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Intangible Assets and Investments at the Sector Level – Empirical Evidence for Germany

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1 Introduction

EU policy has acknowledged that nowadays knowledge has become a key factor for firms to survive and grow in the increasingly globalised economy. This had found expression in the Lisbon agenda that aimed to make the EU “the most competitive and dynamic knowledge-driven economy by 2010” and also in the new EU2020 strategy that emphasizes that growth should be smart, sustainable, and inclusive. Smart growth means developing economies based on knowledge and innovations. Thus strengthening the efficiency and competitiveness of firms in the knowledge driven economy is a major challenge that the EU economies are currently confronted with.

A key characteristic of knowledge is its intangible nature which makes it hard to measure its amount, quality or effects. Furthermore, investments in such intangible knowledge assets may take place in very different forms. In a recent work, Corrado et al. (2004, 2006; henceforth CHS) propose how to define and measure intangible assets. They distinguish three broad categories of intangibles: Business investment in computerized information, innovative property and economic competencies: Computerized information consists of investments for computer software and computerized databases. Innovative property reflects scientific knowledge embedded in patents, licenses, and general know-how (not patented) on the one hand but also the non-scientific innovative and artistic content in commercial copyrights, licenses, and designs on the other hand. This is captured by the following five components: expenditure for R&D in natural and social sciences, mineral exploration, copyright and licences, new product development costs in the financial industry and spending on new architectural and engineering designs. Finally, economic competencies involve investments aimed at raising productivity and profitability other than software and R&D. Corrado et al. specified such economic competencies as value of brand names and other knowledge embedded in firm-specific human and structural organizational resources.

Using the CHS approach, recent evidence at the macro level has shown the importance of investment in intangible assets for economic growth in many countries. However, it has also been revealed that many European countries are lagging behind the US figures. For instance, investment in intangible assets amounts to 11.7% of GDP in the US. It is this even larger than the investment in physical capital (Corrado et al., 2006). Within Europe, the UK invests the highest proportion of GDP for intangible assets, but which is still roughly 1.5 percentage points below the US (10.1%; Marrano and Haskel, 2006). In other European countries it is even less: 9% in Sweden (Edquist, 2009), 7.0% in Germany (Crass et al., 2010), 6-7% in France (Delbecque and Nayman, 2009), 5.2% in Spain and 5.15% in Italy (Hao et al., 2009). A similar pattern emerges for the contribution of intangible assets to growth. In the US, investment in intangible assets has stimulated labour productivity growth by 0.84 percentage points, whereas the contribution in European countries varies between 0.6 to 0.2 percentage points (0.58 in UK, 0.53 in

Germany, 0.34 in Italy and 0.19 in Spain). One exception is Sweden where intangible capital has accounted for 1.8 percentage points of the labour productivity growth rate.

There might be different reasons why European countries are lagging behind and which might lead to quite different policy conclusions. On the one hand European firms might invest less in knowledge capital than their US competitors within the same industry. Another explanation of why these figures differ across countries might be because of varying industry structures in these countries and the fact that industries[1] might behave differently in terms of the amount and composition of intangible investment. Of course, it might also be a mixture of both. The empirical evidence, however, on how much sectors invest in which type of intangible asset and how this affects economic growth at the sector level, is scarce up to now. One aim of the Coinvest project was therefore to extend the CHS approach to the sector level.

This study presents first sector-level evidence for investment in intangible capital in Germany. It consists of two major parts. In the first part, we aim at *measuring spending and investment in intangibles at the sector level*. We will provide different data sources, shed light on differences across sectors but also compare these figures with investment in physical capital and with investment in intangibles in other countries. In the second part, we explore the *role of intangible assets for stimulating growth at the sector level* by performing growth accounting analyses.

In what follows, section 2 starts with a definition of the sector classification that we apply in this study. Section 3 presents data sources for each category of intangible assets as well as their availability at the sector level and over time. We will furthermore show the development of investment in intangibles in the above mentioned six sectors. Whereas the first three subsections discuss figures for each single category, the last subsection 3.4 will condense the information by looking at the three main broad categories innovative property, economic competencies and computerized information, i.e. their sharing out among sectors and their development within sectors over time. Subsequently, section 4 will compare investments in intangible assets with those in tangible capital in German sectors. In order to internationally assess investments in intangible assets in German industries, we will compare our results with sector-level figures from the UK in section 5. Section 6 will examine the role of intangible capital in explaining productivity growth at the sector level by performing growth accounting analyses for the six industries. Besides studying industry-level sources of economic growth, we will trace the sources of aggregate productivity growth and input factor growth to their industry origins. Section 7 finally summarizes our main findings.

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[1] In the following, the terms sector and industry are used interchangeably.

2 Sector classification

To allow a comparison between the countries within the Coinvest project, we follow the work of CHS very closely and estimate investment in intangible assets according to the categories they proposed. We furthermore apply the same industry breakdown. Following Gil and Haskel's (2008) classification of industries for the UK, we exclude all non-business sector categories (public administration, education, health, personal services, private households and extra-territorial). For the remaining business sector (BuSec), we distinguish six main industries of interest though for some of the time series a more detailed industry breakdown is available. Using the European-wide industry classification NACE Rev. 1.1, we define:

1. Agriculture, Fishing & Mining ((in the following: "agriculture & mining", AgMin) – NACE: A,B,C

2. Manufacturing (Mfr) – NACE: D

3. Electricity, Gas & Water (Utility) – NACE: E

4. Construction (Cons) – NACE: F

5. Wholesale and Retail, Hotels and Restaurants, Transport and Communications (in the following: "trade & transport", RetHtTrn) – NACE: G, H, I

6. Financial Intermediation and Business Services (FinBsSvc))– NACE: J, K

To give an overview of the importance of each of the industries, Table 2-1 depicts the share in aggregate gross output, value added and labour input (hours worked). The figures show that in Germany manufacturing makes up the largest share in aggregate gross output. Nearly 44% of total gross output has been produced by manufacturing in the period 1997-2006, followed by the sectors trade & transport and financial & business services, both having a share of about 22%. On the contrary, the financial & business service sector present the largest proportion in value added (37%). Its share is roughly 7 and 13.5 percentage points higher than the value added share of manufacturing and trade & transport sector, respectively. Compared to manufacturing and financial and business services, the sector trade & transport is more labour-intensive. We can observe the highest share of total hours worked in the sector trade & transport (35%), followed by manufacturing (28.5%) and financial & business services (21%). The industry share of construction amounts to 6-10%, depending on the indicator. The other two sectors are rather small with a share of 2-3%.

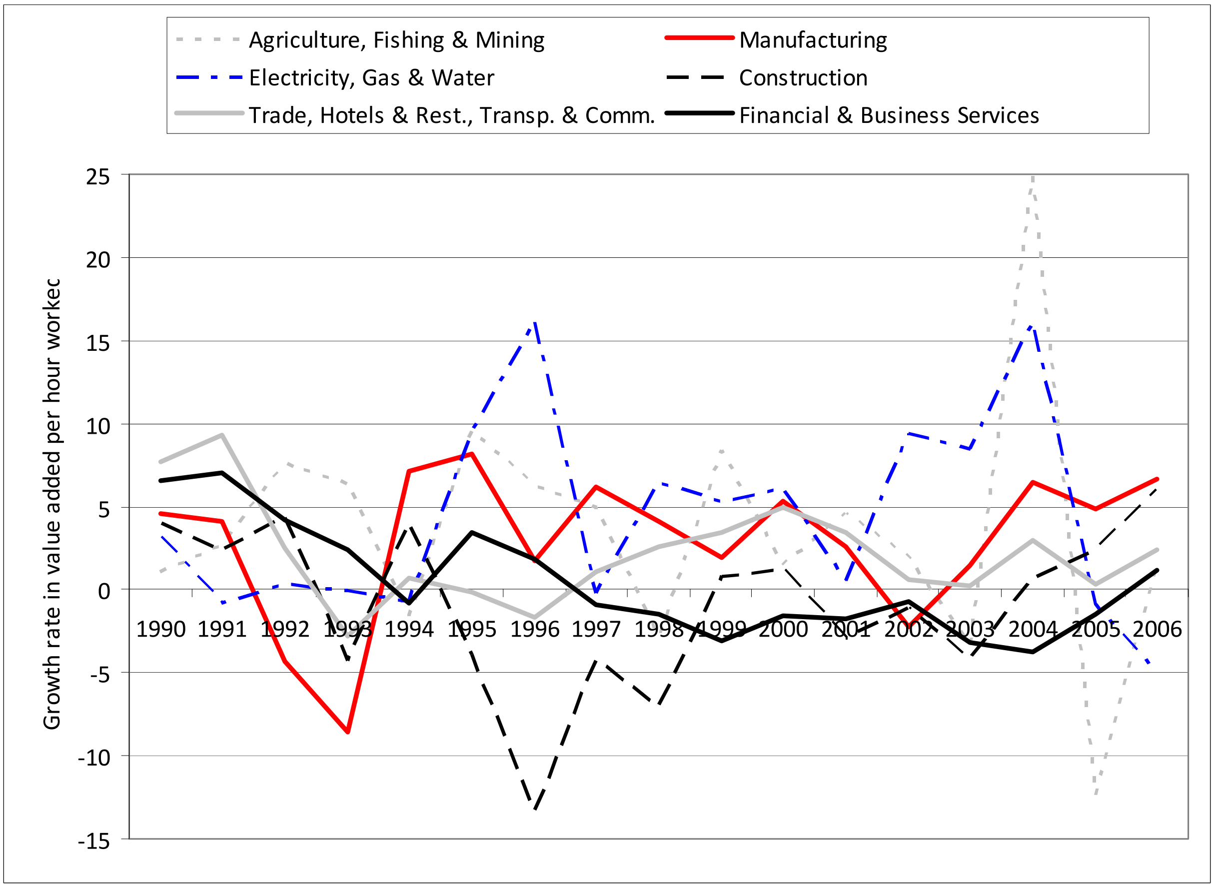
Table 2-1: Industry share in gross output, value added and labour, 1997-2006

Industry share in	1 AgMin	2 Mfr.	3 Utility	4 Cons.	5 RetHtTm	6 FinBsSvs	7 Total
Gross output	0.022	0.439	0.027	0.072	0.220	0.219	1.000
Value added	0.018	0.294	0.028	0.062	0.231	0.367	1.000
Labour	0.045	0.285	0.011	0.102	0.348	0.209	1.000

Notes: Presented are average annual industry shares. Data: EU KLEMS. Own calculation.

Figure 2-1 demonstrates that the annual growth rates in value added per hour worked indeed vary quite a lot across sectors in Germany. The open question that we address in this study is to what extent does intangible capital (or do other factor inputs) account for these differences and to what extent do sector differences translate to aggregate productivity growth?

Figure 2-1: Annual growth rates in value added per hour worked by industries, 1991-2008



Source: EU KLEMS Nov2009 Release, own calculation.

3 Measurement of intangible investment by category and sector

This paper follows the methodological framework set up by CHS (2006). Below we present data sources and estimated time series for different categories of intangible assets at the sector level. With respect to data sources, this work draws on previous work done at the macro level in Germany (see Crass et al., 2010). Crass et al. performed various sensitivity analyses for measuring intangible capital in Germany using alternative data sources, in particular for measuring new development costs in the financial industry, brand equity, and firm-specific human capital. All data sources are described in more detail with respect to data availability, main advantages and drawbacks in Crass et al. Hence, we also refer the interested reader to this paper for further information.

3.1 Computerised information

The first category, computerized information, reflects knowledge embedded in computer programs and computerized databases (Corrado et al. 2004). Therefore, computerized information is made up of two components, the investment in purchased and own account computer software and the investment in new computerized databases.

3.1.1 Investment in own account computer software

Compared to most of the other intangible assets, computer software is already viewed as investment in the German national accounts. For own account computer software we use data provided by the EU KLEMS November 2009 Release. EU KLEMS publishes estimates of the investments in software at the industry level in Germany for the period 1991 to 2007 (Figure 3-1). As in Corrado et al. (2004, 2006) it is assumed that 100% of software spending can be regarded as investment. At EU KLEMS, software figures are available at the 2 digit level, in some cases several 2-digit industries have been summarised.[2] However, for comparability reasons we have consolidated the information into the six industries explored in section 1: Note software investment carried out in the public and private household sector like community social and personal services has been excluded. In case where figures where not available in EU KLEMS using the 6-industry classification (for instance for sector agriculture and fishing (A-B) and mining (C) which we summarize to A-C), the aggregation of indices across sectors has been done using a Tornquist-weight. This procedure applies to sector 1, 5 and 6.

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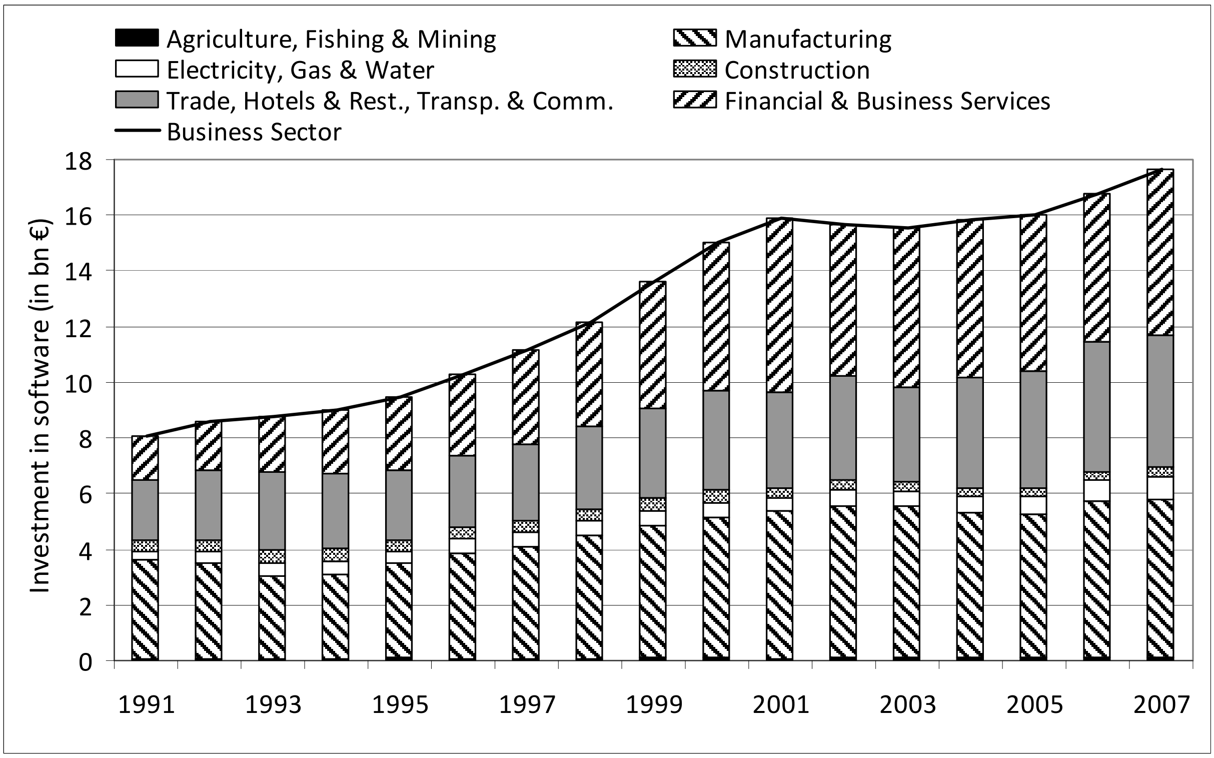
[2] More precisely, the following industry breakdown in given in EU KLEMS based on the industry classification NACE Rev. 1.1: NACE A-B (agriculture & fishing), C (mining and quarrying), D (manufacturing that is further split into the NACE industries 15-16, 17-19, 20, 21-22, 23, 24, 25, 26, 27-28, 29, 30-33, 34-35, 36-37), E (electricity, gas and water supply), F (construction), G (wholesale and retail trade, further broken down into 50, 51 and 52), H (hotels and restaurants), I (transport and storage, further broken down into 60-63 and 64), J (financial intermediation), K (real estate, renting and business activities, further split into 70 and 71-74) as well as the public and private sector (75, 80, 85, 90, 95, 99).

Figure 3-1 depicts the distribution of software investment across sectors in Germany (detailed numbers are given in Table 10-3 in the Appendix). In total, investment in software has been more than doubled from 8 bn € to nearly 18 bn € in 2007 with a slight slump after the new economy boom within the period 2002-2004. However, a more detailed look at the figures reveals that the development turns out to be quite different across industries. In construction, for instance, investment in software declined over time leading to a fall off in the proportion of software investment accounted for by this sector from 4.6% to 1.9%. On the other side, financial and businesses services boosted their software investment from 2.6 bn € in 1991 to 6.0 bn € in 2007 (with a peak of 6.2 bn € in 2001). As a consequence, the proportion of software investment undertaken by this sector has increased from 28% to 34%. Though manufacturing firms have raised their investment in software as well (from 3.4 to 5.6 bn €), they have lost in terms of relative importance. The proportion of software investment that is carried out in manufacturing has declined from 36% to 32%. Software investment in trade & transport has also increased leading to a share in overall investment that fluctuates around 25%.

Figure 3-1: Investment in computer software by sector, 1991-2007



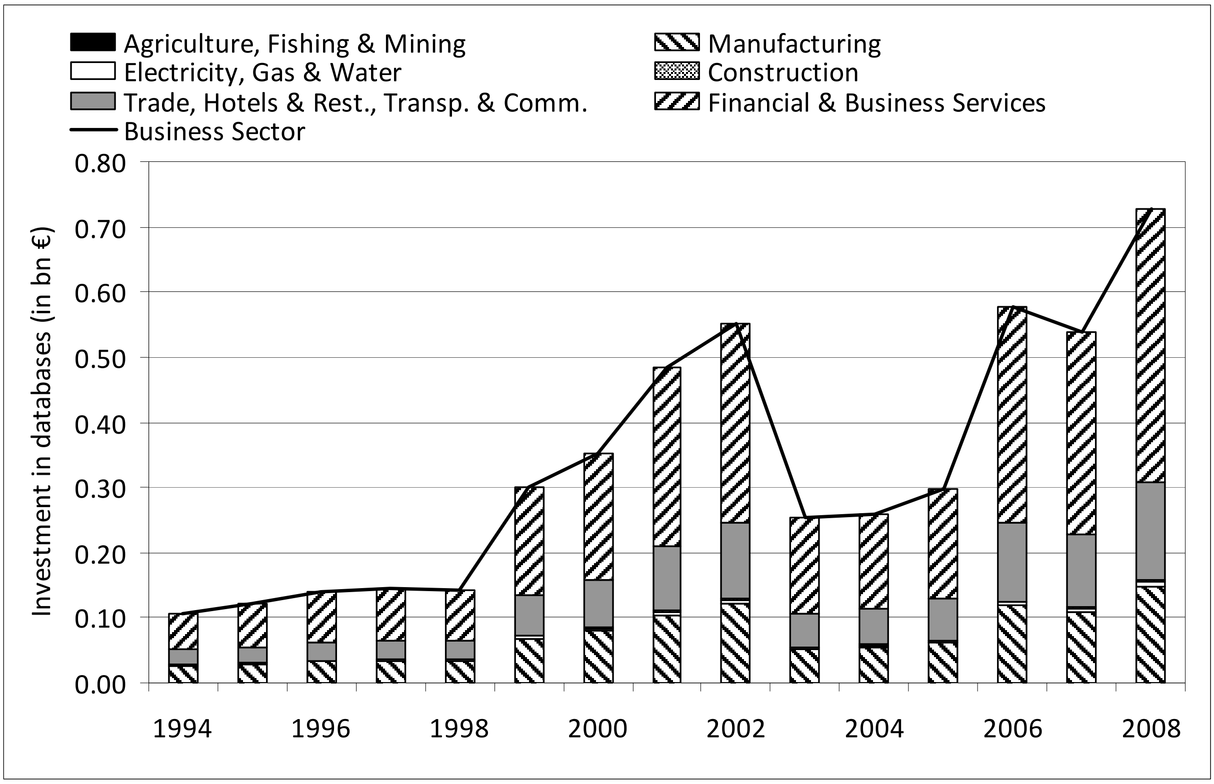
Source: EU KLEMS Nov2009 Release, own calculation.

3.1.2 Investment in new computerized databases

Information for new computerized databases is gathered from the German turnover tax statistics. The overall expenditure for new databases is measured by the sales of NACE class 72.4. Unfortunately, this data source does not contain information about the customers of sector 72.4. Following Gil and Harrison (2008), we distribute the overall expenditure across the six sectors using yearly input-output tables provided by the

Federal Statistical Office of Germany. Unfortunately, input-output tables are only available at the 2-digit level in Germany.[3] Thus, we use industry 72. As was done previously in the case of software, we consider all spending as investment.

Figure 3-2: Investment in new databases by sector, 1994-2008



Source: Statistisches Bundesamt: German turnover tax statistics and input-output tables; own calculation.

As Figure 3-2 shows, the investment in new computerized databases constitute only a very small fraction of the overall amount invested in computerized information in Germany. But the investment in computerized databases has significantly increased over the course of the past decade. We though do not observe a continuous rise but a rather strong slump after the new economy boom in the period 2003-2005 from which the German economy has recovered from 2006 onwards. Interestingly, this picture emerges in all sectors to more or less the same extent implying that the distribution across industries remains quite stable over time. More than half of the investment in new databases (around 56%) is made in the financial and business service sector and just around one fifth in manufacturing.

3.2 Innovative property

The second broad category of intangible assets summarizes investments in innovative property. It covers the amount firms invest in research and development, mineral

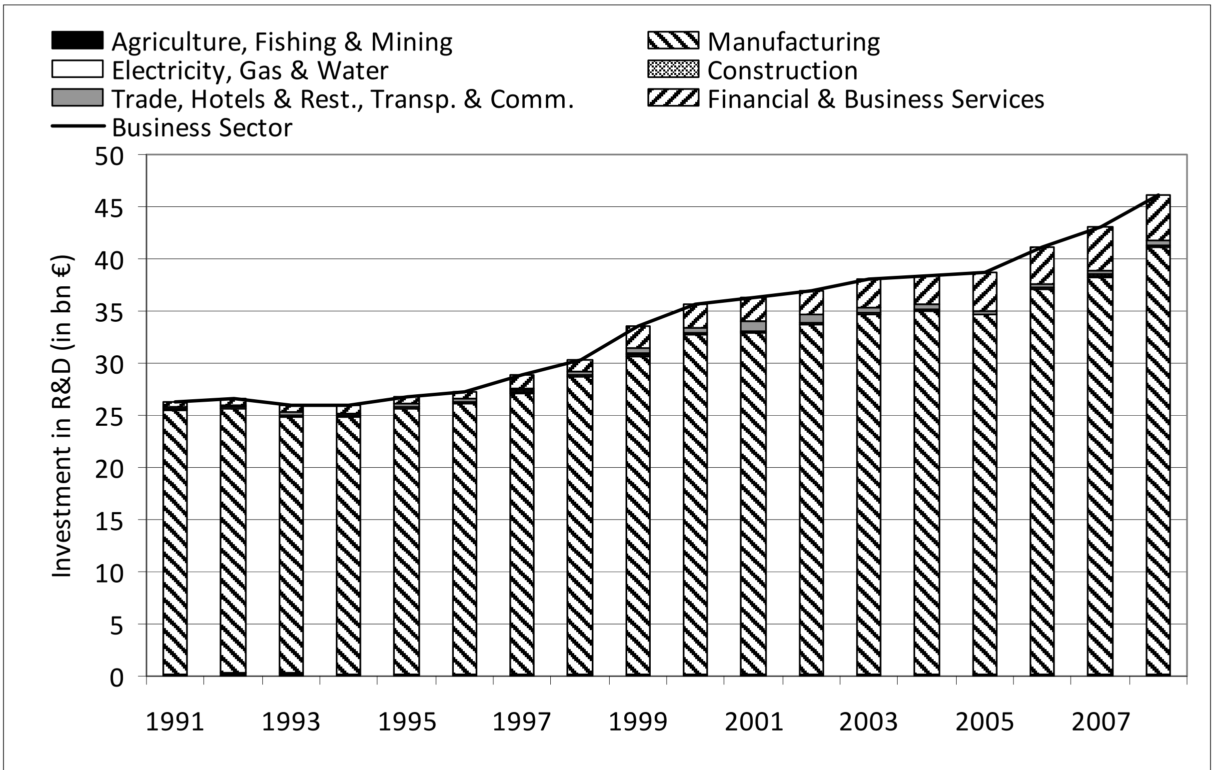
[3] Note that we contacted the German Statistical Office to ask whether input-output tables are available at a more disaggregated level.

exploration, copyright protected work, licenses and new designs. Detailed figures on the following time series by sector are provided in Table 10-4, Table 10-5 and Table 10-6 in the Appendix.

