0 %
Average 2003-2006	4.2 %	2.4 %	1.8 %	0.0 %	0.0 %	0.0 %	0.0 %
Average all years	3.6 %	2.3 %	1.4 %	0.0 %	0.0 %	0.0 %	0.0 %

Table 11: Growth accounting results (Expenditure based)

Year	Labour productivity	MFP	Tangible capital	Organization capital	R&D capital	ICT capital	Total Intangibles
1999	4.2 %	2.9 %	1.3 %	0.0 %	0.0 %	0.1 %	0.1 %
2000	2.6 %	1.5 %	0.4 %	0.2 %	0.3 %	0.2 %	0.7 %
2001	2.0 %	0.7 %	0.6 %	0.2 %	0.3 %	0.2 %	0.7 %
2003	1.5 %	0.2 %	1.3 %	0.1 %	-0.1 %	0.0 %	0.0 %
2004	6.6 %	4.1 %	2.0 %	0.0 %	0.3 %	0.2 %	0.5 %
2005	3.3 %	1.5 %	1.6 %	0.1 %	0.0 %	0.0 %	0.2 %
2006	4.6 %	2.4 %	1.5 %	0.3 %	0.3 %	0.2 %	0.8 %
Average 1999-2001	2.9 %	1.7 %	0.8 %	0.2 %	0.2 %	0.1 %	0.5 %
Average 2003-2006	4.0 %	2.0 %	1.6 %	0.1 %	0.1 %	0.1 %	0.4 %
Average all years	3.5 %	1.9 %	1.2 %	0.1 %	0.1 %	0.1 %	0.4 %

Table 12: Growth accounting results (Performance based)

Year	Labour productivity	MFP	Tangible capital	Organization capital	R&D capital	ICT capital	Total Intangibles
1999	5.0 %	3.4 %	1.3 %	0.3 %	0.0 %	0.1 %	0.3 %
2000	3.6 %	1.9 %	0.4 %	0.8 %	0.3 %	0.2 %	1.2 %
2001	2.0 %	0.5 %	0.6 %	0.5 %	0.3 %	0.2 %	0.9 %
2003	0.3 %	-0.3 %	1.3 %	-0.6 %	-0.1 %	0.0 %	-0.7 %
2004	6.1 %	3.9 %	2.0 %	-0.3 %	0.3 %	0.2 %	0.2 %
2005	3.8 %	2.0 %	1.6 %	0.1 %	0.0 %	0.0 %	0.2 %
2006	4.8 %	2.5 %	1.5 %	0.3 %	0.3 %	0.2 %	0.8 %
Average 1999-2001	3.5 %	1.9 %	0.8 %	0.5 %	0.2 %	0.1 %	0.8 %
Average 2003-2006	3.7 %	2.0 %	1.6 %	-0.1 %	0.1 %	0.1 %	0.1 %
Average all years	3.6 %	2.0 %	1.2 %	0.2 %	0.1 %	0.1 %	0.4 %