3.2.1 Scientific research and development (R&D)

Compared to other types of intangible capital, data on business enterprise research and development (R&D) expenditure have been collected for many years already. The guidelines for collecting internationally comparable data are set out by the Frascati manual (OECD, 2002). In Germany, the R&D survey is conducted by the Stifterverband. It feeds the Analytical Business Enterprise Research and Development database (ANBERD). ANBERD contains OECD estimates that are adjusted for gaps and anomalies that exist in the official data (OECD, 2009). ANBERD provides information on R&D at a 2-digit industry level. Currently, information is available for the time period 1991 to 2006. Regarding the latest years 2007 and 2008, we directly take R&D expenditure from the R&D survey (Stifterverband, 2010) since ANBERD data for Germany are based on the R&D surveys of the Stifterverband. As suggested by CHS, we consider total spending on R&D as investment.

Figure 3-3: Investment in R&D by sector, 1991-2008



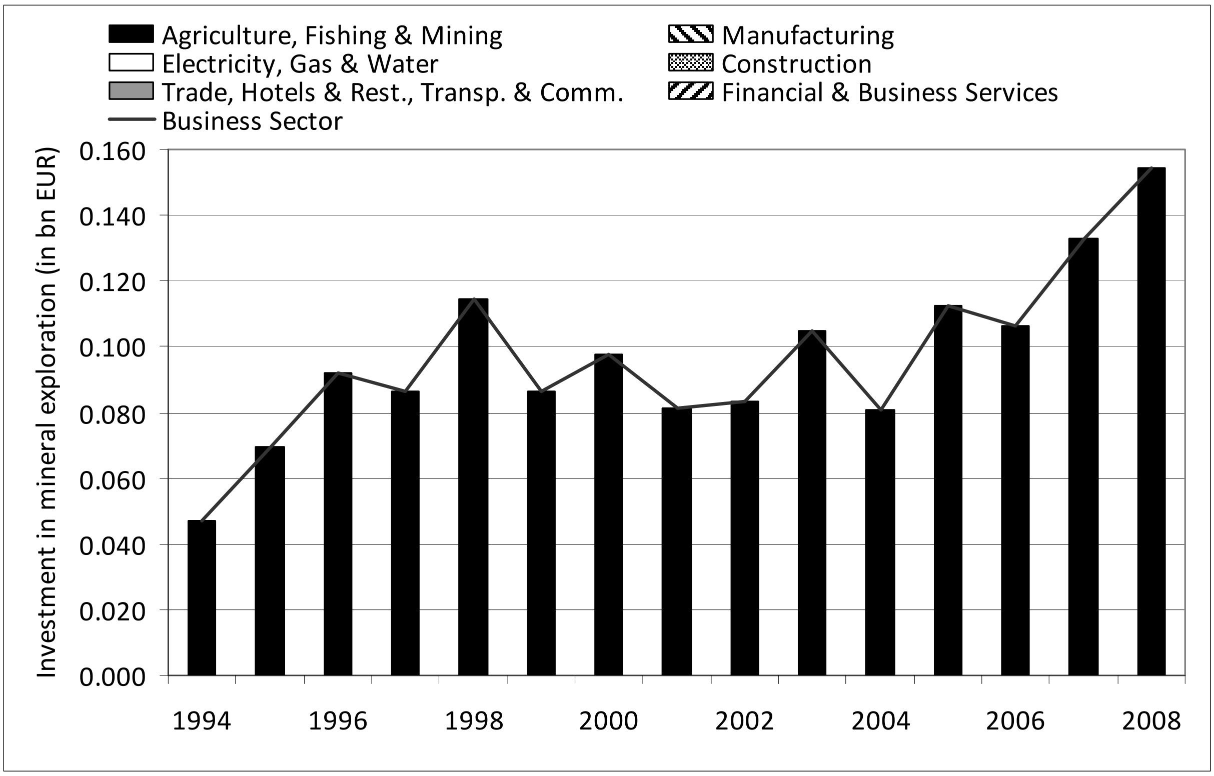
Source: OECD (2009): 1991-2006; Stifterverband (2010): 2007-2008; own calculation.

Figure 3-3 illustrates the development of R&D investment by sector in Germany over the last twenty years. While R&D investment was rather stable up to the mid nineties, we do observe a steady increase since then. The overwhelming majority of scientific R&D is conducted in manufacturing. Roughly 90% of scientific R&D was carried out in this sector. The proportion of R&D performed in manufacturing has fallen over time while it has increased in business related services from 2.6% to 9.4% in 2008. In absolute figures, R&D mounted from 0.68 bn € in 1995 to 3.8 bn € which corresponds to a rise by more than 400%. However, these figures should be taken with care since in part they reflect an artificial development which is due to the fact that the coverage of service firms within the R&D surveys has been improved a lot since the end of the nineties.

3.2.2 Mineral exploration

Mineral exploration should capture all costs involved in the process of finding ore which can be exploited in the future and which will thus lead to sales in the future. Expenditure on current exploitation should not be included. Information stems again from the German turnover tax statistic. The sales of category "test drilling and boring" (45.12) are counted as expenditure on mineral exploration. An industry breakdown is not necessary. We follow Gil and Haskel (2008) and classify expenditure on mineral exploration as belonging to sector Agriculture, Fishing & Mining. Again, we follow CHS and view all spending on mineral exploration as investment. Figure 3-4 depicts the amount of investment. Mineral exploration is the least important type of intangible investment in Germany. Less than 0.2 bn € is spent for it though it has significantly gone up since the mid nineties.

Figure 3-4: Investment for mineral exploration, 1994-2008



Source: Statistisches Bundesamt: German turnover tax statistics; own calculation.

3.2.3 Copyright and license costs

Information-sector industries like book publishers, motion picture producers, sound recording producers, and broadcasters also spend a lot of money for developing and introducing new products. This spending for new product development is usually not regarded as scientific R&D and thus not included in R&D figures. Assuming that new product investment by the information-sector usually leads to a copyright or license, they suggest a category of intangible asset that is called copyright and licence costs. CHS estimated copyright and license costs by twice the new product development costs of the motion picture industry (source: Motion Picture Association). Hao and Manole (2008) used data from Screen digest whereas Morrano and Haskel (2006) make use of information from the national accounts in the UK.

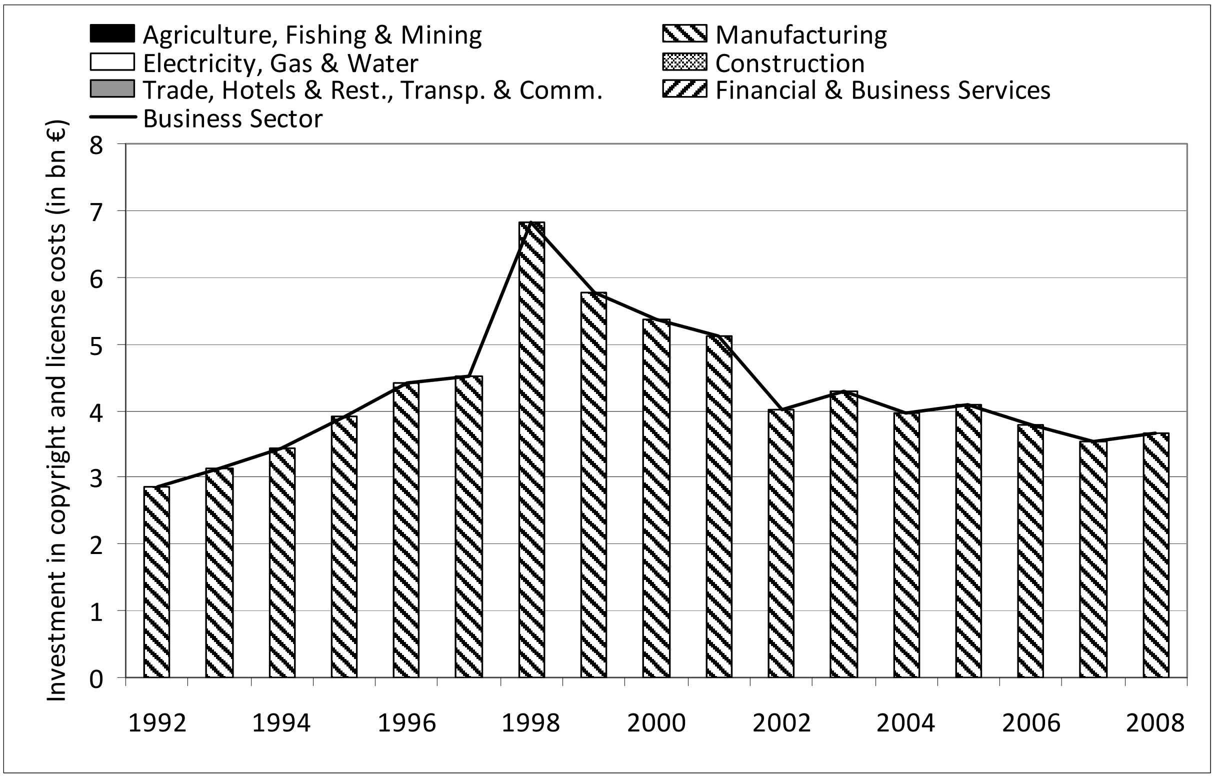
In Germany, the national accounts only provide a combined figure on investment in immaterial assets which consists of software and database, copyright and licenses, livestocks, economically useful plants and costs for the transfer of undeveloped sites. Software accounts for nearly four fifths of the investment in immaterial assets (Statistisches Bundesamt, 2010b). Due to the lack of appropriate survey data, they estimate copyright and license costs using the sales reported in the German turnover tax statistics for NACE class 92.11 (motion picture and video production) and NACE 92.20.2 (radio and television) minus a non-published estimated correction factor which should account for the fact the industry also produces work that is not protected by copyright. Since we cannot identify copyright and license costs separately from the national accounts and since we do not know the correction factor, we simply estimate the costs using the category “motion picture and video production” (NACE 92.11) of the German turnover tax statistic.[4] In the industry classification NACE Rev 1.1 92.11 is assigned to services (recreational, cultural and sporting activities) while publishing is assigned to manufacturing.[5] Gil and Harrison (2008) decided to relate total spending to the manufacturing sector. For comparability reasons, we follow this approach though in our case the service sector seems to be more appropriate. Following Gil and Harrison (2008), we further treat all spending as an investment.

Figure 3-5 illustrates the development of estimated copyright and licence costs over the period 1992-2008. They have increased up to 1998 but have experienced a significantly fall off since then from 6.8 to 3.7 bn € in 2008.

[4] For comparison, based on national accounts Hao et al. (2009) estimated copyright and licence costs to be roughly 4.94 bn € in Germany in 2004. We estimate costs of roughly 4 bn €. The national accounts estimated gross investment in immaterial goods in the private sector at 22.9 bn € (Statistisches Bundesamt 2006), taken into account that software already accounted for 16 bn €, the upper limit for copyright and licences is 6.9 bn €.

[5] The new industry classification NACE 2 defines a separate industry “information and communication” (NACE 58 and 59).

Figure 3-5: Investment for copyright and license costs, 1992-2008



Source: Statistisches Bundesamt: German turnover tax statistics, own calculation.

3.2.4 Development costs in the financial industry

The financial industry also spends a lot of money for developing and introducing new financial products. As for the information-sector industries, most of these outlays for new product development are usually not regarded as scientific R&D and are thus not included in R&D figures. Nakamura (2001) proxied new product development costs in the financial services industry as a proportion of the non-interest expenses of banks and non-depository institutions. He assumed 50% without giving a sound economic explanation. Corrado et al. (2006) broadened the coverage to include other financial institutions (security and commodity brokers and other financial investments and related activities). Since there is no broad survey data in the US on the resources banks and insurance companies devote to new product development, they proposed as a "rudimentary guess" to use as proxy a share of 20% of all intermediate purchases reported in the BEA`s data on gross output and value added by industry.

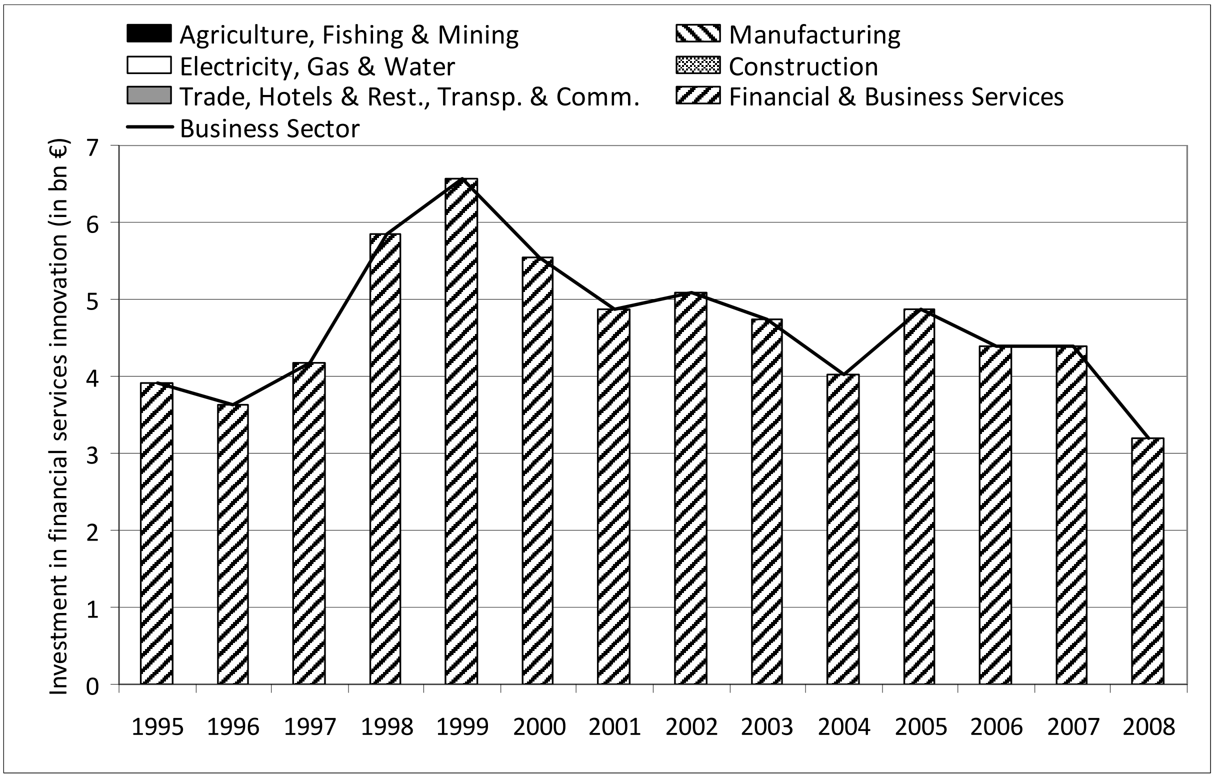
In contrast to the US, the Community Innovation Surveys (CIS) provide data on innovation expenditure in the financial industry for all European countries.[6] The methodology is based on the Oslo manual (OECD and Eurostat, 2005). The German contribution to the CIS is the Mannheim Innovation Panel (MIP) which is carried out annually (for a more detailed description see Crass et al., 2010). As an alternative to the proxies used in the

[6] Similar surveys are available in many other OECD countries except for the US.

literature we therefore prefer to estimate the development costs using the more reliable extrapolated figures on innovation expenditure in the financial industry. Innovation expenditure is related to new products and processes. Process innovations are often associated with the acquisition of new machines which are counted as tangible capital at the same time. To avoid double counting we subtract the expenditure which is related to the acquisition of new machines for product and process innovations from total innovation expenditure (for more details see Crass et al., 2010). Following CHS, the full amount that the financial industry spends on developing new products is considered as investment. We furthermore relate these costs completely to the sector “Financial Intermediation and Business Services”.

The time series on investment in financial services innovation is illustrated in Figure 3-6. Between 1995 and 1999, German banks and insurances have raised their investments in innovation from 3.9 bn € to 6.6 bn €. In the last decade, however, we observe a continuous fall off and in 2008 investment for innovation were even below the figures for 2005. The steep increase at the end of the last decade can be explained by new opportunities that emerged at that time due to new information and communication technologies (e.g. internet banking, telephone banking, etc.). It also turns out that this direct survey information leads to considerable smaller estimates of investment in financial services innovation than the alternative measure. In 1995 our estimate is just 47% of that of Hao and Manole (2008). This proportion has even fallen to 25% in 2008.

Figure 3-6: Investment in financial services innovation, 1995-2008



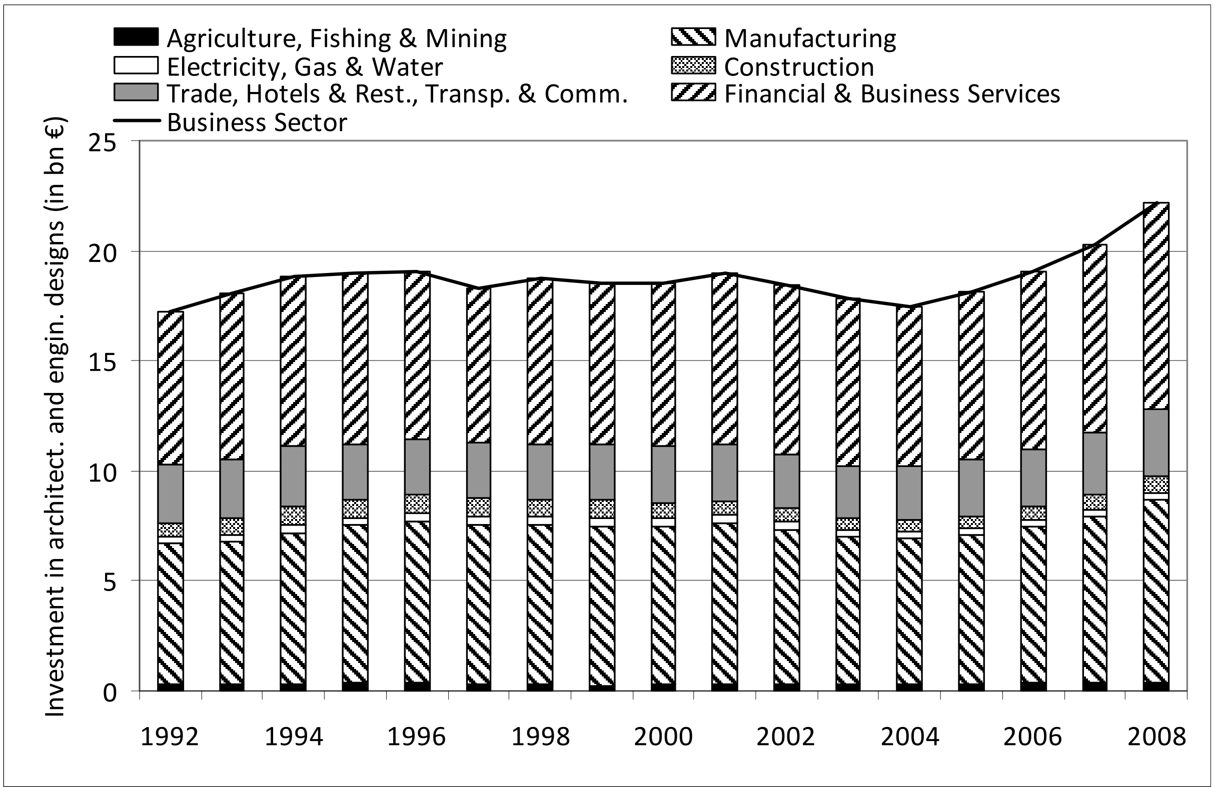
Source: ZEW: Mannheim Innovation Panel (MIP), own calculation.

3.2.5 New architectural and engineering design

Following Corrado et al. (2006) we measure new architectural and engineering design as half of the turnover of the architectural and design industry (NACE class 74.2). Turnover data are derived from the German turnover tax statistics. Like for databases, we have to allot sales to the six industries using input-output tables (based on industry 74). This provides us with an estimate of investment in new architectural and engineering design at the sector level.

As Figure 3-7 shows, the amount firms invested in new architectural and engineering designs had been rather stable over the period 1992-2004, ranging between 18 and 19 bn €. This rather stable development is surprising since we expected the increasing trend to outsource design activities to be reflected in the time series. Since 2004, however, we observe a continuous increase up to 22 bn € in 2008. The figure also reveals that the distribution across sectors is very stable over time. In part this might be due to the fact that we use input-output tables to get sector-level estimates. 37-39% of all investment for new designs has been undertaken by manufacturing firms. The proportion is even slightly higher in financial and business services at about 40-42%. Roughly 1.8% of this intangible item is produced by agriculture & mining and utility, respectively. Trade and transport account for 14%.

Figure 3-7: Investment for architectural and engineering design by sector, 1992-2008



Source: Statistisches Bundesamt: German turnover tax statistics, input-output table; own calculation.

3.3 Economic competencies

The third and final broad category is economic competencies. It includes spending on strategic planning, spending on redesigning or reconfiguring existing products in existing markets, investments to retain or gain market share, and investments in brand names (Corrado et al. 2004, 2006). At the sector level, we estimate the time series in the following way (detailed figures are reported in Table 10-7 and Table 10-8 in the Appendix):

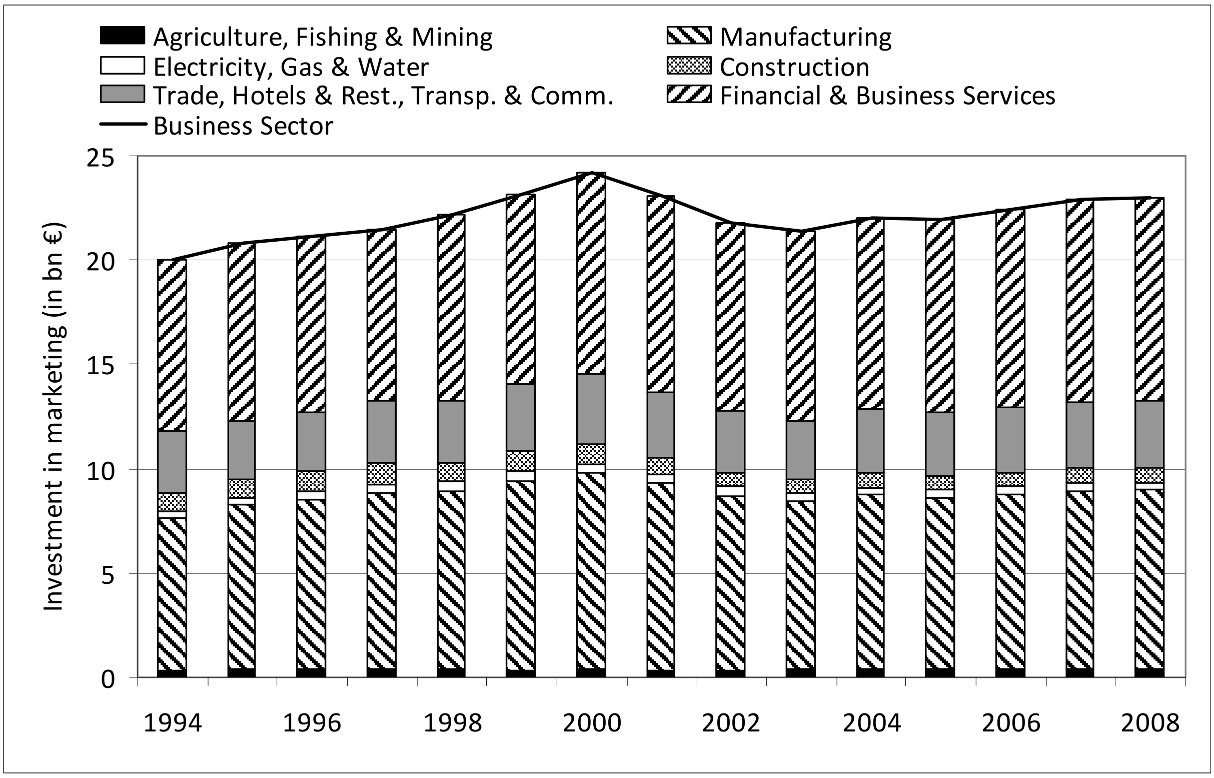
3.3.1 Brand equity

Corrado et al. (2004, 2006) propose a broad conceptualization of marketing activities by including both *advertising* and *market research*. Advertising expenditure is seen as the firm's primary investment into brand equity. Crass et al. (2010) carried out a sensitivity analysis on alternative definitions for *advertising* expenditure and on alternative data sources in Germany. In a nutshell, we propose to use data on external (purchased) advertising expenditure published by the Central Association of the German Advertising Industry (Zentralverband der deutschen Werbewirtschaft ZAW). We use gross advertising expenditure which comprises net revenues of the media firms (distribution costs of advertising) and production costs of advertising. Following CHS we exclude half of the advertisement on newspapers. Firms may not commission all advertising activities to outside media firms but some of them may be carried out in-house as well. Based on information gathered within the MIP, we estimate that own-account marketing outlays make up roughly 15% of external marketing expenditure. We assume that this premium is the same for all components, i.e. advertising expenditure as well market research, and thus use a premium of 15% on external advertising expenditure to account for internal (own account) corporate advertising activities.

Purchased market research is estimated using the sales of industry 74.13.1 reported in the German turnover tax statistics. Unlike all previous studies we exclude 74.13.2 which is related to research for public opinion polling since these outlays do not increase brand equity. Whereas Corrado et al. (2004, 2006) simply assumed that own-account market research equals purchased market research we use the same premium as for advertising.

To get sector level estimates, we furthermore have to distribute total expenditure for both intangible assets to the six industries using input-output tables. We use again industry 74 since we do not posses more disaggregated input-output tables. Finally, we get from spending to investment figures by assuming that 60% of the outlays can be considered as investment while the rest is viewed as short-term focussed (see Landes and Rosenfield, 1994, Corrado et al., 2006).

Figure 3-8: Investment in brand equity by sector, 1994-2008



Source: ZAW Central Association of the German Advertising Industry, Statistisches Bundesamt: German turnover tax statistics, input-output tables, own calculation.

Figure 3-8 presents investment in brand equity in Germany by sector. German firms have increasingly invested in brand equity up to 2000. Maybe not surprisingly, investments have gone down with the beginning of the recession in 2001. Since 2004 we can see a slight recovery, however, even in 2008 the investment was still below the 2000 value. Due to the fact that we are forced to use input-output tables at the 2-digit industry level, we estimate the same (and rather stable) distribution across industries as for new architectural and engineering design. In particular, we estimate that about 38% of the investment in marketing is done in manufacturing, 14% in trade and transport and 41% in financial and business services.[7]

3.3.2 Firm-specific human capital

The costs of employer-provided worker training are the second important ingredient of "economic competencies". Investment in firm-specific human capital consists of initial

[7] For the year 2006, we tried to check the robustness of this distribution. Using the extrapolated figures on marketing expenditure reported by the MIP at the industry level and adding the advertising expenditure in retail from ZAW (MIP does not include retail), we would get that both figures for manufacturing and services are nearly the same. However, hotels and restaurants are not included in the MIP and not published by ZAW. Thus, the proportion of services might be slightly higher. Nonetheless, we think that the share of marketing investment in manufacturing are likely to be slightly underestimated and that of services overestimated.

vocational training and continuing vocational training. We use the reports on the financing of education[8] to calculate the costs of initial vocational training in the business sector. Comparable data are available from 1995 onwards. Expenses for continuing vocational training comprises direct and indirect costs. Direct costs include operating expenses for organising and running further training whereas indirect costs reflects the costs of the continued payment of wages if the further training takes place within normal working hours. We make use of the Mannheim Innovation Panel (MIP) to estimate direct costs of continuing vocational training. The time series starts in 1994 and provides annual data on internal and external expenditure for professional training at the 2-digit industry level. We calculate the indirect costs of continuing vocational training by using the proportion of direct costs to total costs which is on average 35%. This is the average share reported from the IW survey on further training activities (Werner, 2006; for a more detailed description see Crass et al., 2010).

The main virtue of using training expenditure provided by MIP/CIS is that training expenditure is defined as *internal and external expenditure for professional training* and that the *industry breakdown is directly available*. A flaw is that some industries have not been collected over the whole period. First, the sector agriculture and mining just covers NACE code section C. Second, information for NACE code section F (construction) is only available for the period 1998-2001 and for NACE section E (electricity, gas and water supply) from 1997 onwards. Fortunately, however, only a small proportion of the total expenditure for firm-specific human capital are due to these missing industries and we estimated missing years by means of a fixed proportion in total training expenditure in non-missing years. We furthermore follow CHS and assume that total spending has investment character.

Figure 3-9 illustrates overall investment in firm-specific human capital by sector. The German business sector has invested between 30 and 35 bn € each year in initial and continuing vocational training. Manufacturing accounted for roughly one third of the investment in firm-specific human capital. This proportion is slightly higher than its proportion in labour input (see Table 2-1). Its share has increase from 32% to 37% in 1998 but has dropped since than to 30% in 2006. The reverse pattern can be observed for financial and business services. Their share amounts to 35% at the beginning and end of the period but has fallen in between to 29%. Though trade & transport is the most labour intensive sector, only around one fourth of total investment in firm-specific human capital is performed in this sector. Figure 3-9 elicits that this share is quite stable over time in Germany. Construction accounted for 4% and utility for 2-3%.

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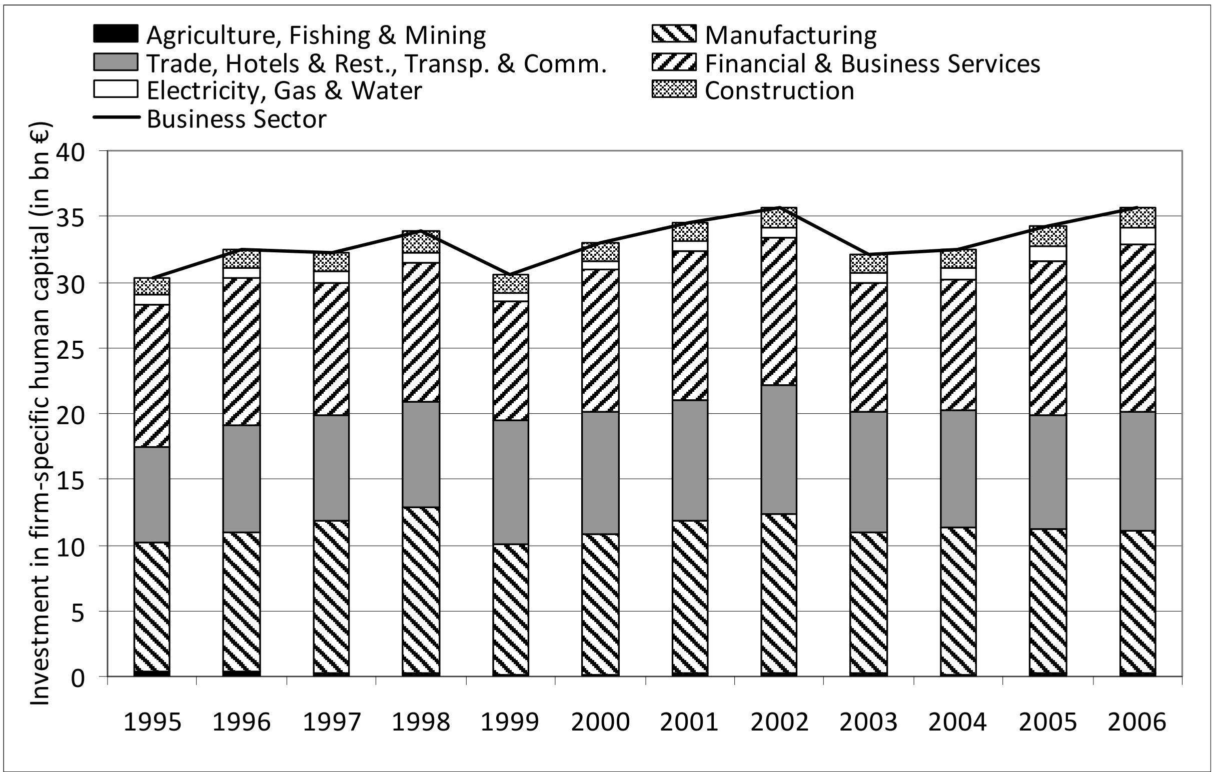
[8] Until 2007, these reports were published by the Bund-Länder-Kommission für Bildungsplanung und Forschungsförderung – BLK. The German Federal Statistical Office has taken on the job of publishing the report from 2008 on. Hao et al. (2009) estimate the costs of apprentice training and continuing vocational training using the Labor Cost Survey 2004 of EUROSTAT, the Continuing Vocational Training Survey 2005 of EUROSTAT and EU KLEMS.

Figure 3-9: Investment in firm-specific human capital by sector, 1995-2006



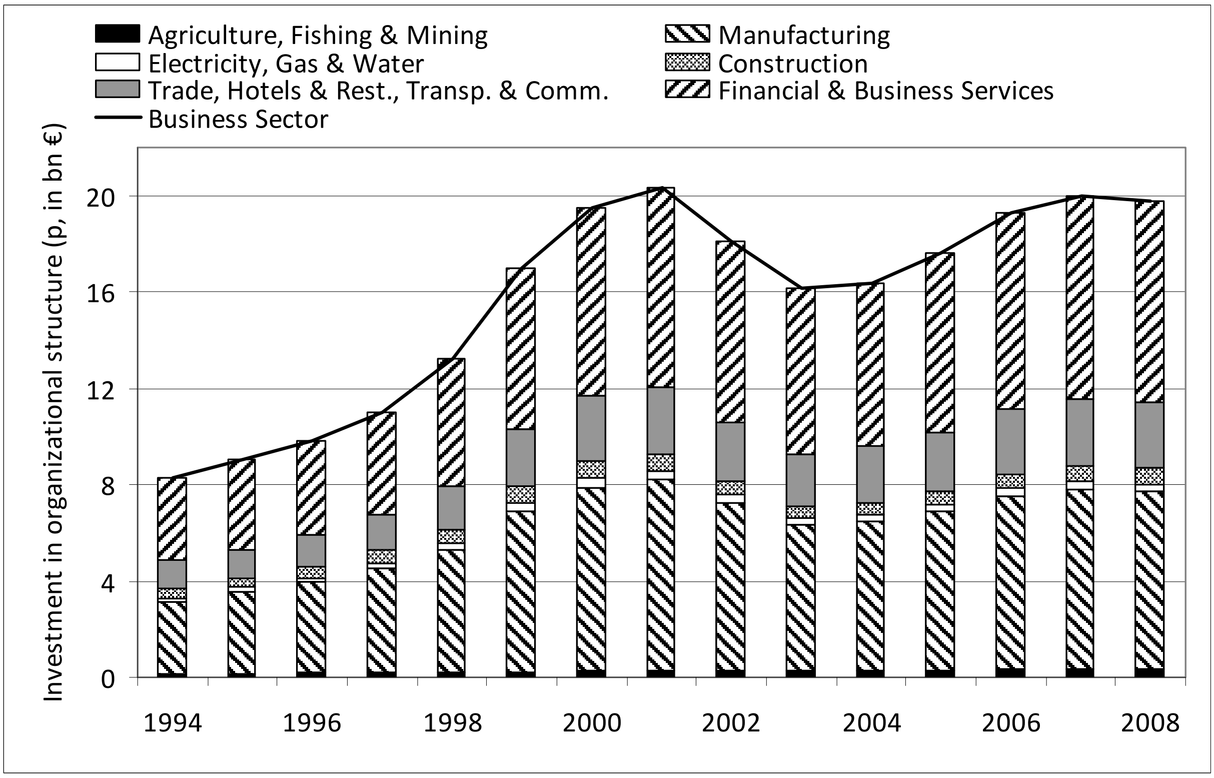
Source: ZEW: Mannheim Innovation Panel (MIP), BLK and Statistisches Bundesamt: reports on the financing of education (several years), IW survey on further training activities; own calculation.

3.3.3 Organizational structure

The final intangible item is aimed at capturing organizational capital which is also viewed as an important driver for gaining competitive advantage. Investment in organizational capital includes outlays for purchased organizational structure as well as expenditure for own-account organizational structure.

To measure investment in *purchased organizational structure*, Hao et al. (2009) used the revenue of management consulting, provided by the 2004 Annual Survey of the European Management Consultancy Market, provided by the European Federation of Management Consultancies Associations. Gil and Haskel (2008) suggested employing the revenues of the management consulting industry as proxy for purchased organizational structure. We follow their approach. For the period 2002-2008 we use the sales of the management consulting industry (74.14.1) provided by the German turnover tax statistics. Before 2002, figures are only available at the 4-digit level, i.e. for industry 74.14 which also contains public relation consultancy. We calculate the sales proportion between 74.14.1 and 74.14.2 in year 2002 and correct all figures before 2002 by using this correction factor. Using sales for a specific industry again implies that we do directly have an industry breakdown. We employ again the input-output table for industry 74 to get sector-level estimates for the six industries. We furthermore follow previous studies that assume that 80% of purchased organizational structure expenditure can be considered as investment.

Figure 3-10: Investment in purchased organizational structure by sector, 1994-2008

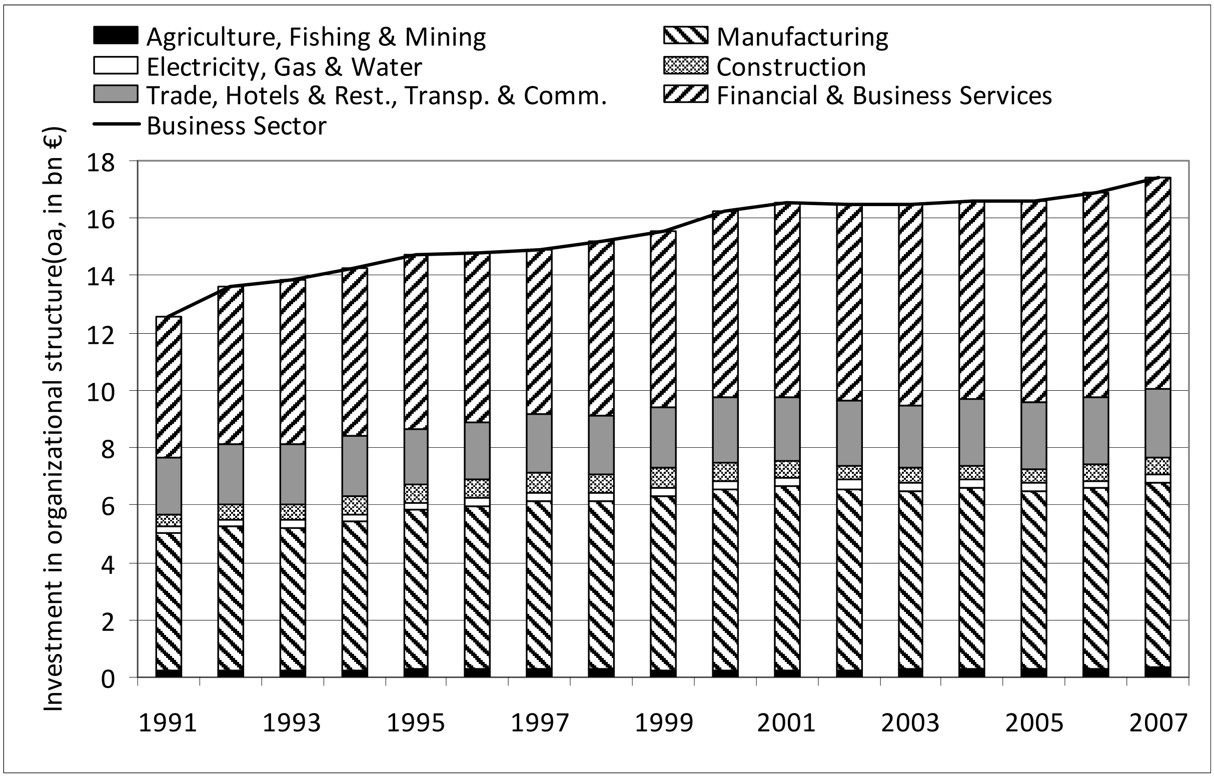


Source: Statistisches Bundesamt: German turnover tax statistics, input-output table, own calculation.

The most salient finding that can be gauged from Figure 3-10 is that investment in purchased organization structure has more than doubled within fourteen years. It has been raised from 8 bn € in 1994 to 20 bn € in 2008 with a severe slump in the recession period between 2001 and 2004. Since we use the same input-output-table information to allot the investment onto the sectors, the distribution across sectors is the same as for architectural and engineering design or marketing investment. Future research would benefit a lot if more detailed 3-digit input-output tables are available.

Admittedly, the expenditure on *own-account organizational structure* is only roughly measured. We follow the general approach of Corrado et al. (2006) and assume that 20% of a manager's time is spent on organizational building activities. Thus 20% of the managers' earnings can be considered as spending on own-account organizational structure. Information on manager's earnings is not directly available at a yearly base. We make use of different data sources to calculate this item. The German Structure of Earnings Survey 2006, published by the German Federal Statistical Office, reports the wage bill of salaries of senior managers in the private sector for the year 2006 (Statistisches Bundesamt, 2008). We calculated the share of senior managers wage bill to total wage bill and multiplied it by the time series on labour compensation provided by the EU KlEMS Nov2009 Release. Having estimated managers' earnings, we apply a share of 20%. Since an industry breakdown is not available, we applied once more the input-output table. We use again information from industry 74, and thus we implicitly assume that the breakdown is the same for investment in purchased and own-account organizational structure. Figure 3-11 depicts the development over the period 1991-2007. Investment in own account organizational structure has been continuously increased while the distribution across sectors has remained stable.

Figure 3-11: Investment in own account organizational structure by sector, 1991-2007



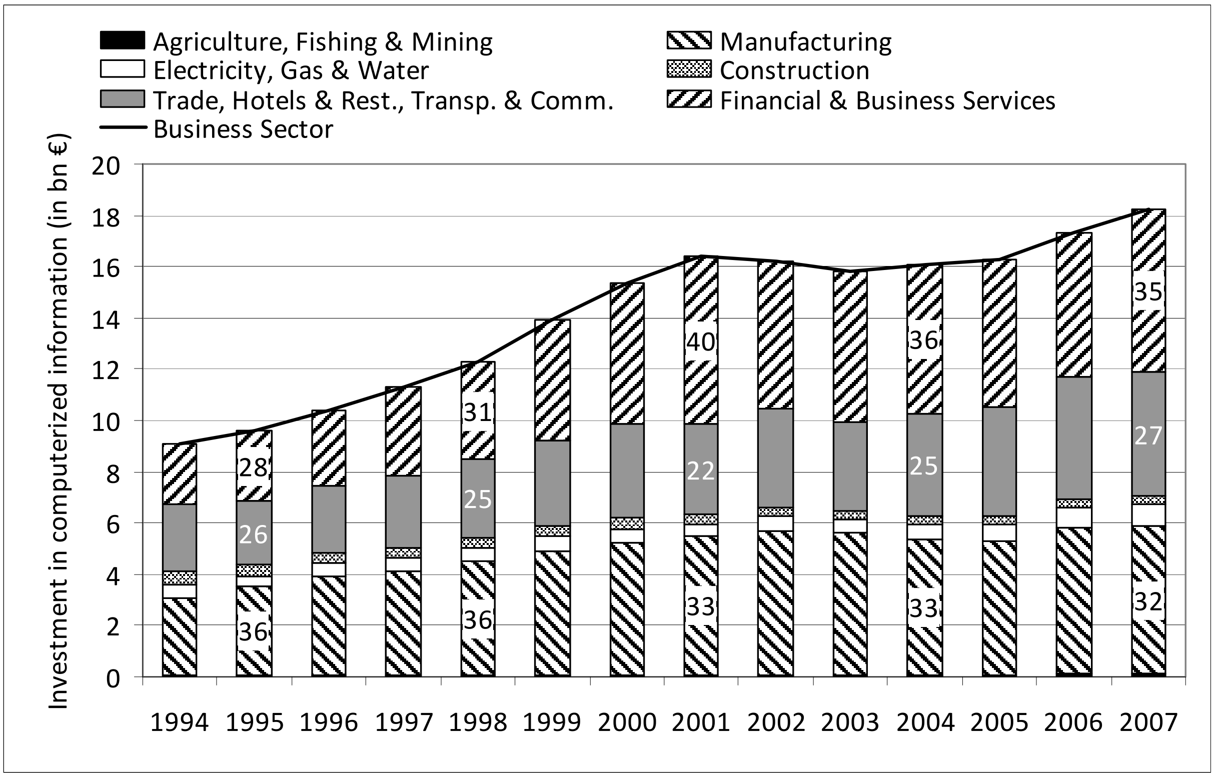
Source: EU KLEMS Nov2009 Release; Statistisches Bundesamt: German Structure of Earnings Survey 2006, input-output table; own calculation.

3.4 Summary: Computerized information, innovative property and economic competences

Having presented figures on intangible investment for each category at the sector level, this section condenses the information by looking at the three broad categories computerized information, innovative property and economic competences and their distribution across industries in Germany. Figure 3-13, Figure 3-14 and Figure 3-15 depict the distribution of each intangible asset across industries.

Since *computerized information* mainly consists of investment in software, we can refer to what has been already said on the development and distribution of software in section 2.1. Most strikingly, firms have intensified their efforts to invest in computerized information by nearly 100% in the period 1994 to 2007. At the same time, a shift has taken place from manufacturing towards business services. The share of software investment that is accounted for by manufacturing has declined from 36% to 32% whereas it has increased in the service sector industries. The increase in software investment was particularly strong in financial and business sector services in the first half of the period. In the meantime, firms in trade and transport have caught up. They account for 27% of all software investment in Germany.

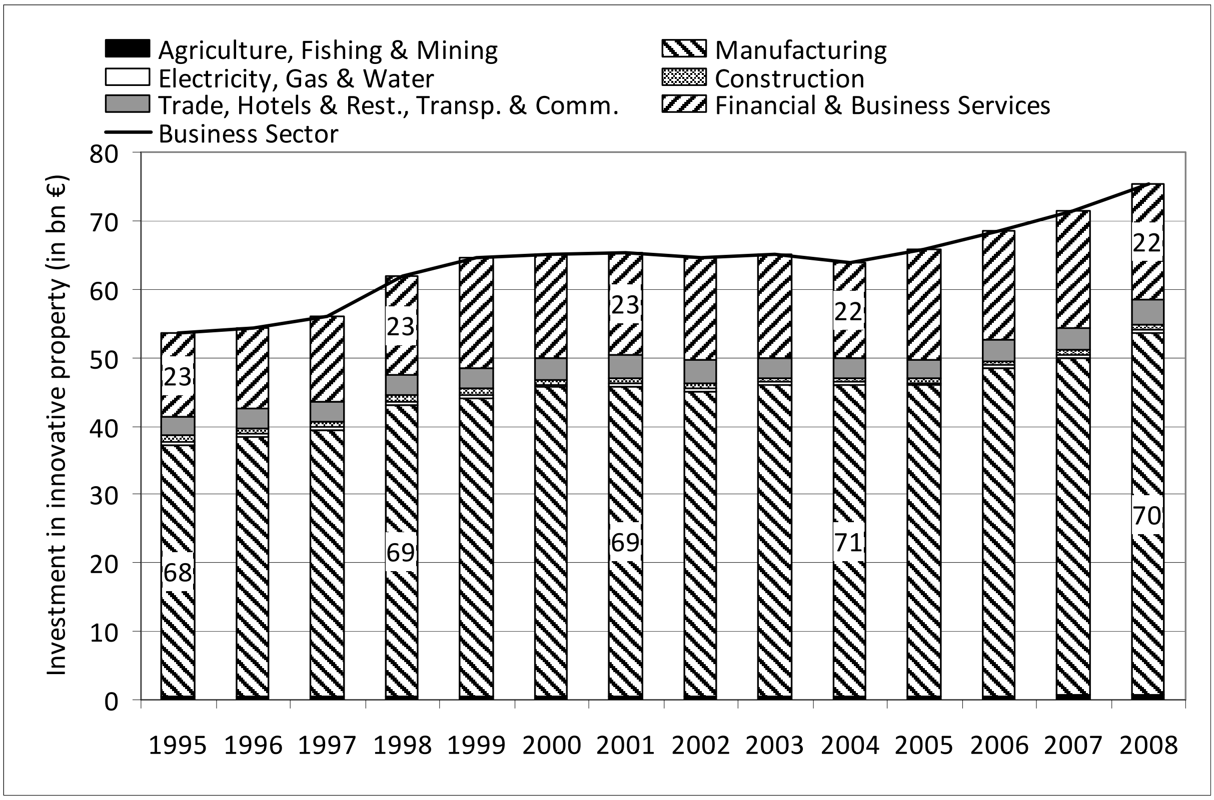
Figure 3-12: Distribution of computerized information by industries, 1994-2007



Source: EU KLEMS Nov2009 Release; Statistisches Bundesamt: German turnover tax statistics; own calculation.

The second broad category *innovative property* is highly concentrated in two industries, manufacturing and financial and business services as it is shown in Figure 3-13. The overall trend in investment in innovative property is increasing. From 1995 to 2008 investment in innovative property has grown by 40%. This trend can be observed in all sectors to more or less the same extent since the distribution across industries is nearly unaltered over time. Around 70% of total investment in innovative property is carried out in manufacturing, predominately in terms of scientific R&D. But the share of financial and business services is non-negligible. They make up around 22% of innovative property investment in the German economy, mainly for new design and financial services innovation.

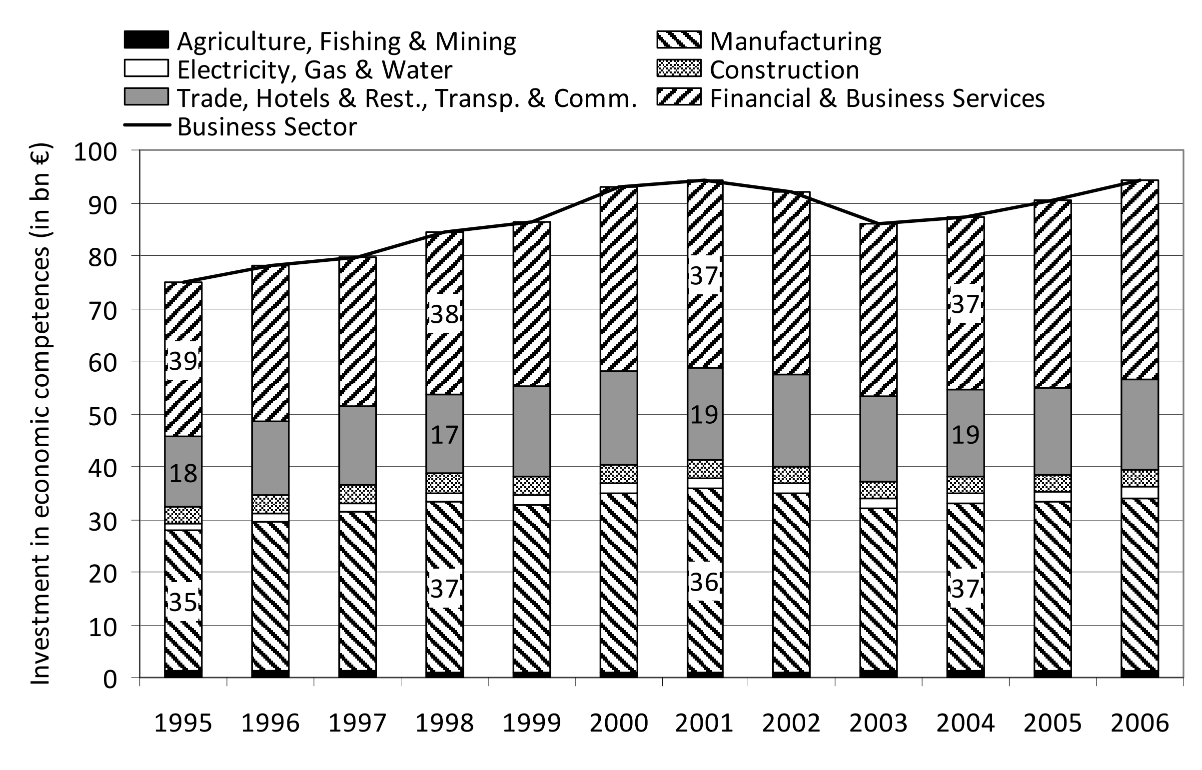
Figure 3-13: Distribution of innovative property across industries, 1995-2008



Source: Statistisches Bundesamt: German turnover tax statistics, input-output tables; ZEW: Mannheim Innovation Panel (MIP), EU KLEMS Nov2009 Release, own calculation.

Investments in *economic competencies* are less concentrated across sectors than those in innovative property as can be seen from Figure 3-14. Furthermore, the distribution across industries is quite stable over the period which is in part due to way how we estimate sector-level investment using input-output tables. If at all, the share of manufacturing and trade & transport has slightly increased whereas it has dropped for financial and business services. 35-37% of all investments aimed at improving economic abilities have been carried out in manufacturing. Financial and business service firms accounted for nearly the same amount. Around one fifth of the investment in economic competencies has been carried out in firms operating in trade & transport.

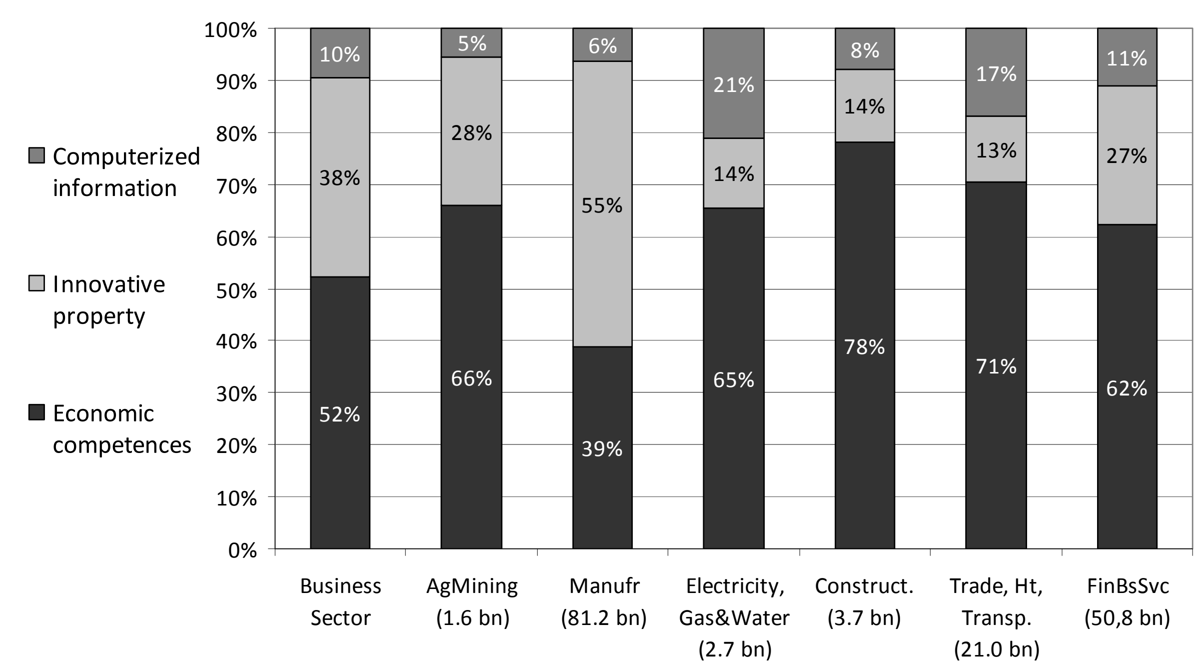
Figure 3-14: Distribution of economic competencies across industries, 1995-2006



Source: Statistisches Bundesamt: German turnover tax statistics, German Structure of Earnings Survey 2006, input-output tables; ZEW: Mannheim Innovation Panel (MIP); EU KLEMS Nov2009 Release; ZAW; BLK and Statistisches Bundesamt: reports on the financing of education (several years), IW survey on further training activities; own calculation.

Finally, Figure 3-15 delineates the relative importance of each intangible item in the German business sector and within each industry. We use the year 2004 as reference to ease comparison with other countries participating in the Coinvest project. In the business sector, around 38% of the investments in intangible capital are related to scientific R&D, another 10% to investments in software and databases. However, roughly half of the investment in intangible capital is devoted to improving economic competencies (52%), a category that is not accounted for by national accounts. The relative importance of different types of intangible assets varies quite a lot across sectors. For instance, manufacturing firms direct 39% of their investments in intangibles to economic competencies. This share is above 60% in all other industries, being highest in construction with 78%. Manufacturing firms do not only perform most of the R&D, but R&D is likewise the most important type of intangible asset in this sector. Investments in innovative property make up 55% of all intangible investment. Compared to other intangible assets, innovative property is far less important in financial and business services (27%) and trade and transport (28%). In the other three sectors innovative property accounts for about 13-14% of intangible investment. We can observe a strong variation in the relative importance of software and databases, ranging from 5% in agriculture and mining to 17% in trade and transport and even 21% in utility. Although most of the investment in software and databases are performed by firms in manufacturing and financial and business services, computerized information constitutes only a relatively small proportion in intangible investment in these industries (manufacturing: 6%, financial and business services: 11%).

Figure 3-15: Distribution of intangible investments by sector, 2004

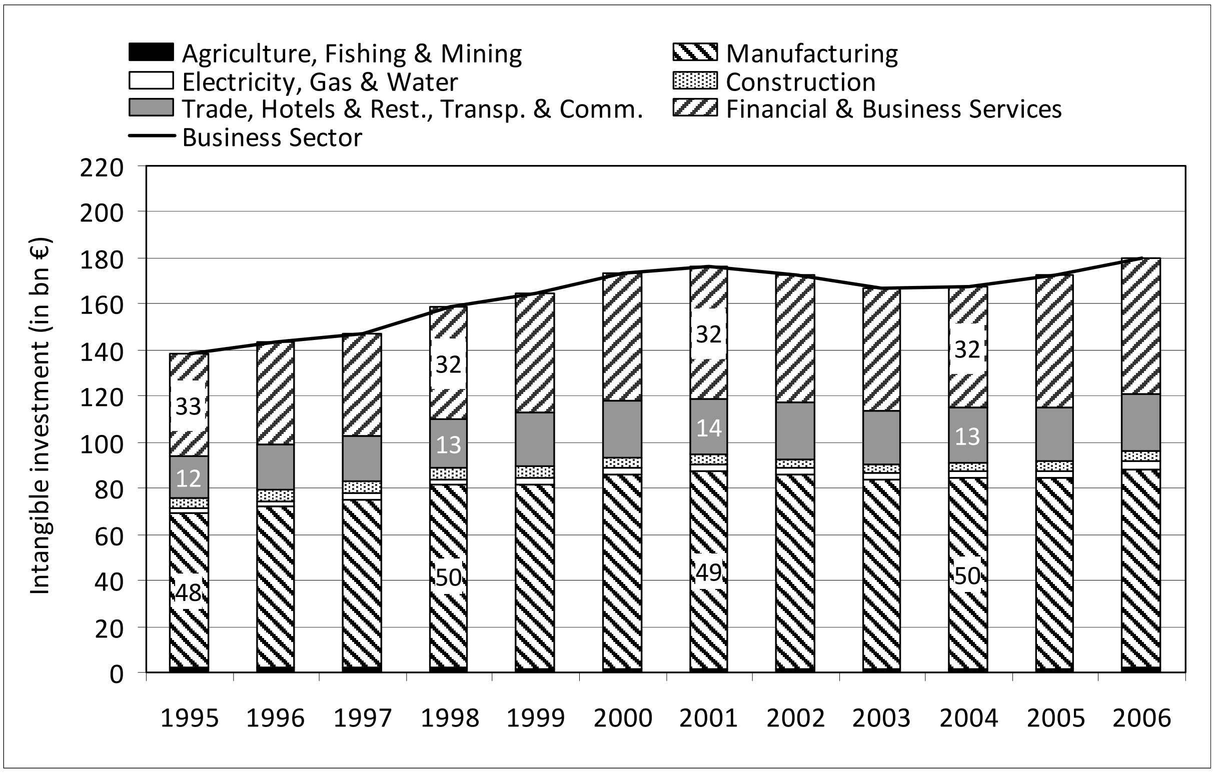


Source: Statistisches Bundesamt: German turnover tax statistics, German Structure of Earnings Survey 2006, input-output tables; ZEW: Mannheim Innovation Panel (MIP); EU KLEMS Nov2009 Release; ZAW; BLK and Statistisches Bundesamt: reports on the financing of education (several years), IW survey on further training activities; own calculation.

4 Comparison of tangible and intangible investment across sectors

This section is aimed at comparing intangible investment with tangible investment at the sector level. Adding up the various time series presented in the last section, we get the total amount of intangible investment in the German business sector and its distribution across sectors (see Figure 4-1). *Over the period 1995-2006*, that is the period for which we have complete data, *investment in intangible capital has grown* from 138.6 bn€ to 180 bn €. This implies an increase *by 30%*. As already pointed out, this raise was disproportionately high in computerized information and innovative property. The figure also indicates that *investment in intangibles react to business cycles*. The increase was particularly strong in the boom period 1998-2000 whereas firms have cut investments in the recession period 2001-2004 by nearly 5%. However, with the slight recovery from 2005 onwards, investments in intangibles have accelerated again. The figure furthermore shows a stable distribution across industries over time. Nearly *half of the investment in intangibles is done by manufacturing firms*. This industry proportion is much higher than the share of manufacturing in gross output, value added or for instance in labour input. Financial and business services account for about one third of all intangible investments.

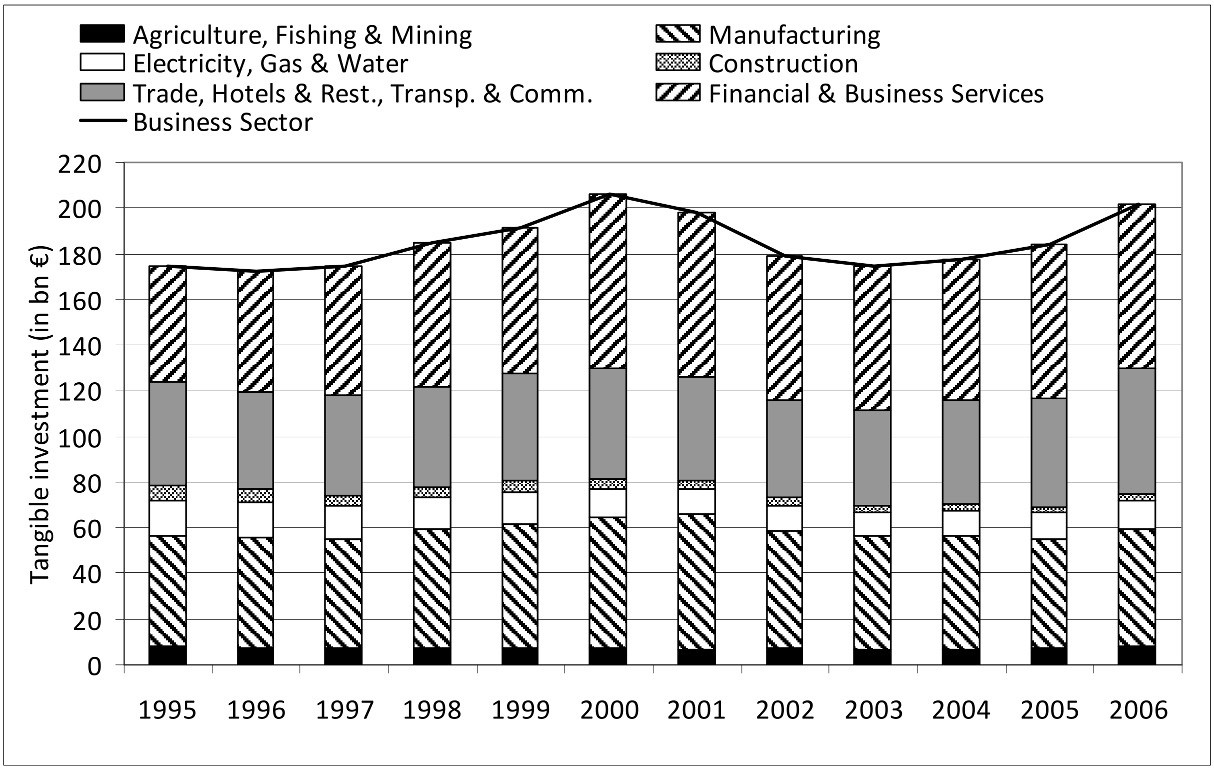
Figure 4-1: Investment in intangible assets by sector, 1995-2006



Source: Table 10-1, own calculation.

These figures can be directly compared to the development of tangible investment in Figure 4-2. Tangible investment is here defined as the nominal gross fixed capital formation provided by EU KLEMS Nov2009 Release. It comprises investments in computing equipment, communications equipment, transport equipment, other machinery and equipment, and total non-residential investment in the business sector (but without software). Note the German Federal Statistical Office provides (significantly higher) figures of the nominal gross fixed capital formation in Germany (Statistisches Bundesamt, 2010a). This can be explained by the fact that they also include software and residential investment. The picture that emerges for tangible investment is similar to that for intangible investment in a qualitative sense, but not in quantitative terms. That is, intangible investment has also increased over the period but to a far lesser extent than intangible investment (+15%). On the other hand, tangible investment were also cut in the recession period and to be precise significantly more than intangible investments (-15% between 2000 and 2003). Tangible investment had started to increase again from 2004 onwards but had not reached the 2000 level in 2006. Compared to intangible investments we also see more variation in the industry shares over time. In 1995 27% of investment in tangible capital was allotted to manufacturing, this proportion has fallen to 25%. Similarly, the contributions of utility, construction and agriculture and mining have declined. In contrast, financial and business services have increased their share form 29 to 36%.

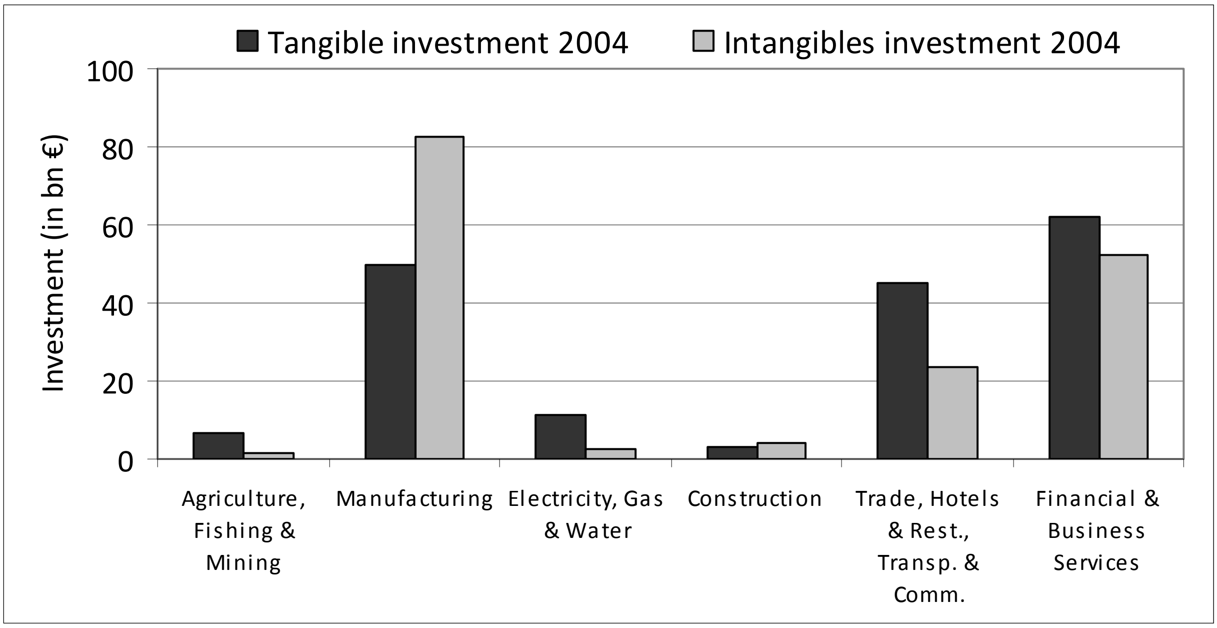
Figure 4-2: Tangible investment by sector, 1995-2006



Source: EU KLEMS Nov2009 Release, own calculation.

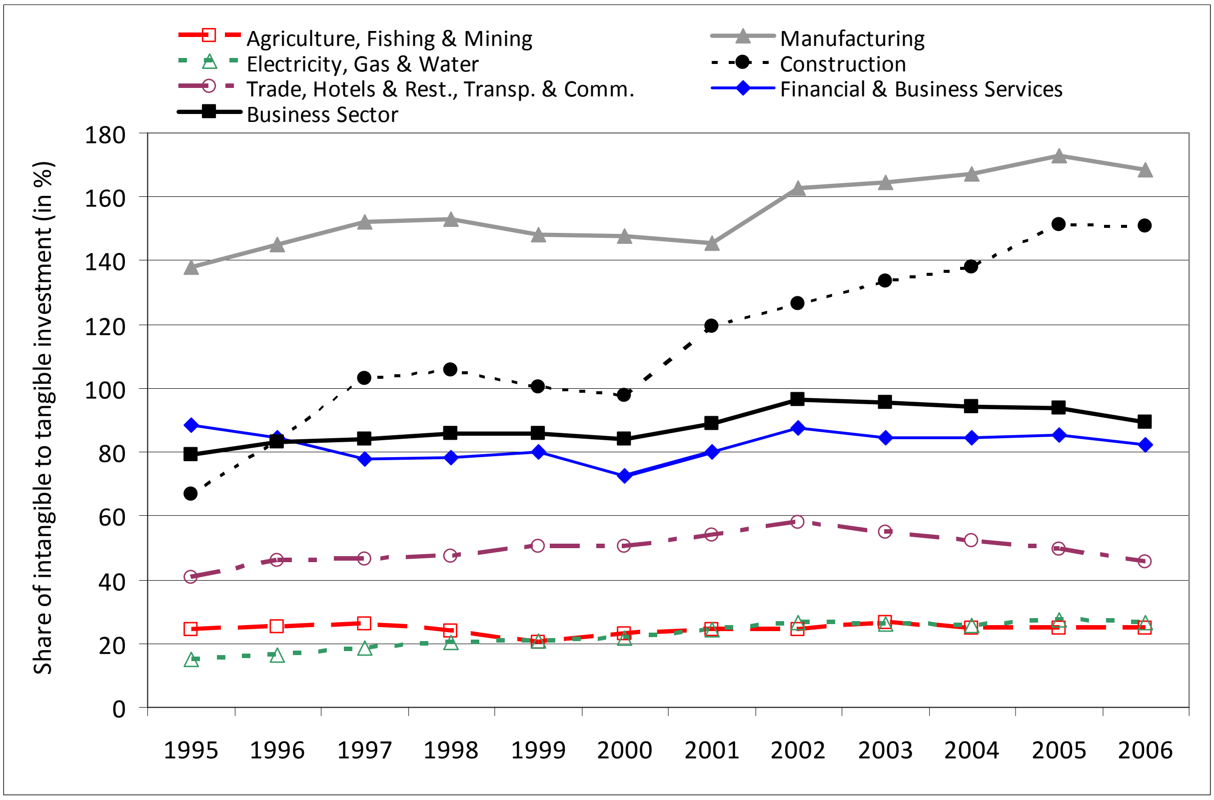
Figure 4-3 shows absolute investment in intangible and tangible capital at the sector level for the year 2004 whereas Figure 4-4 illustrates the relation between both types of investment at the sector level for the period 1995-2006. The different dynamics of intangible and tangible investment find expression in an *increasing relation of intangible to tangible investment*. For the whole business sector, the proportion has increased from 80% to 89%. The figures further highlight the outstanding position of intangible capital in manufacturing. In this sector intangible investment is significantly larger than tangible investment. Intangible investment has even gained importance as it share has climbed from 138% to 168%. Though firms in the financial and business service sector have expanded their investment for intangible capital the importance relative to tangible capital is nearly unaltered. It fluctuates around 80% over the period. In the sector trade & transport, intangible investments have grown faster than tangible investments leading to a rise in the proportion from 40 to 58%. It turns out that this was a short-term effect and that this proportion has fallen again to 45%. Rather surprising is the development of the ratio of intangible to tangible investment in construction. It has increased from 67% to 151%. This can be explained by a sharp decline in tangible investment figures reported by EU KLEIMS (from 6.8 to 2.9 bn €) whereas the intangible investment turned out to be stable at 3-4 bn € each year.

Figure 4-3: Tangible and intangible investment by sector in 2004



Source: Intangible investment: see Table 10-1, tangible investment: EU KLEMS Nov2009 Release; own calculation.

Figure 4-4: Share of intangible to tangible investments by sector, 1995-2006

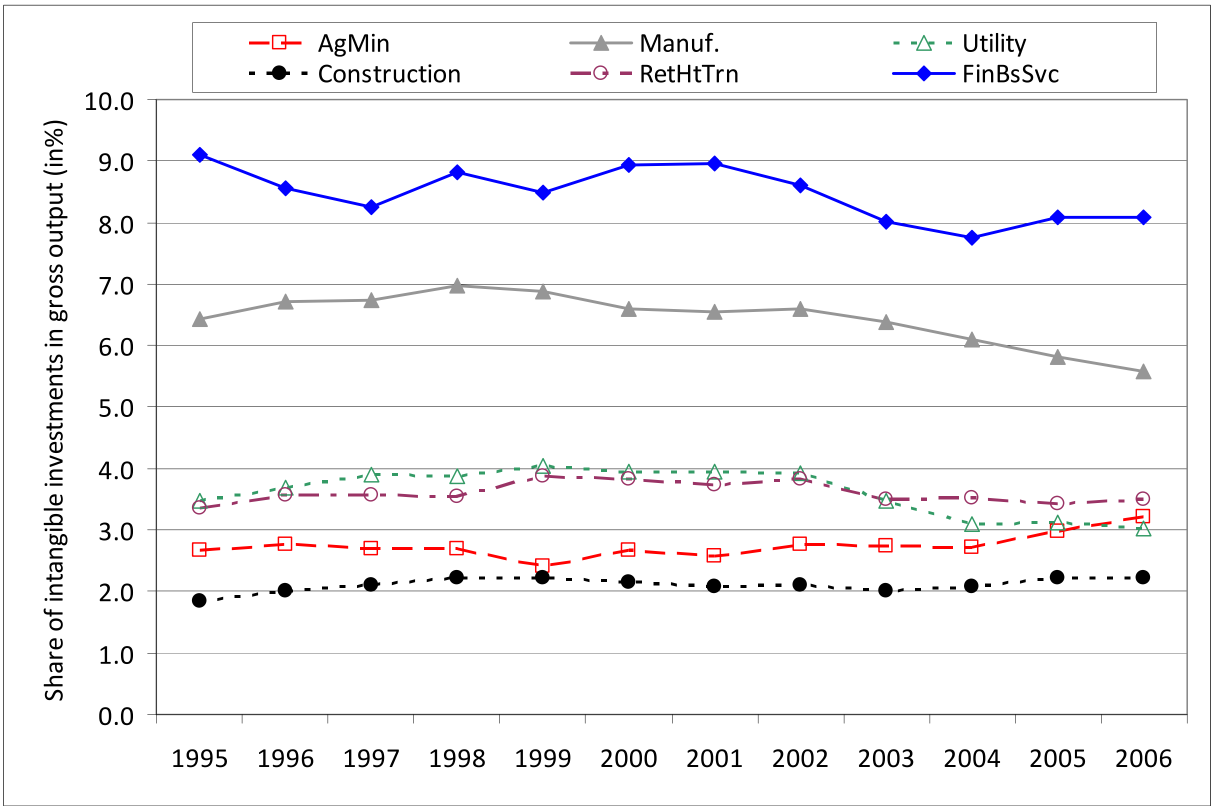


Source: Intangible investment: see Table 10-1, tangible investment: EU KLEMS Nov2009 Release; own calculation.

5 Intangible investment as share of industry gross output and value added

This section is aimed at comparing the importance of intangible investment across sectors by looking at the share in industry gross output and value added, respectively. The previous sections have shown that investments in intangibles have increased in absolute terms and have also gained importance compared to tangible capital. Figure 5-1, however, reveals that the *share of intangible investment in gross output has fallen in the two largest sectors, manufacturing and financial and business services*. In the latter industry, which spends the highest proportion on intangible investment throughout the whole period, it has declined from 9.1 to 8.1%. We observe a similar downward trend for the overall period in manufacturing where the share dropped from 6.7 to 5.6%. In manufacturing, however, this decline was not continuous. It took place after 1998. Between 1995 and 1998 intangible assets even gained importance in terms of gross output.

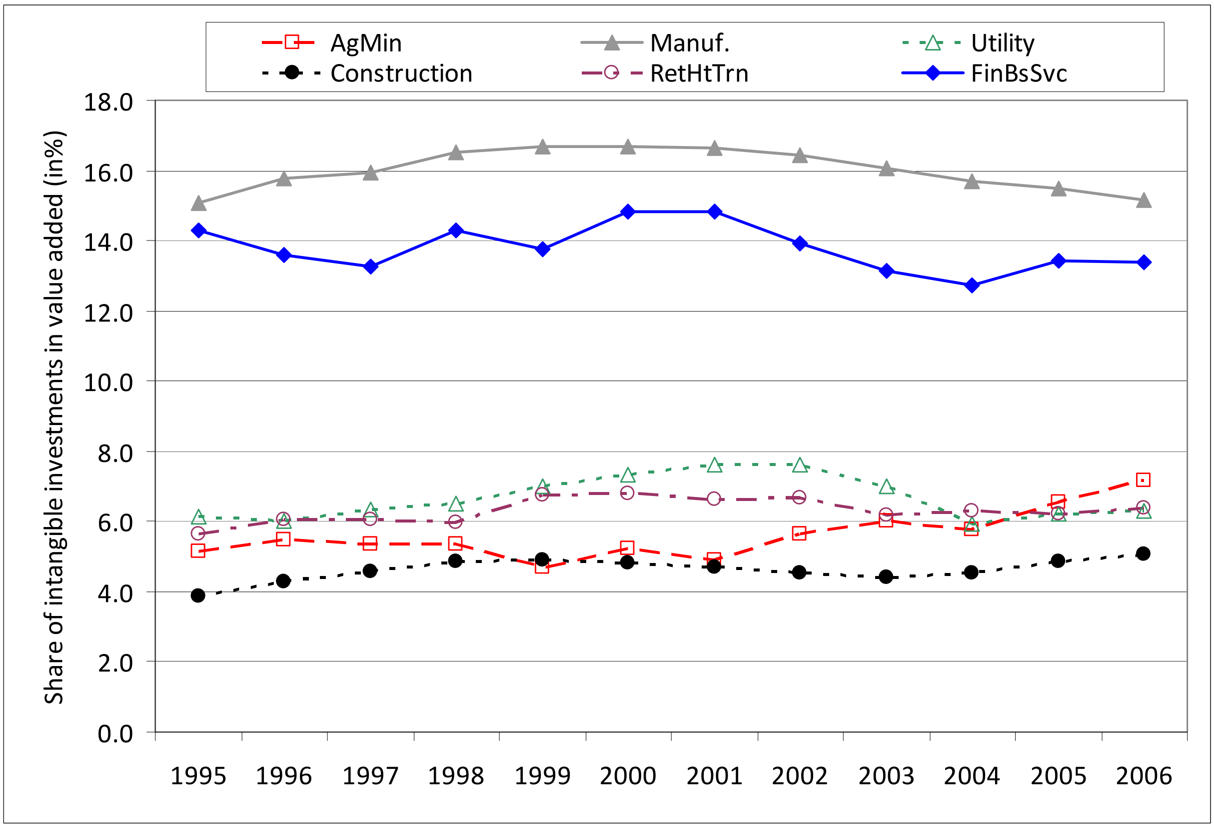
Figure 5-1: Intangible investment as a share of industry gross output, 1995-2006



Source: Intangible investment: see Table 10-1, gross output: EU KLEMS Nov2009 Release; own calculation.

A similar picture emerges for financial and business services when we relate intangible investment to value added (from 14.3 to 13.4%), see Figure 5-2. In manufacturing, the share of intangible investment to value added has gain increased until 1998 and has fallen afterwards. In 2006 it has reached a comparable level than in 1995 (15%). In terms of gross output, financial and business services spend the highest proportion on intangible investment. In terms of value added manufacturing is ranked first.

Figure 5-2: Intangible investment as a share of industry value added, 1995-2006



Source: Intangible investment: see Table 10-1, value added: EU KLEMS Nov2009 Release; own calculation.

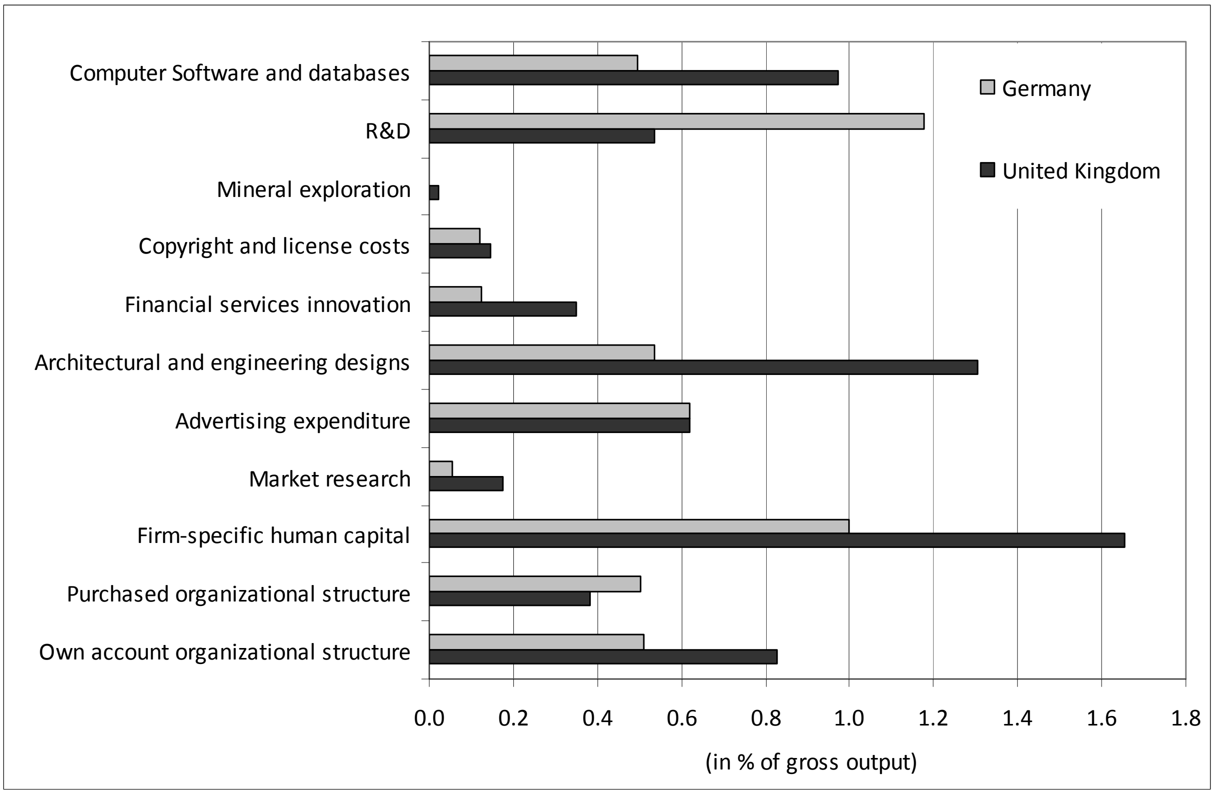
In the other four sectors intangible investments make up a significantly smaller proportion of gross output. It varies around 2% (construction), 3% (agriculture & mining) and 3.5% (trade & transport, utility). The same holds for the share in value added which ranges between 4 and 7.5% for the four sectors.

6 Comparing intangible investment at the sector level in Germany and the UK

To evaluate intangible investments in different sectors in Germany, we compare our results with industry-level findings for the UK by Gil and Haskel (2008). In order to ensure comparability of intangibles we follow Marrano and Haskel (2006) and calculate UK investment figures by assuming that 60% and 80% of expenditures on advertising and own-account organizational structure are investment, respectively. Investment in new architectural and engineering designs is calculated using the authors' instruction to multiply expenditure by 50 percent to obtain investment (Gil and Haskel 2008).

Before showing sector-level results, we first present total investment in intangibles by asset class in 2004 as a share of the gross output. Data on gross output is taken from EU KLEMS for both countries. Figure 6-1 reveals already salient differences at the macro level for both countries. Investment in intangibles represents 7% of gross output in the UK (10.1 % of GDP, Haskel, 2009). The share is thus significantly higher than in Germany with 5.1 % (7.0 % of GDP, Crass et al., 2010). On the other hand, the business sector in Germany invests twice as much as the UK in R&D (1.2% compared to 0.55%). In contrast, the UK invests a significantly larger proportion in software, design, firm-specific training and own-account organizational structure. How can these differences be explained?

Figure 6-1: Intangible investment as share of gross output in Germany and the UK, by category in 2004

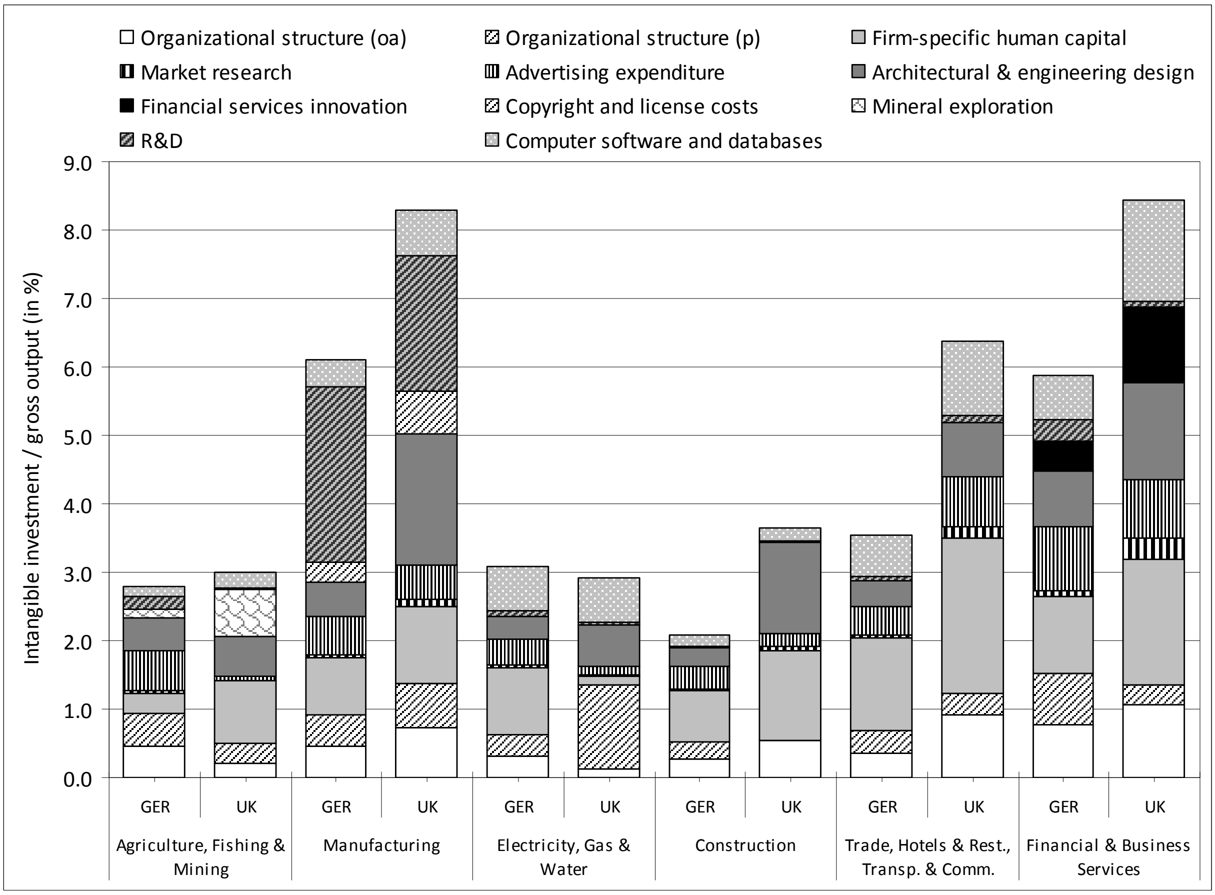


Source: Germany: see Table 10-1, UK: Gil and Haskel (2008); own calculation.

Methodological differences might be one explanation. As was set forth in Crass et al. (2010) for some asset categories a trade off exists between more accurate data sources and international comparability. Deviations exist for instance with respect to new architectural and engineering designs. The UK figure does not only include purchased designs but also own-account investment in new architectural and engineering designs (Gil and Haskel, 2008). If we exclude own-account investments, the findings are much more similar across both countries (0.94% in the UK and 0.87 in Germany). An alternative data source and methodology was also used for new product development costs in the financial industry. While our figures rely on survey data, the UK figures are estimated as 20 percent of financial services industry's intermediate purchases (Gil and Haskel 2008). The same is true for intangible investments in firm-specific human capital.

On the other hand, in all four categories service sectors make up an import contribution. Since services present a larger proportion in the UK business sector than in Germany, these differences might also be explained by differences in industry structure. A comparison of investment in intangibles at the sector level provides information about this.

Figure 6-2: Share of intangible investment to gross output in Germany and the UK, by sector in 2004



Source: Germany: see Table 10-1, UK: Gil and Haskel (2008); own calculation.

Figure 6-2 shows that the UK share of intangible investment is larger in all sectors except for utility. When comparing manufacturing firms, we can ascertain that German firms invest a higher proportion of gross output in R&D (2.6% vs. 2.0%) and in advertising (0.6 vs. 0.5%). UK manufacturing firms, on the other hand, have a significantly stronger orientation towards investment in new designs. But they also invest a higher proportion of gross output in software, organisational structure, firm-specific human capital and copyright and license cost. Similar differences in investment strategies can be detected in financial and business services. The proportion that German firms invest in R&D is three times larger than that in the UK. In contrast to manufacturing, they also invest a significantly larger proportion of gross output in purchased organizational structure. UK firms in financial and business services outperform their German counterpart with respect to investments in software, design, firm-specific human capital, market research, own-account organisational structure and financial service innovations. Another striking finding is that UK firms in trade & transport demonstrate a higher share in all asset classes.

Comparing different asset classes, we find that investment in new architectural and engineering design is consistently higher across all sectors in the UK.[9] Computerized information is around two times larger in UK manufacturing, financial and business services and trade & transport (similar shares in other three sectors). On the other hand, German firms invest a higher proportion of gross output in R&D in all sectors. Advertising is also more common in Germany except for the sector trade & transport.

7 Growth accounting at the sector level

This section highlights the contribution of intangible assets for stimulating growth at the sector level by performing growth accounting analyses for the six industries. The methodology we used to perform growth accounting at the sector level is based on the 'direct aggregation across industries' approach that is described by Jorgenson et al. (1987) and Jorgensen et al. (2005, 2007) and that is also used in Clayton et al. (2009). This approach allows us to study industry-level sources of economic growth as well as to trace the sources of aggregate productivity growth and input factor growth to their industry origins. In the following section 6.1, we will explore the methodology in more detail. Section 6.2 sets out the data that we used to perform growth accounting and section 6.3 illustrates our empirical results.

7.1 Methodology[10]

Decomposition of growth in real gross output at the industry level

Assuming that we have production data at the sector level, the starting point is the decomposition of industry growth. At the industry level, growth in capital, labour, intermediate inputs and total factor productivity contributes to growth in real gross output ($\Delta \ln Y_j$). The growth contribution of capital is equal to the growth in capital services in industry j ($\Delta \ln K_j$) weighted by the capital input share ($\overline{v}_{K,j}$). Capital services are defined as the productive inputs, per period, that flow to production from a capital asset (OECD 2001). Capital services differ from capital stocks because short-lived assets

[9] A more detailed analysis on design spending in the UK is provided by Galindo et al. (2010).

[10] We refer to Jorgenson et al. (1987), Jorgensen et al. (2005, 2007) and Clayton et al. (2009).

such as equipment and software provide more services per unit of stock than long-lived assets such as land. The flow of capital services is more appropriate as capital input in the production analysis than the capital stock (Jorgensen and Griliches 1967). The capital input share $\bar{v}_{K,j}$ is defined as the average (over a two-year period) proportion of capital compensation to gross output in industry *j*. Similarly, the contribution of labour can be calculated as the growth in labour quality services ($\Delta \ln L_j$) times the labour input share ($\bar{v}_{L,j}$) which is measured as the average labour compensation in gross output in industry *j*. The contribution of intermediate inputs to growth in industry gross output is given by $\bar{v}_{X,j} \cdot \Delta \ln X_j$ where $\Delta \ln X_j$ measures the growth rate in intermediate inputs and $\bar{v}_{X,j}$ is the share of intermediate inputs in industry gross output.[11] The contribution of total factor productivity is simply the growth rate of TFP ($\Delta \ln TFP_j$). That is, we can decompose growth in industry real gross output into the following sources:

$$\Delta \ln Y_j = \bar{v}_{K,j} \cdot \Delta \ln K_j + \bar{v}_{L,j} \cdot \Delta \ln L_j + \bar{v}_{X,j} \cdot \Delta \ln X_j + \Delta \ln TFP_j \qquad (1)$$

In the empirical analysis below, we furthermore allow for heterogeneous labour and capital. That is, we differentiate between different types of capital assets and labour inputs. With respect to capital, for instance, we separately calculate the contribution of tangible and intangible capital. We furthermore decompose tangible capital into ICT capital and non-ICT capital. Types of intangible capital assets correspond to the categories introduced in chapter 2. The question is then how to capital services. Under the assumption of a strict proportionality between capital services and capital stocks for each heterogeneous asset, the growth of total capital services in industry j ($\Delta \ln K_j$) can be calculated as a translog index (i.e. a Toernquist index) of different types of capital assets (see Jorgensen 1963, and Jorgensen and Griliches, 1967). That is, $\Delta \ln K_j$ is a weighted average of the growth rates of each capital stock $\Delta \ln K_{k,j}^{St}$, where the superscript *St* indicates that we mean the capital stock and *k* denotes the type of capital:

$$\Delta \ln K_j = \sum_k \bar{w}_{k,j} \cdot \Delta \ln K_{k,j}^{St} \qquad (2)$$

The weight $\bar{w}_{k,j}$ reflects the proportion of capital income of asset *k* in total capital income in industry *j*, averaged over a two-year period. Capital income of asset *k* is usually calculated as the capital stock of asset *k* times the rental price of capital *k* (user costs of capital).

Accordingly, growth in labour services in industry *j* are estimated as a labour-income weighted average of the growth rates of each type of labour input *l*:

---

[11] $\bar{v}_{X,j}$ is equal to 1- $\bar{v}_{L,j}$ - $\bar{v}_{K,j}$.

$$\Delta \ln L_j = \sum_l \bar{w}_{l,j} \cdot \Delta \ln L_{l,j} \tag{3}$$

Decomposition of real value added growth at the industry level

Since at the aggregate level, output growth is usually based on growth in value added instead of growth in gross output, we additionally provide the decomposition of industry value added growth. Using the definition of value added, we can also write equation (1) in the following way:

$$\Delta \ln Y_j = \bar{v}_{VA,j} \cdot \Delta \ln VA_j + \bar{v}_{X,j} \cdot \Delta \ln X_j \tag{4}$$

Equation (4) states that industry growth in gross output can be decomposed into the contribution of value added and intermediate goods. $\bar{v}_{VA,j}$ denotes the two-year average share of value added in gross output in industry j. Equalising equation (1) and (4), we can identify the sources of real value added growth in industry j:

$$\Delta \ln VA_j = \frac{\bar{v}_{K,j}}{\bar{v}_{VA,j}} \cdot \Delta \ln K_j + \frac{\bar{v}_{L,j}}{\bar{v}_{VA,j}} \cdot \Delta \ln L_j + \frac{1}{\bar{v}_{VA,j}} \Delta \ln TFP_j \tag{5}$$

Growth in real value added in industry j is fed by the weighted contribution of industry capital, labour input and TFP. The weights on capital (labour) account for the share of capital (labour) income in gross output in industry j and for (the inverse of) the share of industry value added in industry gross output.

Aggregate real value added growth and industry contributions

Depending on the assumptions about industry value added functions and factor mobility and factor prices, one yields alternative measures for aggregate value added. We use the 'direct aggregation across industries' approach that is the least restrictive approach. This approach only assumes that a value added function exists in each industry, but it does not assume that these are identical across industries. We furthermore allow input factors such as capital and labour to be mobile across industries and factor prices to be different across industries.[12] It can be shown that in this case, the growth rate in aggregate real value added ($\Delta \ln VA$) has to be calculated as the weighted sum of industry real value added growth rates:

[12] Alternatives are the aggregate production function approach and the production possibility frontier approach. The first approach assumes the existence of an aggregate production function. This function exists under the strong assumptions that i) the industry gross output function is separable in value added (VA) and intermediate inputs; ii) the VA functions are – up to a scalar multiplier – identical across industries; iii) the functions that aggregate heterogeneous capital and labour are identical in all industries and iv) that each type of capital and labour must have the same factor price in all industries. If these assumptions are fulfilled, aggregate VA is the unweighted sum of industry VA. The second approach relaxes the restriction that the industry VA functions must be the same across industries. Aggregate VA is then a weighted sum of industry VA.

$$\Delta \ln VA = \sum_j \bar{w}_j \cdot \Delta \ln VA_j = \sum_j CT_{VA,j} \tag{6}$$

$CT_{VA,j} = \bar{w}_j \cdot \Delta \ln VA_j$ measures what industry j contributes (CT) to aggregate real value added growth. Summing up all contributions across industries gives the aggregate growth rate. The weight w_j reflects the share of industry *j*'s nominal value added in aggregate nominal value added[13], and it is thus a measure of the relative size of industry j. $\bar{w}_j$ is average share of a two-year period, that is:

$$w_j = \frac{P_{VA,j} \cdot VA_j}{\sum_j P_{VA,j} \cdot VA_j} \qquad \textit{and} \qquad \bar{w}_j = 0.5\left(w_{j,t} - w_{j,t-1}\right)$$

Decomposition of real value added growth at the aggregate level

The methodology not only allows us to identify the industry origins of aggregate growth but also to identify what change in aggregate growth is due to capital input, labour input and TFP. When we insert equation (5) into (6), we end up with the following decomposition of real value added growth:

$$\Delta \ln VA = \sum_j \bar{w}_j \cdot \left(\frac{\bar{v}_{K,j}}{\bar{v}_{VA,j}} \cdot \Delta \ln K_j + \frac{\bar{v}_{L,j}}{\bar{v}_{VA,j}} \cdot \Delta \ln L_j + \frac{1}{\bar{v}_{VA,j}} \Delta \ln TFP_j \right)$$

$$\Delta \ln VA = \sum_j \bar{w}_j \cdot \frac{\bar{v}_{K,j}}{\bar{v}_{VA,j}} \cdot \Delta \ln K_j + \sum_j \bar{w}_j \cdot \frac{\bar{v}_{L,j}}{\bar{v}_{VA,j}} \cdot \Delta \ln L_j + \sum_j \bar{w}_j \cdot \frac{1}{\bar{v}_{VA,j}} \Delta \ln TFP_j$$

$$\Delta \ln VA = \sum_j CT_{K,j} + \sum_j CT_{L,j} + \sum_j CT_{TFP,j} \tag{7}$$

$$\Delta \ln VA = CT_K + CT_L + CT_{TFP} \tag{8}$$

The last equation illustrates the decomposition of aggregate value added growth. It can be traced back to the contribution of capital input (CT_K), labour input (CT_L) and TFP (CT_{TFP}). The total contribution of capital input (CT_K) is the sum of the industry contributions of capital input across all industries. To put it differently, $CT_{K,j}$ measures what industry j contributes to aggregate capital input. It is calculated as the growth of capital services in industry j weighted by the average capital compensation to gross output in industry *j*, the average proportion of gross output to value added in industry j and the relative size of industry *j*'s value added in aggregate value added. Similarly,

[13] See Table 2-1. Two-year averages of these industry shares in values added serves as weights for summing up the growth rates of industry value added.

$CT_{L,j}$ and $CT_{TFP,j}$ show how much each industry contributed to aggregate labour input and aggregate TFP.

7.2 Industry data

In order to perform an industry growth decomposition that accounts for intangible capital, we need first of all production data at the sector level. To ensure cross-country comparability, we make use of EU KLEMS data (release November 2009). EU KLEMS output data provides information on *gross output*, *value added* and *intermediate inputs*, both in real and nominal values as well as corresponding price deflators. Intermediate inputs consist of material, energy and services. Data are available from 1970 onwards, but since we have complete data on intangibles only for the period from 1995 to 2006, we are restricted to this period. As already explored in section 2, EU KLEMS provide data on different levels of sector disaggregation.[14] The available industry breakdown of intangible data is again the binding factor, so that we are restricted to the six industries mentioned in section 1.[15] Note that EU KLEMS already includes figures for aggregate gross output or value added. Our figures will deviate from these numbers because our aim is to account for intangible capital which makes some changes in the calculation necessary.

As already explored in subsection 6.1, we want to account for heterogeneous capital and labour. The EU KLEMS capital data base provides us with time series on nominal *investment* (nominal gross fixed capital formation), differentiated by the following types of capital: computing equipment (IT), communications equipment (CMT), software (SOFT), transport equipment (TraEq), other machinery and equipment (oMach) and non-residential investment (oCon).[16] This list makes clear that the term 'capital' that is already accounted for in EU KLEMS numbers on gross output and value added is a combination of mostly tangible capital and one category of intangible capital (software). The use of disaggregate capital time series, however, allows us to strictly define tangible capital (IT, CMT, TraEq, oMach, oCon) and intangible capital (software plus the other categories already explored in section 2) and to modify numbers on aggregate gross output or value added, once when we only incorporate tangible capital and in a second version in which we account for all types of intangible capital. EU KLEMS data also

[14] The following industry breakdown is given in EU KLEMS based on the industry classification NACE Rev. 1.1: NACE A-B (agriculture & fishing), C (mining and quarrying), D (manufacturing that is further split into the NACE industries 15-16, 17-19, 20, 21-22, 23, 24, 25, 26, 27-28, 29, 30-33, 34-35, 36-37), E (electricity, gas and water supply), F (construction), G (wholesale and retail trade, further broken down into 50, 51 and 52), H (hotels and restaurants), I (transport and storage, further broken down into 60-63 and 64), J (financial intermediation), K (real estate, renting and business activities, further split into 70 and 71-74) as well as the public and private sector.

[15] In case where figures where not available in EU KLEMS using the 6-industry classification (for instance for sector agriculture and fishing (A-B) and mining (C) which we summarize to A-C), we apply a Tornquist weight to aggregate indices across sectors. This procedure applies to sector 1, 5 and 6.

[16] We do not take into account investments in residential structures.

deliver *price deflators* and nominal and real *capital stocks* for each type of asset (IT, CMT, SOFT, TraEq, oMach, oCon). EU KLEMS also provides time-constant estimates of (geometric) depreciation rates for each capital asset. In most cases the depreciation rate for one asset is constant across industries. In some cases, however, the rates differ across industries. For industries 1, 5 and 6 we then use an average rate (see Table 10-9). The novelty within the Coinvest project refers to the inclusion of intangible assets into the growth accounting framework. The collection of data on expenditure for *intangible assets* and its conversion into time series of *investment* have already been explained. In a second step, we use the perpetual inventory method to build *capital stocks* for each type of intangible assets. The underlying depreciation rates are set out in Table 10-9. For intangible assets these are based on Corrado et al. (2006). As *price deflator*, we use the implicit value added deflator for each type of intangible asset.

Basic data on *capital income* at the sector level, needed for calculating weights in the growth accounting analysis, is also taken from EU KLEMS capital data. It publishes capital compensation by type of asset k= IT, CMT, TraEq, oMach, oCon, SOFT. We use the sum of capital compensation for assets k= IT, CMT, TraEq, oMach, oCon as a measure for capital income of tangible capital.

One problem that we are confronted with is the fact that we neither do observe capital compensation for intangible capital in total nor for each type of intangible asset. Hence, we also lack information on total capital income. To solve this problem, we employ the following procedure. Starting point is the fact that *capital compensation of asset k* can be calculated as its rental price times the capital stock. The rental price or user cost of capital consists of the nominal rate of return ror_k (reflecting the opportunity cost of holding the asset k) plus the nominal cost of depreciation for asset k and minus the nominal gain from holding the asset for each accounting period, i.e. the capital gain (see Azeez Erumban, 2008). For each capital asset, we already possess information on capital stocks and depreciation rates. We furthermore estimate capital gains for each asset by using a three-year moving average of the change in capital prices. However, what about the rate of return? In order to get an estimate of the rate of return, we use the suggestion by Hall and Jorgensen (1967). That is, we assume that the rate of return is unknown but constant across all assets ($ror_k = ror$). Under this assumption, we can estimate the common rate of return as the total capital income minus the sum of depreciation costs over all assets plus the sum of capital gains for all assets and finally divided by the total nominal capital stock. Having an estimate for the rate of return of asset k ($ror_k = ror$), we can then use the above formula to estimate the rental price of each asset k and subsequently the capital income for each type of capital. Note that, once again, we have two estimates of the rate of return (ror). In version one, we assume that total capital income equals the capital compensation for tangible capital. In version two, in which we account for intangible assets, total capital income is estimated as the income for tangible capital plus the sum of investments for intangible capital as an estimate for the compensation of intangible capital.[17]

Finally, in order to measure the growth of total labour services and the growth in labour services per hour worked, we extract data on total labour costs and total hours worked from EU KLEMS output data (November 2009 release). The EU KLEMS March 2008 release provides time series on heterogeneous labour input, i.e. labour compensation and hours worked for 18 different groups of labour. Employees and self-employed persons are differentiated according to their educational degree (high-, medium- and low-skilled), gender and their age (below 29, 30-49 and above 50). This type of information, however, is only available until 2005. The missing observations for 2006 are estimated based on the total labour compensation for 2006 and the share of labour compensation for each group in 2005.

Complete data for all time series are available for the years 1995-2006. Since we take a two-year period average for the weights and measure capital gains within the rate of return calculation as a three-year moving average of changes in capital prices, we loose observations and can only use the period 1997-2006 for the growth accounting. That is, the first growth rate measures changes in labour productivity between 1996 and 1997

All calculations were done by using a STATA program which was written in the course of the COINVEST project by the UK team to facilitate that all participating countries apply the same methodology.[18] This program was slightly extended for instance to additionally allow for subgroups of intangible capital.

7.3 Growth accounting results

This section delineates the sources of economic growth at the sector level, at the aggregate level and the industry contributions to economic growth and capital and labour input.

Decomposition of growth in real gross output at the industry level

We start with the decomposition of growth in real gross output at the industry level (equation (1), in combination with (2) and (3) to account for heterogeneous inputs). The upper panel of Table 7-1 describes a situation in which the growth accounting framework only includes tangible capital (assets k= IT, CMT, TraEq, oMach, oCon). In the second panel, we additionally account for intangible capital. The first row depicts the growth rate in gross output across industries. Over the period 1997 to 2006, gross output increased on average by roughly 2.3% to 3.2% per year in four out of six industries (manufacturing, financial & business services, trade & transport and utility) while it declined in

[17] The average rate of return in version one is 0.083 and in version two 0.086. Both are highly correlated indicated by a correlation coefficient of about 0.986.

[18] We thank Jonathan Haskel and Anarosa Pesole for sharing the STATA program.

agriculture & mining (-0.4%) and construction (-2.7%). At the same time, labour input intensity has changed. That is, the number of hours worked has been reduced in most industries, except in financial and business services where we observe an average annual increase of around 3.7%. When we take both developments together, we get the change in labour productivity (in terms of gross output). The average annual growth rate in labour productivity was highest in utility at about 6.4%, but likewise high in manufacturing (+4.6%). In agriculture & mining and trade & transportation, the figures indicate a moderate growth in labour productivity of about 2.4% and 2.6%, respectively. Labour productivity has even been slightly slowed down in the remaining two industries.

Table 7-1: Contributions to labour productivity growth (in terms of gross output) by sector, 1997-2006

	Sector					
	1 AgMin	2 Mfr.	3 Utility	4 Cons.	5 RetHtTm	6 FinBsSvs
	Excluding Intangibles					
Gross output	-0.44	2.94	2.69	-2.66	2.33	3.15
Hours worked	-3.00	-1.65	-3.69	-2.37	-0.02	3.66
Labour Productivity	**2.56**	**4.59**	**6.38**	**-0.29**	**2.35**	**-0.51**
Capital deepening	-0.06	0.21	1.44	-0.03	0.33	0.44
ICT capital	0.02	0.04	0.09	0.02	0.11	0.39
Non-ICT capital	-0.08	0.17	1.35	-0.05	0.22	0.05
Intangible capital	-	-	-	-	-	-
Labour quality	-0.22	0.07	0.04	0.08	-0.01	-0.03
Intermediate input deepening	1.21	3.34	4.07	0.09	1.21	-0.22
TFP	1.62	0.97	0.83	-0.43	0.81	-0.70
	Including Intangibles					
Gross output	-0.45	2.90	2.72	-2.65	2.34	3.20
Hours worked	-3.00	-1.65	-3.69	-2.37	-0.02	3.66
Labour Productivity	**2.55**	**4.55**	**6.41**	**-0.28**	**2.36**	**-0.46**
Capital deepening	0.16	0.83	1.86	0.13	0.58	0.87
ICT capital	0.02	0.04	0.09	0.02	0.12	0.39
Non-ICT capital	-0.06	0.20	1.39	-0.05	0.23	0.06
Intangible capital	**0.20**	**0.59**	**0.38**	**0.17**	**0.23**	**0.42**
Labour quality	-0.22	0.07	0.04	0.08	-0.01	-0.03
Intermediate input deepening	1.03	3.09	3.89	0.08	1.13	-0.03
TFP	1.56	0.56	0.62	-0.57	0.66	-1.26

Notes: Reported are average annual percentages. Tangible capital includes ICT capital consisting of computing equipment and communications equipment, non-ICT capital consisting of transport equipment, other machinery and equipment and non-residential investment. Intangible capital comprises software, databases, scientific R&D, mineral exploration, copyright and license costs, financial services innovation, purchased and own-account architectural and engineering design, advertising, market research, training and purchased and own account organizational structure. Data: See section 2 and 6.2. Own calculation.

The decomposition of the sources of growth between primary inputs and TFP emphasizes that *intermediate inputs contributed the most to labour productivity growth in all sectors in Germany, except in financial and business services*. This pattern emerges in both panels. Looking at the lower panel, the intermediate input deepening accounts for a raise of labour productivity of about 3.9 percentage points in utility. In manufacturing, growth in intermediate inputs led to a 3.1 percentage point increase in labour productivity which is nearly 73% of the overall increase in manufacturing. The contribution of intermediate inputs to growth is much smaller in absolute terms in the sectors agriculture & mining and trade & transport where this figure is roughly 1 percentage point. In construction intermediate inputs contributed only a negligible amount to labour productivity growth and in financial services, this effect was even negative.

A second striking result is that *growth in labour quality contributed only to a very limited extent to industry growth in labour productivity*. In both panels, the contribution never exceeds 0.08 percentage points and is even slightly negative for three out of six industries (agriculture & mining and both service sectors). Results for the UK have shown a much higher absolute and relative contribution of labour input to labour productivity, in particular for manufacturing and both service sectors (contribution varies between 0.2 and 0.3 percentage points with a smaller labour productivity growth at the same time; see Clayton et al., 2009).

When we only account for tangible capital, the contribution of capital to growth is also relatively small, except for utility (+1.4 percentage points). In manufacturing, capital deepening has induced an increase in labour productivity of about 0.2 percentage points. It is only slightly larger in the two service sectors and even slightly negative in remaining two sectors (agriculture & mining, construction). The slow down in growth in these two sectors can be traced back to a negative contribution of Non-ICT capital whereas ICT capital has stimulated growth in all industries. Another salient result pertains to the relative importance of ICT and non-ICT capital. *Whereas non-ICT capital is much more important for generating growth in sectors such as manufacturing, trade & transport and utility, ICT has a larger contribution in the other three sectors*; in particular financial business services where it raised annual average growth by 0.4 percentage points.

When we include intangible capital, total capital deepening gets positive and larger in all industries. It then ranges between 0.13 percentage points in construction and 1.86 percentage points in utility, manufacturing being in between with an increase of about 0.9 percentage points. *Growth in intangible assets has stimulated labour productivity growth in all sectors.* The contribution varies between 0.17 (construction) and 0.59 (manufacturing) percentage points. Compared to the UK, however, intangible capital deepening seems to be somewhat smaller in absolute and relative terms in most sectors. For instance, it amounts to 0.97 percentage points in UK manufacturing (Clayton et al., 2009), but only 0.59 percentage points in Germany. Another outstanding result is the fact that the *contribution of intangible capital in Germany was higher than that of ICT and non ICT capital separately in all German sectors, except for utility*. In manufacturing, agriculture & mining and construction, intangible capital deepening was even larger than tangible capital deepening.

Growth in TFP, defined as growth in output per unit of input, *plays a major role in explaining industry growth in labour productivity*. In manufacturing, growth in TFP boosts labour productivity growth by nearly 1 percentage point when do not include intangible capital. This implies that roughly 21% of labour productivity growth in this sector cannot be explained by growth in capital, labour and intermediate inputs. In trade & transport TFP accounts for 0.8 percentage points increase in labour productivity which means 34% of overall labour productivity growth. The role of TFP is particularly strong in agriculture & mining, which could be related to the fact that we do not account for factor input land. On the other hand, its contribution was negative in financial and business services and construction. The *inclusion of intangible capital has led to a decline in the contribution of TFP in all sectors* which implies that part of the effect of TFP in the upper panel was due to the fact that we missed intangible capital. Of course, the *reduction in the contribution of TFP turns out to be particularly strong in those industries where growth in intangible capital revives labour productivity growth to a larger extent*, i.e. in manufacturing, utility and financial & business services. Accounting for intangible capital furthermore illustrates that (except for agriculture &mining) manufacturing does not show the highest contribution of TFP growth any longer but that the effect of TFP growth is now larger in trade & transport and utility.

Table 7-2 disentangles the contribution of intangible capital into its different components. The results reveal that growth of *innovative property capital is the most influential type of intangible capital for labour productivity in manufacturing and financial & business services*, followed by economic competencies and computerized information. *In all other sectors,* growth of intangible capital that measures *economic competencies play the most prominent role for labour productivity growth*, followed by innovative property capital and computerized information.

The contributions of *innovative property capital* show the highest variance across industries. They range from a 0.39 percentage points increase in labour productivity in manufacturing to a 0.04 percentage points increase in trade & transport. Innovative property capital thus accounts for 65% of the total contribution of intangible capital in manufacturing. The lion's share (0.29 percentage points or a share of 49%) can be allotted to the growth in scientific R&D. In manufacturing, a raise in labour productivity of about 0.06 percentage points which corresponds to a share of 9.6% of intangible capital deepening is due to new architectural and engineering designs. The contribution of innovative property capital in manufacturing (0.39) is roughly twice as big as in the financial and business service sector (0.2). Growth in intangible capital based on new architectural and engineering designs is by far the most important source of growth (0.09 percentage points) among intangible assets in this sector, followed by financial service innovations (0.07) and scientific R&D (0.04). As a general result, architectural and engineering designs are the most important component of innovative property capital in all sectors, except in manufacturing.

Table 7-2: **Contributions of different types of intangible assets to labour productivity growth (in terms of gross output) by sector, 1997-2006**

	Excluding Intangibles					
	1 AgMin	2 Mfr.	3 Utility	4 Cons.	5 RetHtTm	6 FinBsSvs
Gross output	-0.44	2.94	2.69	-2.66	2.33	3.15
Hours worked	-3.00	-1.65	-3.69	-2.37	-0.02	3.66
Labour Productivity	**2.56**	**4.59**	**6.38**	**-0.29**	**2.35**	**-0.51**
Capital deepening	-0.06	0.21	1.44	-0.03	0.33	0.44
ICT capital	0.02	0.04	0.09	0.02	0.11	0.39
Non-ICT capital	-0.08	0.17	1.35	-0.05	0.22	0.05
Intangible capital	-	-	-	-	-	-
Labour quality	-0.22	0.07	0.04	0.08	-0.01	-0.03
Intermediate input deepening	1.21	3.34	4.07	0.09	1.21	-0.22
TFP	1.62	0.97	0.83	-0.43	0.81	-0.70
	Including Intangibles					
	1 AgMin	2 Mfr.	3 Utility	4 Cons.	5 RetHtTm	6 FinBsSvs
Labour Productivity	**2.545**	**4.554**	**6.410**	**-0.284**	**2.362**	**-0.458**
Capital deepening	0.162	0.832	1.863	0.131	0.585	0.867
ICT capital	0.023	0.040	0.094	0.017	0.117	0.390
Non-ICT capital	-0.061	0.200	1.388	-0.051	0.234	0.059
Intangible capital	**0.199**	**0.592**	**0.380**	**0.165**	**0.234**	**0.417**
Computerized Information	**0.012**	**0.039**	**0.086**	**0.014**	**0.048**	**0.065**
Software	0.012	0.038	0.085	0.014	0.047	0.063
Databases	0.000	0.001	0.001	0.000	0.001	0.003
Innovative property	**0.065**	**0.386**	**0.068**	**0.041**	**0.040**	**0.204**
Scientific R&D	0.015	0.289	0.013	0.003	0.008	0.045
Mineral exploration	0.013	0.000	0.000	0.000	0.000	0.000
Copyright licenses	0.000	0.039	0.000	0.000	0.000	0.000
Financial services innovation	0.000	0.000	0.000	0.000	0.000	0.068
Architectural & engineering design	0.037	0.057	0.055	0.038	0.032	0.091
Economic competencies	**0.122**	**0.167**	**0.226**	**0.110**	**0.146**	**0.148**
Advertising	0.031	0.025	0.032	0.008	0.015	0.003
Market research	0.002	0.001	0.002	0.000	0.001	-0.002
Firm-specific human capital	0.018	0.062	0.111	0.059	0.082	0.045
Organizational structure (p)	0.032	0.034	0.037	0.017	0.021	0.036
Organizational structure (oa)	0.040	0.045	0.046	0.025	0.028	0.066
Labour quality	-0.217	0.073	0.038	0.078	-0.011	-0.031
Intermediate input deepening	1.035	3.093	3.889	0.076	1.131	-0.032
TFP	1.565	0.556	0.620	-0.570	0.657	-1.262

Notes: See Table 7-1.

The growth contributions of *economic competencies* are less spread across industries than those of innovative properties. Economic competencies have raised labour productivity growth between 0.11 (construction) and 0.22 (utility) percentage points. In manufacturing these competencies have stimulated growth by roughly 0.17 percentage points. Among economic competencies, not all types of assets are equally important. Growth in firm-specific human capital has contributed the most in four out of six sectors (manufacturing, utility, construction and trade& transport), followed by own-account as well as purchased organizational capital. Regarding the size of these effects, note that the contribution of firm-specific human capital turned out to be higher than that of new architectural and engineering design in all four industries. In the remaining two sectors (financial & business services and agriculture & mining) own-account organizational capital was the most important source of growth among economics competencies. Compared to firm-specific human capital and organizational capital, growth in branding capital (advertising) was associated with a relatively smaller increase in labour productivity growth. It was roughly 0.03 percentage points in manufacturing, utility and agriculture & mining, and more or less negligible in the other three sectors.

The *contribution of growth in intangible capital related to investments in computerized information is relatively small in all sectors*. It never exceeds 0.1 percentage points. Within computerized information, software is decisive whereas the role of database is negligible.

In order to account for the effect that business cycle conditions were quite different across the period 1997 to 2000, we perform the growth accounting for various sub periods. Table 7-3 splits the sample into three periods: the first period 1997-2000 was characterised by an economy-wide boom period. On the contrary, the period 2000-2003 was marked by recession, whereas the economy experienced an economic upswing again in the period 2003-2006.[19] This is also reflected by the figures on labour productivity growth, except for utility and agriculture & mining in which we observe highest growth rates in the second period.

The results confirm much of what has been said so far, but they also reveal some interesting new insights: The main results can be summarized as follows:

- The contribution of intangible capital to growth turned out to be positive in all sub periods in all sectors, except for financial & business services in the third period.
- In most sectors, including manufacturing and the two service sectors, the absolute increase in labour productivity growth due to intangible capital has been declined over the three periods. This decrease can be observed for each single component of intangible capital. It is particularly strong for economic competencies and less so for innovative property and computerized information.
- But still, intangible capital deepening was higher than ICT capital deepening or non-ICT capital deepening in all three periods in manufacturing, agriculture & mining and construction. In both service sectors, however, this pattern has changed over time and ICT capital deepening (financial business services) and non-ICT capital deepening (trade & transport) have become the more important than intangible capital deepening from 2001 onwards.
- Though the growth in labour productivity was similar in magnitude in manufacturing in the boom period 1997-2000 and in the upswing period 2003-

[19] For comparison reasons within Coinvest, we also split the sample into two periods 1997-2000 and 2000-2006, see Table 10-10.

2006, the sources of growth differ quite a lot. Besides intermediate input deepening, intangible capital was the second most important source of growth in the first period that has stimulated growth by 1 percentage point whereas the contribution of TFP was relatively small (+0.5). In the third period, however, the upswing is much more supported by growth in TFP (+1.7) than by intangible capital (+0.25). But also the contribution of tangible capital has declined (from +0.36 to +0.16).

- In all sectors, the contribution of labour quality to growth in labour productivity was highest in the recession period.

Table 7-3: Contributions to labour productivity growth (in terms of gross output) by sector and subperiods (1997-2000, 2001-2003, 2004-2006)

	AgMin			Mfr.			Utility			Cons.			RetHtTm			FinBsSvs		
	97-00	01-03	04-06	97-00	01-03	04-06	97-00	01-03	04-06	97-00	01-03	04-06	97-00	01-03	04-06	97-00	01-03	04-06
	Excluding Intangibles																	
Labour Productivity	**1.31**	**4.07**	**2.72**	**6.11**	**0.92**	**6.25**	**4.71**	**9.13**	**5.87**	**-1.71**	**-3.24**	**4.55**	**3.53**	**0.67**	**2.43**	**0.15**	**-2.03**	**0.14**
Capital deepening	-0.12	-0.10	0.07	0.29	0.14	0.17	1.85	1.58	0.74	-0.10	-0.10	0.14	0.36	0.27	0.36	0.83	0.22	0.14
ICT capital	0.02	0.02	0.02	0.05	0.03	0.02	0.12	0.09	0.06	0.02	0.01	0.02	0.15	0.08	0.09	0.60	0.30	0.18
Non-ICT capital	-0.15	-0.13	0.05	0.23	0.11	0.15	1.73	1.49	0.69	-0.13	-0.11	0.13	0.21	0.19	0.27	0.22	-0.09	-0.03
Intangible capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Labour quality	-0.35	-0.01	-0.24	0.02	0.20	0.02	0.04	0.10	-0.02	0.05	0.15	0.04	-0.08	0.14	-0.08	-0.06	0.16	-0.19
Intermed. input deep.	-0.07	3.37	0.76	4.59	0.72	4.31	2.34	6.23	4.22	-0.68	-2.06	3.26	1.96	-0.08	1.50	0.34	-1.53	0.35
TFP	1.86	0.81	2.13	1.21	-0.14	1.76	0.49	1.21	0.92	-0.98	-1.23	1.10	1.29	0.34	0.65	-0.96	-0.88	-0.16
	Including Intangibles																	
Labour Productivity	**1.31**	**4.05**	**2.69**	**6.01**	**0.98**	**6.19**	**4.78**	**9.13**	**5.87**	**-1.71**	**-3.21**	**4.54**	**3.58**	**0.65**	**2.44**	**0.29**	**-2.14**	**0.22**
Capital deepening	0.11	0.09	0.31	1.38	0.52	0.42	2.56	2.01	0.79	0.21	-0.09	0.25	0.83	0.45	0.40	1.92	0.38	-0.04
ICT capital	0.02	0.02	0.02	0.06	0.03	0.02	0.13	0.09	0.06	0.02	0.01	0.02	0.16	0.09	0.09	0.62	0.31	0.17
Non-ICT capital	-0.13	-0.10	0.08	0.30	0.12	0.14	1.79	1.54	0.70	-0.14	-0.11	0.12	0.23	0.20	0.27	0.23	-0.09	-0.03
Intangible capital	**0.22**	**0.16**	**0.22**	**1.02**	**0.37**	**0.25**	**0.64**	**0.38**	**0.04**	**0.32**	**0.01**	**0.11**	**0.44**	**0.16**	**0.03**	**1.07**	**0.16**	**-0.19**
Computerized Inform.	0.01	0.01	0.01	0.06	0.03	0.01	0.13	0.08	0.03	0.03	0.01	0.00	0.07	0.04	0.03	0.13	0.07	-0.02
Software	0.01	0.01	0.01	0.06	0.03	0.01	0.13	0.08	0.03	0.03	0.01	0.00	0.07	0.03	0.03	0.12	0.06	-0.02
Databases	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Innovative property	0.08	0.05	0.06	0.60	0.27	0.21	0.12	0.06	0.01	0.08	0.01	0.02	0.07	0.04	0.01	0.45	0.10	-0.01
Scientific R&D	0.02	0.01	0.01	0.42	0.22	0.18	0.02	0.01	0.01	0.01	0.00	0.00	0.01	0.02	0.00	0.06	0.04	0.04
Mineral exploration	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copyright licenses	0.00	0.00	0.00	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fin. services innovation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.02	-0.03
Arch. & engin. design	0.04	0.03	0.04	0.10	0.04	0.02	0.09	0.06	0.00	0.07	0.01	0.02	0.06	0.02	0.01	0.21	0.04	-0.02
Economic competencies	0.12	0.10	0.15	0.35	0.07	0.03	0.39	0.23	0.00	0.22	-0.01	0.09	0.30	0.09	0.00	0.49	0.00	-0.16
Advertising	0.03	0.02	0.05	0.07	-0.01	0.00	0.08	0.02	-0.02	0.03	-0.03	0.01	0.04	0.00	0.00	0.08	-0.05	-0.05
Market research	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Firm-specific human cap.	0.01	0.03	0.02	0.13	0.03	0.01	0.15	0.12	0.05	0.09	0.02	0.05	0.17	0.06	-0.01	0.15	-0.01	-0.04
Organ. structure (p)	0.03	0.02	0.04	0.07	0.02	0.01	0.07	0.04	-0.01	0.04	-0.01	0.01	0.04	0.01	0.01	0.11	0.01	-0.03
Organ. structure (oa)	0.04	0.03	0.04	0.09	0.03	0.01	0.08	0.06	-0.01	0.05	0.01	0.01	0.05	0.02	0.00	0.16	0.04	-0.04
Labour quality	-0.36	-0.01	-0.24	0.02	0.20	0.02	0.04	0.10	-0.03	0.05	0.15	0.04	-0.08	0.14	-0.08	-0.06	0.16	-0.19
Intermed. input deep.	-0.08	3.13	0.44	4.08	0.85	4.03	2.01	6.06	4.23	-0.69	-1.91	3.08	1.80	-0.04	1.41	0.37	-1.07	0.46
TFP	1.64	0.85	2.18	0.53	-0.59	1.73	0.17	0.97	0.87	-1.28	-1.36	1.17	1.03	0.10	0.71	-1.94	-1.61	-0.01

Notes: See Table 7-1.

Decomposition of real value added growth at the industry level

Since growth accounting at the aggregate level is based on a value added concept, Table 7-4 additionally depicts the decomposition of growth in real value added at the industry level (equation (5)). Growth in real value added in industry j is the weighted sum of industry capital, labour input and TFP growth. The weights on capital (labour) account for the share of capital (labour) income in gross output in industry j and for (the inverse of) the share of industry value added in industry gross output.

Table 7-4: Contributions to labour productivity growth (in terms of value added) by sector and type of intangible assets, 1997-2006

	Sector					
	1 AgMin	2 Mfr.	3 Utility	4 Cons.	5 RetHtTm	6 FinBsSvs
	Excluding Intangibles					
Labour productivity growth	**2.90**	**3.73**	**4.60**	**-0.85**	**2.13**	**-0.54**
Capital deepening	-0.12	0.61	2.81	-0.06	0.63	0.83
ICT capital	0.05	0.11	0.18	0.04	0.21	0.73
Non-ICT capital	-0.17	0.50	2.63	-0.10	0.42	0.10
Intangible capital	-	-	-	-	-	-
Labour quality	-0.47	0.22	0.07	0.18	-0.02	-0.06
TFP	3.48	2.90	1.71	-0.96	1.53	-1.31
	Including Intangibles					
Labour productivity growth	**3.09**	**3.65**	**4.65**	**-0.77**	**2.16**	**-0.69**
Capital deepening	0.34	2.03	3.37	0.29	1.02	1.40
ICT capital	0.05	0.10	0.17	0.04	0.21	0.64
Non-ICT capital	-0.12	0.49	2.53	-0.11	0.41	0.09
Intangible capital	**0.41**	**1.44**	**0.67**	**0.36**	**0.40**	**0.67**
Computerized Information	0.03	0.10	0.15	0.03	0.08	0.11
Software	0.03	0.09	0.15	0.03	0.08	0.10
Databases	0.00	0.00	0.00	0.00	0.00	0.00
Innovative property	0.13	0.95	0.12	0.09	0.07	0.33
Scientific R&D	0.03	0.71	0.02	0.01	0.01	0.07
Mineral exploration	0.03	0.00	0.00	0.00	0.00	0.00
Copyright licenses	0.00	0.10	0.00	0.00	0.00	0.00
Financial services innovation	0.00	0.00	0.00	0.00	0.00	0.11
Architectural & engineering design	0.08	0.14	0.10	0.08	0.06	0.15
Economic competencies	0.25	0.40	0.40	0.24	0.25	0.24
Advertising	0.06	0.06	0.05	0.02	0.03	0.00
Market research	0.00	0.00	0.00	0.00	0.00	0.00
Firm-specific human capital	0.04	0.15	0.20	0.13	0.14	0.07
Organizational structure (p)	0.07	0.08	0.06	0.04	0.04	0.06
Organizational structure (oa)	0.08	0.11	0.08	0.06	0.05	0.11
Labour quality	-0.44	0.18	0.07	0.17	-0.02	-0.05
TFP	3.19	1.44	1.21	-1.23	1.16	-2.04

Notes: See Table 7-1.

Most of the results with respect to the sources of growth in value added are qualitatively the same as before for growth in gross output. The most salient results are the following ones:

- The contribution of intangible capital to growth turned out to be positive in all sectors. It is highest in manufacturing where it raised growth by 1.44 percentage points. That is, intangible capital accounts for nearly 40% of labour productivity growth (based on value added). In the other five industries, intangible capital deepening ranges roughly between 0.35 and 0.7 percentage points and its relative importance is lower.

- The former result that intangible capital deepening is more important than ICT and non-ICT capital deepening, respectively, is confirmed for most industries (manufacturing, agriculture & mining, construction, financial & business services). In manufacturing, agriculture & mining and construction, the contribution of intangible capital was even larger than that of overall tangible capital. In trade & transport, non-ICT capital deepening turned out to be slightly more important. In financial & business services, the contribution of ICT capital was nearly as large as that of intangible capital.

- In manufacturing and financial & business services the growth of innovative property capital is the most influential type of intangible capital for labour productivity. In manufacturing the main source of intangible capital deepening can be again traced back to scientific R&D (it accounts for 75%) whereas it is new architectural and engineering design in financial and business services. In both sectors, innovative property is followed by economic competencies and computerized information is bottom of the list. In all other sectors, the main source of intangible capital deepening can be allotted to the growth in economic competencies. It is followed by innovative property capital and computerized information.

- With respect to the relative importance of specific types of economic competencies, the same picture emerges as before: Growth in firm-specific human capital has contributed the most in four out of six sectors (manufacturing, utility, construction and trade& transport), followed by own-account as well as purchased organizational capital. In the remaining two sectors growth in own-account organizational capital was the most important source of growth among economics competencies.

- The inclusion of intangible capital reduces the contribution of TFP growth significantly in 5 out of 6 sectors (the exception being agriculture & mining). The reduction in the contribution of TFP turns out to be particularly strong in those industries where growth in intangible capital revives labour productivity growth to a larger extent. But still, TFP growth plays the most important role for growth in labour productivity based on value added in manufacturing, agriculture & mining and trade & transport. For instance, in manufacturing, TFP growth raised labour productivity growth by 1.4 percentage points. This corresponds to roughly 40% of the overall increase in labour productivity. On the contrary, the effect of TFP growth was negative on labour productivity in financial and business services and construction.

- Growth in labour quality contributed only to a small extent to industry growth in labour productivity based on value added. The contributions are slightly larger compared to when we use gross output to measure labour productivity, in particular for manufacturing and construction.

Decomposition of real value added growth at the aggregate level

Using the direct aggregation approach, we calculate aggregate value added growth as weighted sum of industry value added growth and investigate the sources of aggregate growth using equation (8). Table 7-5 displays the contributions of capital, labour quality and TFP to aggregate growth with (upper panel) and without (bottom panel) accounting for intangible capital.

Table 7-5: Contributions to aggregate labour productivity growth, 1997-2006

	Excluding Intangibles			
	97-00	01-03	04-06	Total
Value added growth	2.55	0.35	2.51	1.88
Hours worked	0.41	-0.01	-0.30	0.07
Labour productivity growth	**2.14**	**0.36**	**2.81**	**1.81**
Capital deepening	0.93	0.47	0.52	0.67
ICT capital	0.43	0.24	0.17	0.30
Non-ICT capital	0.50	0.23	0.35	0.37
Intangible capital	-	-	-	-
Labour quality	-0.06	0.39	-0.13	0.05
TFP	1.28	-0.50	2.42	1.09
	Including Intangibles			
	97-00	01-03	04-06	Total
Value added growth	2.81	0.01	2.47	1.87
Hours worked	0.41	0.04	-0.29	0.09
Labour productivity growth	**2.40**	**-0.03**	**2.75**	**1.78**
Capital deepening	2.49	0.93	0.64	1.47
ICT capital	0.39	0.21	0.15	0.27
Non-ICT capital	0.51	0.22	0.31	0.36
Intangible capital	1.58	0.50	0.19	0.84
Labour quality	-0.05	0.35	-0.12	0.05
TFP	-0.04	-1.31	2.23	0.26

Notes: See Table 7-1.

Note that treating expenditure for intangible goods as intermediate input instead of long-term investment generally implies that we underestimate labour productivity and overestimate the contribution of total factor productivity to labour productivity growth. In the period 1997-2000 we clearly observe these two biases. In the period 2001-2006, however, we would overestimate labour productivity growth when we neglect intangible capital. But in all periods the inclusion of intangible capital leads to a significant reduction in the contribution of TFP to labour productivity growth. Overall, it declined from 1.1 to 0.26 percentage points.

In the period 1997-2006 the average annual labour productivity growth was nearly 1.8%. The most important contribution to growth stems from intangible capital deepening. It accounts for 0.84 percentage points or nearly half of the overall growth in labour productivity. However, what was already evident at the industry level transferred to the aggregate level: The absolute and relative contribution of intangible capital deepening has declined over time. While labour productivity growth was mainly backed by intangible capital deepening in the boom period 1997-2000, intangible capital contributed only to a small extent to the economic upswing in 2003-2006. Growth in TFP was the main source of labour productivity growth in this period.

Compared to tangible capital, it turns out that the contribution of intangible capital was larger in the overall period (+0.84 compared to +0.64 percentage points). However, this was mainly due to the boom period 1997-2000. Between 2001 and 2003 tangible and intangible capital contributed to a similar extent to labour productivity growth (+0.43 and +0.5). In the upswing phase 2003-2006, tangible capital deepening, however, was more important as source of growth than intangible capital (+0.46 compared to +0.19). In the latter period, we even observe that non-ICT capital stimulated growth more than intangible capital and that ICT capital deepening was nearly as large. Overall, the results reveal a decline over time in the absolute contribution of ICT capital and intangible capital whereas we do not observe this pattern for non-ICT capital.

Industry contributions to aggregate labour productivity growth and to capital, labour and TFP deepening

Finally, the direct aggregation approach allows us to investigate the industry contributions to value added growth (using equation (6)) and to capital, labour and TFP deepening (using equation (7)). Table 7-6 and Table 7-7 present the industry contributions when we exclude and include intangible capital into the growth accounting framework. For sector and each indicator (value added, capital, labour and TFP) the weight, growth rate and the sector contribution to the aggregate figure is displayed. The following main conclusions can be drawn from the tables:

- With respect to value added, the lion’s share can be allotted to manufacturing. 73% of aggregate value added growth stems from manufacturing despite its share in aggregate value added being just around 35%. A second important source of aggregate value added growth originates in trade & transport (roughly

31%). On the contrary, construction and financial & business services have contributed negatively to value added growth.

- Regarding ICT capital deepening the leading sector contribution stems from financial & business services. Around 64% of the contribution of ICT capital to labour productivity growth comes from this sector. The second largest contributor to ICT capital deepening is trade & transport (19%), followed by manufacturing (13%).

- Regarding non-ICT capital deepening, the industry contributions are much more evenly spread across industries. The major contributor is manufacturing. Its contribution (48%) is again larger than the weight manufacturing possesses in the level of aggregate value added. Trade & transport is second on the list (29%), followed by utility (21%).

- Intangible capital deepening stems to a large extent from high growth rates in intangibles in manufacturing. 60.5% of the contribution of intangible capital to labour productivity can be traced back to manufacturing. The financial and business services sector is the second largest contributor to intangible capital deepening (21.5%). Another 12% originates in trade & transport.

- Aggregate TFP growth is mostly accounted for by manufacturing and trade & transport. Utility and agriculture show also a positive but relatively small contribution whereas the financial & business service sector and construction even negatively contribute to aggregate TFP growth.

- Regarding the contribution of labour quality, we also find manufacturing on the top of the list though its relative size in labour is smaller than for instance for trade & transport.

Table 7-6: Industry contributions to aggregate growth (excluding intangibles), 1997-2006

	Excluding Intangibles													
	1 AgMin		2 Mfr.		3 Utility		4 Cons.		5 RetHtTm		6 FinBsSvs		Business Sector	
	abs.	in %	abs.	in %	abs.	in %	abs.	in %	abs.	in %	abs.	in %	abs.	in %
Value added														
VA weight	0.024		0.336		0.032		0.074		0.270		0.264			
VA growth	2.898		3.730		4.598		-0.847		2.133		-0.542			
CT to agg. VA growth	0.071	*3.9*	1.255	*69.4*	0.138	*7.6*	-0.086	*-4.8*	0.576	*31.9*	-0.146	*-8.1*	1.808	*100.0*
Total capital														
Capital weight	0.002		0.077		0.019		0.011		0.055		0.106			
Capital growth	-1.418		2.737		4.853		-0.354		3.112		1.974			
CT to agg. capital growth	-0.003	*-0.5*	0.204	*30.6*	0.089	*13.4*	-0.007	*-1.1*	0.170	*25.5*	0.213	*32.0*	0.666	*100.0*
thereof:														
CT to agg. ICT cap. growth	0.001	*0.3*	0.037	*12.5*	0.006	*2.0*	0.003	*1.0*	0.058	*19.7*	0.190	*64.4*	0.295	*100.0*
CT to agg. non-ICT cap. growth	-0.005	*-1.3*	0.167	*45.0*	0.083	*22.4*	-0.010	*-2.7*	0.112	*30.2*	0.024	*6.5*	0.371	*100.0*
CT to intangible cap. growth	-				-		-		-		-		-	
Labour quality growth (LQG)														
Labour quality weight	0.022		0.259		0.013		0.063		0.216		0.158			
Labour quality growth	-0.507		0.275		0.159		0.211		-0.029		-0.097			
CT to agg. LQG	-0.011	*-20.0*	0.073	*132.7*	0.002	*3.6*	0.014	*25.5*	-0.006	*-10.9*	-0.017	*-30.9*	0.055	*100.0*
TFP														
TFP weight	0.051		1.003		0.063		0.170		0.507		0.501			
TFP growth	1.565		0.970		0.833		-0.430		0.814		-0.699			
CT to agg. TFP growth	0.072	*6.6*	0.977	*89.9*	0.047	*4.3*	-0.092	*-8.5*	0.412	*37.9*	-0.342	*-31.5*	1.087	*100.0*

Notes: Presented are average annual industry contributions. Data: See section 2 and 6.2. Own calculation.

Table 7-7: Industry contributions to aggregate growth (including intangibles), 1997-2006

	Including Intangibles													
	1 AgMin		2 Mfr.		3 Utility		4 Cons.		5 RetHtTm		6 FinBsSvs		Business Sector	
	abs.	in %	abs.	in %	abs.	in %	abs.	in %	abs.	in %	abs.	in %	abs.	in %
Value added														
VA weight	0.022		0.354		0.030		0.068		0.255		0.270			
VA growth	3.086		3.650		4.646		-0.766		2.158		-0.691			
CT to agg. VA growth	0.069	*3.9*	1.291	*72.7*	0.132	*7.4*	-0.074	*-4.2*	0.549	*30.9*	-0.190	*-10.7*	1.777	*100.0*
Total capital														
Capital weight	0.003		0.125		0.018		0.013		0.064		0.131			
Capital growth	2.538		5.882		5.549		1.574		4.090		2.744			
CT to agg. capital growth	0.007	*0.5*	0.716	*48.7*	0.101	*6.9*	0.020	*1.4*	0.260	*17.7*	0.365	*24.8*	1.469	*100.0*
thereof:														
CT to agg. ICT cap. growth	0.001	*0.4*	0.035	*13.2*	0.005	*1.9*	0.003	*1.1*	0.052	*19.6*	0.169	*63.8*	0.265	*100.0*
CT to agg. non-ICT cap. growth	-0.003	*-0.8*	0.173	*47.5*	0.076	*20.9*	-0.010	*-2.7*	0.105	*28.8*	0.023	*6.3*	0.364	*100.0*
CT to intangible cap. growth	0.009	*1.1*	0.508	*60.5*	0.020	*2.4*	0.027	*3.2*	0.103	*12.3*	0.172	*20.5*	0.839	*100.0*
Labour quality growth (LQG)														
Labour quality weight	0.019		0.229		0.012		0.056		0.190		0.140			
Labour quality growth	-0.507		0.275		0.159		0.211		-0.029		-0.097			
CT to agg. LQG	-0.010	*-20.8*	0.064	*133.3*	0.002	*4.2*	0.012	*25.0*	-0.005	*-10.4*	-0.015	*-31.3*	0.048	*100.0*
TFP														
TFP weight	0.045		0.886		0.055		0.150		0.447		0.442			
TFP growth	1.565		0.556		0.620		-0.570		0.657		-1.262			
CT to agg. TFP growth	0.072	*27.5*	0.511	*195.0*	0.030	*11.5*	-0.106	*-40.5*	0.294	*112.2*	-0.539	*-205.7*	0.262	*100.0*

Notes: Presented are average annual industry contributions. Data: See section 2 and 6.2. Own calculation.

8 Conclusion

Knowledge investment has become a key factor for firms around the world to gain competitive advantage and firms across different sectors are likely to differ in their strategy to invest in intangible capital. This study was aimed at measuring and assessing investment in intangible assets at the sector level in Germany. The assessment was done by comparing efforts across countries (to be precise with the UK) and by calculating their contribution to industry growth in labour productivity.

Our results show that firms have intensified their efforts to invest in intangible capital. In absolute terms, investment has grown from 138.6 bn € to 180 bn € over the period 1995-2006 which corresponds to a growth rate of 30%. This increase was not continuous but followed the overall economic development. We furthermore showed that intangible investment gained importance relative to tangible investment. Its share increased from 80% to 89%. Despite this positive trend, we have to ascertain that the increase in gross output was even larger. That is, the share of intangible investment in gross output has fallen in the two largest sectors, manufacturing (from 6.7% to 5.6%) and financial and business services (from 9.1% to 8.1).

Nearly half of the investment in intangibles is carried out by manufacturing firms. This industry proportion is much higher than the share of manufacturing in gross output, value added or for instance in labour input. The outstanding position of intangible capital in manufacturing is also documented by the fact that this sector invests more in intangible than intangible capital and that this proportion has even climbed from 138% to 168%. Financial and business services account for about one third of all intangible investments. Though firms in this sector have expanded their investment for intangible capital the importance relative to tangible capital is nearly unaltered (around 80%).

In particular, German firms have expanded their investment in computerized information by nearly 100%. At the same time, a shift has taken place in investment in software and databases from manufacturing towards business services. Despite this intensification, the share of computerized information in overall investment in intangibles remains rather small. Software and databases account for 10% in the business sector in 2004. This share, however, varies across industries between 5% in agriculture & mining and 21% in utility, manufacturing is at the lower end (6%) and financial and business in the mid (11%).

Investment in innovative property makes up 55% of all intangible investment in 2004. It has also demonstrated a positive trend though it has been less marked than in computerized information. From 1995 to 2008 investment in innovative property has grown by 40%. The investments are highly concentrated in two industries, namely manufacturing and financial and business services. Manufacturing firms do not only perform most of the investment in innovative property in general and R&D in specific, but innovative property is likewise the most important type of intangible asset in this sector (55%). Compared to other intangible assets, innovative property is far less important in financial and business services (27%) and trade and transport (28%).

Investments in economic competencies have increased by 25%. They are less concentrated across sectors and the distribution across industries is quite stable over the period. The relative importance of economic competencies varies quite a lot across sectors. Manufacturing firms direct 39% of their investments in intangibles to economic competencies. This share is above 60% in all other industries, being highest in construction with 78%.

Compared to the UK, the share of intangible investment in gross output is smaller in all sectors in Germany except for utility. A more differentiated picture, however, can be drawn when we look at distinct asset classes. For instance, manufacturing firms in Germany invest a higher proportion of gross output in R&D and in advertising whereas investment in new designs, software, organisational structure, firm-specific human capital and copyright and licenses are higher in the UK. In general, investment in new architectural and engineering design is consistently higher across all sectors in the UK. Computerized information is around two times larger in UK manufacturing, financial and business services and trade & transport (similar shares in other three sectors). On the other hand, German firms invest a higher proportion of gross output in R&D in all sectors. Advertising is also more common in Germany except for the sector trade & transport.

The decomposition of the sources of growth between primary inputs and TFP emphasizes that intermediate inputs contributed the most to labour productivity growth in all sectors in Germany, except in financial and business services. Growth in labour quality contributed only to a very limited extent to industry growth in labour productivity. The contribution of tangible capital to growth is also relatively small, except for utility. Whereas non-ICT capital is much more important for generating growth in sectors such as manufacturing, trade & transport and utility, ICT has a larger contribution in the other three sectors. When extend the growth accounting framework, we corroborate that growth in intangible assets has stimulated labour productivity growth in all sectors. The contribution varies between 0.17 (construction) and 0.59 (manufacturing) percentage points. Compared to the UK, however, intangible capital deepening seems to be somewhat smaller in absolute and relative terms in most sectors. The contribution of intangible capital turns out to be higher than that of ICT and non ICT capital separately in all German sectors, except for utility. Growth in TFP plays a major role in explaining industry growth in labour productivity but its contribution decreases when we include intangible capital in all sectors.

The results further highlight hat growth of innovative property capital is the most influential type of intangible capital for labour productivity in manufacturing and financial & business services, followed by economic competencies and computerized information. In all other sectors, growth of intangible capital that measures economic competencies play the most prominent role for labour productivity growth, followed by innovative property capital and computerized information. The absolute contribution of growth in intangible capital related to investment in computerized information is relatively small in all sectors.

But it is also worthy to compare the relative contribution. In manufacturing, for instance, innovative property accounts for 55% of intangible investment, but for 65% of the total contribution of intangible capital. In the financial and business service sector this deviation is even more pronounced. 27% of intangible investments are allotted to innovative property which accounts for nearly 50% of the growth contribution of intangible capital. The growth contribution is likewise comparable high for computerized information. In financial and business services this item makes up 11% of intangible investment, but 16% of its growth contribution. In manufacturing, the corresponding shares are 5% and 6.7%. In contrast, economic competencies are relatively less growth-enhancing. In manufacturing, they account for 39% of intangible investment, but only for 28% of the total contribution of intangible capital. In financial and business services this difference is even larger. 62% of intangible investment is allotted to economic competencies. But they make up only 35% of the growth contribution of intangible capital.

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10 Appendix: Tables

Table 10-1: Data sources

Investment item	Sources		Industry breakdown availability	Period available
Computerized information				
Software	EU KLEMS Nov2009 Release	Calculated by EU KLEMS	Industry breakdown available in EU KLEMS Nov2009 data	1991-2007
Databases	German Federal Statistical Office: Turnover tax statistics	Turnover of NACE 72.4	Input-Output Table (K72)	1994-2008
Innovative property				
Scientific R&D	EUROSTAT: ANBERD	Calculated by ANBERD	Industry breakdown available in ANBERD data	1991-2006
Mineral exploration	German Federal Statistical Office: Turnover tax statistics	Turnover of NACE 45.12	no breakdown	1994-2008
Copyright licenses	German Federal Statistical Office: Turnover tax statistics	Turnover of NACE 92.11	Input-Output Table (K92)	1992-2008
Financial services innovation	Mannheim Innovation Panel (MIP)	Extrapolation of innovation expenditures to the total population of enterprises in the financial industry.	no breakdown	1995-2007
Architectural & engineering design	German Federal Statistical Office: Turnover tax statistics	Turnover of NACE 74.2	Input-Output Table (K74)	1992-2008
Economic competencies				
Advertising	Central Association of the German Advertising Industry (ZAW) & Mannheim Innovation Panel (MIP)	Gross advertising expenditure (ZAW) plus 15% for own-account marketing expenditures (based on MIP)	Input-Output Table (K74)	1991-2008
Market research	German Federal Statistical Office: Turnover tax statistics	Turnover of NACE 74.13	Input-Output Table (K74)	1994-2008
Firm-specific human capital	Mannheim Innovation Panel (MIP)	Extrapolation of training expenditures.	Industry breakdown available in MIP data	1999-2006
Organizational structure (p)	German Federal Statistical Office: Turnover tax statistics	Turnover of NACE 74.14.1	Input-Output Table (K74)	1994-2008
Organizational structure (oa)	German Federal Statistical Office: Structure of earnings survey & EU KLEMS Nov2009	20% of managers' compensation	Input-Output Table (K74)	1991-2007

Source: own representation.

Table 10-2: Investment in intangible assets in the business sector, 1994-2008 (bn Euro)

Type of Investment	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Computerized information															
Software	9.0	9.5	10.3	11.1	12.1	13.6	15.0	15.9	15.7	15.5	15.8	16.0	16.8	17.7	n.y.
Databases	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.5	0.6	0.3	0.3	0.3	0.6	0.5	0.7
Innovative property															
Scientific R&D	25.9	26.8	27.2	28.9	30.3	33.6	35.6	36.3	36.9	38.0	38.4	38.6	41.1	43.0	46.1
Mineral exploration	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Copyright licenses	3.4	3.9	4.4	4.5	6.8	5.8	5.4	5.1	4.0	4.3	4.0	4.1	3.8	3.5	3.7
Financial services innovation	n.a.	3.9	3.6	4.2	5.8	6.6	5.5	4.9	5.1	4.7	4.0	4.9	4.4	4.4	3.2
Architectural & engineering design	18.9	19.0	19.1	18.3	18.8	18.5	18.5	18.9	18.4	17.8	17.4	18.2	19.1	20.3	22.2
Economic competencies															
Advertising	17.9	18.9	19.4	20.0	20.8	21.7	22.9	21.7	20.4	19.9	20.2	20.4	20.9	21.2	21.2
Market research	2.1	1.9	1.8	1.5	1.4	1.5	1.3	1.3	1.4	1.5	1.8	1.6	1.6	1.7	1.8
Firm-specific human capital	n.a.	30.3	32.5	32.2	33.9	30.6	33.0	34.5	35.7	32.1	32.5	34.2	35.6	n.y.	n.y.
Organizational structure (p)	8.3	9.0	9.8	11.0	13.2	17.0	19.5	20.4	18.1	16.1	16.4	17.6	19.3	20.0	19.8
Organizational structure (oa)	14.2	14.7	14.8	14.9	15.2	15.5	16.2	16.5	16.5	16.5	16.6	16.6	16.9	17.4	n.y.
Total investment in intangibles	n.a.	138.2	143.1	146.9	158.6	164.8	173.4	176.2	172.9	166.9	167.4	172.6	180.1	n.y.	n.y.

Notes: n.a.: figure not available; n.y.: figure not yet available.

Source: German turnover tax statistics, Mannheim Innovation Panel (MIP), German Structure of Earnings Survey 2006, EU KLEMS Nov2009 Release, Input-Output Table, ZAW, own calculation.

Table 10-3: Investment in software and databases by industries, 1994-2007

	Business Sector	AgMin	Mfr.	Utility	Cons.	RetHtTrn	FinBsSvc
		Investment in computer software					
1991	8.09	0.07	3.53	0.34	0.38	2.17	1.60
1992	8.59	0.08	3.45	0.37	0.44	2.47	1.78
1993	8.79	0.07	2.99	0.44	0.49	2.80	1.99
1994	8.97	0.07	3.00	0.48	0.50	2.65	2.27
1995	9.48	0.09	3.41	0.39	0.44	2.51	2.64
1996	10.27	0.09	3.77	0.52	0.41	2.60	2.89
1997	11.14	0.08	4.04	0.52	0.38	2.78	3.35
1998	12.14	0.08	4.41	0.53	0.39	3.00	3.73
1999	13.60	0.09	4.76	0.54	0.43	3.24	4.54
2000	15.01	0.09	5.08	0.50	0.45	3.61	5.29
2001	15.90	0.08	5.27	0.50	0.36	3.44	6.25
2002	15.68	0.09	5.46	0.57	0.37	3.74	5.44
2003	15.54	0.09	5.45	0.56	0.33	3.40	5.71
2004	15.84	0.09	5.21	0.59	0.31	3.94	5.70
2005	16.00	0.09	5.15	0.66	0.30	4.21	5.58
2006	16.76	0.11	5.61	0.76	0.33	4.63	5.33
2007	17.68	0.11	5.66	0.83	0.33	4.76	5.99
		Investment in databases					
1994	0.11	0.00	0.03	0.00	0.00	0.02	0.05
1995	0.12	0.00	0.03	0.00	0.00	0.02	0.07
1996	0.14	0.00	0.03	0.00	0.00	0.03	0.08
1997	0.15	0.00	0.03	0.00	0.00	0.03	0.08
1998	0.14	0.00	0.03	0.00	0.00	0.03	0.08
1999	0.30	0.00	0.07	0.00	0.00	0.06	0.17
2000	0.35	0.00	0.08	0.00	0.00	0.07	0.19
2001	0.48	0.00	0.10	0.00	0.00	0.10	0.27
2002	0.55	0.00	0.12	0.01	0.00	0.12	0.30
2003	0.25	0.00	0.05	0.00	0.00	0.05	0.15
2004	0.26	0.00	0.05	0.00	0.00	0.05	0.15
2005	0.30	0.00	0.06	0.00	0.00	0.06	0.17
2006	0.58	0.00	0.12	0.01	0.00	0.12	0.33
2007	0.54	0.00	0.11	0.01	0.00	0.11	0.31
2008	0.73	0.00	0.15	0.01	0.00	0.15	0.42

Source: See Table 10-1. Own calculation.

Table 10-4: Investment in scientific R&D by industries, 1991-2008

	Business Sector	AgMin	Mfr.	Utility	Cons.	RetHtTrn	FinBsSvc
		Investment in R&D					
1991	26.25	0.22	25.20	0.14	0.09	0.14	0.46
1992	26.58	0.25	25.39	0.12	0.08	0.19	0.56
1993	25.93	0.24	24.64	0.09	0.06	0.24	0.65
1994	25.91	0.18	24.65	0.10	0.07	0.23	0.68
1995	26.82	0.15	25.54	0.11	0.07	0.22	0.71
1996	27.19	0.15	26.00	0.10	0.08	0.23	0.62
1997	28.91	0.15	27.02	0.09	0.09	0.24	1.31
1998	30.32	0.15	28.49	0.10	0.09	0.39	1.10
1999	33.62	0.15	30.55	0.11	0.09	0.54	2.19
2000	35.59	0.19	32.49	0.08	0.07	0.54	2.21
2001	36.33	0.14	32.84	0.06	0.05	0.96	2.28
2002	36.94	0.15	33.55	0.06	0.05	0.93	2.20
2003	38.03	0.10	34.58	0.08	0.03	0.56	2.68
2004	38.36	0.11	34.93	0.08	0.03	0.52	2.69
2005	38.65	0.11	34.52	0.10	0.03	0.29	3.60
2006	41.14	0.11	37.04	0.10	0.03	0.35	3.52
2007	43.02	0.12	38.16	0.13	0.06	0.44	4.11
2008	46.06	0.13	41.00	0.13	0.06	0.45	4.29

Source: See Table 10-1. Own calculation.

Table 10-5: Investment in non-scientific R&D by industry, 1991-2008

	AgMin	Manufacturing	FinBsSvc
	Mineral exploration	Copyright & licences	Financial services innovation
1991	n.a.	n.a.	n.a.
1992	n.a.	2.86	n.a.
1993	n.a.	3.14	n.a.
1994	0.05	3.43	n.a.
1995	0.07	3.92	3.91
1996	0.09	4.41	3.63
1997	0.09	4.52	4.18
1998	0.11	6.82	5.84
1999	0.09	5.76	6.57
2000	0.10	5.36	5.53
2001	0.08	5.11	4.88
2002	0.08	4.01	5.09
2003	0.10	4.29	4.73
2004	0.08	3.96	4.01
2005	0.11	4.08	4.87
2006	0.11	3.79	4.39
2007	0.13	3.53	4.40
2008	0.15	3.67	3.19

Source: See Table 10-1. Own calculation.

Table 10-6: Investment in new architectural and engineering design by industry, 1992-2008

	Business Sector	AgMin	Mfr.	Utility	Cons.	RetHtTrn	FinBsSvc
		Investment in new architectural and engineering design					
1992	17.24	0.31	6.39	0.30	0.65	2.66	6.93
1993	18.05	0.32	6.47	0.33	0.74	2.68	7.52
1994	18.86	0.33	6.85	0.35	0.84	2.80	7.70
1995	18.98	0.36	7.17	0.34	0.80	2.50	7.81
1996	19.09	0.36	7.34	0.35	0.86	2.56	7.62
1997	18.32	0.33	7.21	0.36	0.85	2.52	7.05
1998	18.77	0.33	7.22	0.38	0.79	2.51	7.53
1999	18.50	0.26	7.23	0.39	0.78	2.56	7.28
2000	18.55	0.28	7.22	0.34	0.71	2.59	7.41
2001	18.94	0.27	7.37	0.36	0.65	2.59	7.71
2002	18.44	0.27	7.07	0.37	0.56	2.50	7.67
2003	17.81	0.30	6.71	0.31	0.54	2.36	7.58
2004	17.42	0.30	6.62	0.30	0.53	2.46	7.22
2005	18.17	0.30	6.81	0.30	0.56	2.55	7.65
2006	19.06	0.36	7.08	0.31	0.61	2.64	8.06
2007	20.31	0.38	7.54	0.33	0.65	2.82	8.59
2008	22.19	0.42	8.24	0.36	0.71	3.08	9.38

Source: See Table 10-1. Own calculation.

Table 10-7: Investment in brand equity and human capital by industry, 1994-2008

	Business Sector	AgMin	Mfr.	Utility	Cons.	RetHtTrn	FinBsSvc
		Investment in Brand Equity					
1994	19.99	0.34	7.26	0.37	0.89	2.96	8.16
1995	20.84	0.40	7.87	0.37	0.88	2.75	8.57
1996	21.17	0.40	8.14	0.39	0.95	2.84	8.45
1997	21.50	0.39	8.46	0.42	1.00	2.96	8.27
1998	22.22	0.39	8.55	0.45	0.94	2.98	8.92
1999	23.16	0.33	9.06	0.49	0.97	3.20	9.11
2000	24.22	0.37	9.42	0.44	0.92	3.38	9.68
2001	23.03	0.33	8.96	0.43	0.78	3.15	9.38
2002	21.82	0.32	8.37	0.44	0.66	2.95	9.07
2003	21.40	0.37	8.06	0.38	0.65	2.84	9.11
2004	21.99	0.38	8.36	0.38	0.66	3.10	9.11
2005	21.98	0.36	8.24	0.36	0.67	3.09	9.26
2006	22.45	0.42	8.34	0.37	0.72	3.11	9.49
2007	22.90	0.43	8.51	0.37	0.73	3.18	9.68
2008	22.97	0.43	8.53	0.37	0.73	3.18	9.71
		Investment in Human Capital					
1995	30.30	0.40	9.73	0.70	1.32	7.33	10.82
1996	32.47	0.35	10.61	0.75	1.39	8.10	11.27
1997	32.17	0.30	11.52	0.81	1.38	8.09	10.06
1998	33.86	0.21	12.64	0.81	1.63	8.07	10.49
1999	30.63	0.17	9.87	0.68	1.45	9.44	9.03
2000	32.95	0.16	10.64	0.63	1.32	9.32	10.87
2001	34.54	0.24	11.59	0.77	1.38	9.25	11.31
2002	35.69	0.27	12.07	0.86	1.49	9.83	11.17
2003	32.14	0.20	10.70	0.84	1.39	9.28	9.73
2004	32.49	0.18	11.13	0.90	1.41	8.95	9.91
2005	34.21	0.24	10.99	1.08	1.49	8.67	11.73
2006	35.63	0.22	10.81	1.18	1.52	9.07	12.82

Source: See Table 10-1. Own calculation. Brand equity consists of investment for advertising and market research.

Table 10-8: Investment in organizational capital by industry, 1991-2008

	Business Sector	AgMin	Mfr.	Utility	Cons.	RetHtTrn	FinBsSvc
		Investment in Purchased Organizational Capital					
1994	8.26	0.14	3.00	0.15	0.37	1.22	3.37
1995	9.03	0.17	3.41	0.16	0.38	1.19	3.71
1996	9.79	0.18	3.77	0.18	0.44	1.31	3.91
1997	11.02	0.20	4.34	0.21	0.51	1.52	4.24
1998	13.22	0.23	5.09	0.27	0.56	1.77	5.31
1999	16.99	0.24	6.64	0.36	0.71	2.35	6.68
2000	19.52	0.30	7.59	0.36	0.74	2.73	7.80
2001	20.36	0.29	7.92	0.38	0.69	2.79	8.29
2002	18.13	0.27	6.95	0.37	0.55	2.45	7.54
2003	16.14	0.28	6.08	0.29	0.49	2.14	6.87
2004	16.36	0.28	6.22	0.28	0.49	2.31	6.78
2005	17.62	0.29	6.60	0.29	0.54	2.48	7.42
2006	19.28	0.36	7.16	0.31	0.62	2.67	8.15
2007	19.98	0.37	7.42	0.33	0.64	2.77	8.45
2008	19.77	0.37	7.35	0.32	0.63	2.74	8.36
		Investment in Own Account Organizational Capital					
1991	12.58	0.25	4.79	0.23	0.41	2.00	4.91
1992	13.60	0.24	5.04	0.24	0.51	2.10	5.46
1993	13.88	0.24	4.97	0.26	0.57	2.06	5.78
1994	14.23	0.25	5.17	0.26	0.63	2.11	5.81
1995	14.72	0.28	5.56	0.26	0.62	1.94	6.06
1996	14.80	0.28	5.69	0.27	0.66	1.99	5.91
1997	14.89	0.27	5.86	0.29	0.69	2.05	5.73
1998	15.19	0.27	5.85	0.31	0.64	2.04	6.10
1999	15.54	0.22	6.08	0.33	0.65	2.15	6.11
2000	16.22	0.25	6.31	0.30	0.62	2.26	6.48
2001	16.51	0.24	6.42	0.31	0.56	2.26	6.72
2002	16.47	0.24	6.32	0.33	0.50	2.23	6.85
2003	16.50	0.28	6.22	0.29	0.50	2.19	7.02
2004	16.59	0.28	6.30	0.28	0.50	2.34	6.87
2005	16.58	0.27	6.21	0.27	0.51	2.33	6.98
2006	16.89	0.32	6.27	0.28	0.54	2.34	7.14
2007	17.40	0.33	6.46	0.28	0.55	2.41	7.36

Source: See Table 10-1. Own calculation.

Table 10-9: Depreciation rates for growth accounting

Asset	Depreciation Rate
Intangible Assets	
Software	0.315
Databases	0.315
Scientific R&D	0.2
Mineral exploration	0.2
Copyright licenses	0.2
Financial services innovation	0.2
Architectural and engineering design	0.2
Advertising	0.6
Market research	0.6
Firm-specific human capital	0.4
Organizational structure	0.4
Tangible Assets	
Computing equipment (IT)	0.315
Communications equipment (CT)	0.115
Transport equipment (TraEq)	
Agriculture, Fishing & Mining	0.170
Manufacturing	0.177
Electricity, Gas & Water Supply	0.191
Construction	0.195
Trade, Hotels & Rest., Transp. & Comm.	0.190
Financial & Business Services	0.190
Other machinery and equipment (OMach)	
Agriculture, Fishing & Mining	0.129
Manufacturing	0.109
Electricity, Gas & Water Supply	0.094
Construction	0.139
Trade, Hotels & Rest., Transp. & Comm.	0.126
Financial & Business Services	0.146
Non-resident structures (OCon)	
Agriculture, Fishing & Mining	0.024
Manufacturing	0.033
Electricity, Gas & Water Supply	0.023
Construction	0.034
Trade, Hotels & Rest., Transp. & Comm.	0.029
Financial & Business Services	0.038

Table 10-10: Contributions to labour productivity growth by sector and subperiods (1997-2000, 2000-2006)

	Excluding Intangibles											
	AgMin		Mfr.		Utility		Cons.		RetHtTm		FinBsSvs	
	97-00	00-06	97-00	00-06	97-00	00-06	97-00	00-06	97-00	00-06	97-00	00-06
Gross output	-0.89	-0.14	4.11	2.17	0.92	3.88	-1.37	-3.52	3.82	1.33	4.61	2.18
Hours worked	-2.20	-3.53	-1.99	-1.42	-3.79	-3.62	0.34	-4.17	0.28	-0.22	4.47	3.13
Labour Productivity	**1.31**	**3.39**	**6.11**	**3.59**	**4.71**	**7.50**	**-1.71**	**0.66**	**3.53**	**1.55**	**0.15**	**-0.94**
Capital deepening	-0.12	-0.02	0.29	0.16	1.85	1.16	-0.10	0.02	0.36	0.32	0.83	0.18
ICT capital	0.02	0.02	0.05	0.03	0.12	0.07	0.02	0.01	0.15	0.09	0.60	0.24
Non-ICT capital	-0.15	-0.04	0.23	0.13	1.73	1.09	-0.13	0.01	0.21	0.23	0.22	-0.06
Intangible capital	-	-	-	-	-	-	-	-	-	-	-	-
Labour quality	-0.35	-0.12	0.02	0.11	0.04	0.04	0.05	0.09	-0.08	0.03	-0.06	-0.01
Intermed. input deep.	-0.07	2.07	4.59	2.51	2.34	5.23	-0.68	0.60	1.96	0.71	0.34	-0.59
TFP	1.86	1.47	1.21	0.81	0.49	1.06	-0.98	-0.06	1.29	0.50	-0.96	-0.52
	Including Intangibles											
	AgMin		**Mfr.**		**Utility**		**Cons.**		**RetHtTm**		**FinBsSvs**	
	97-00	**00-06**	**97-00**	**00-06**	**97-00**	**00-06**	**97-00**	**00-06**	**97-00**	**00-06**	**97-00**	**00-06**
Gross output	-0.89	-0.16	4.01	2.17	0.98	3.88	-1.37	-3.51	3.87	1.33	4.76	2.17
Hours worked	-2.20	-3.53	-1.99	-1.42	-3.79	-3.62	0.34	-4.17	0.28	-0.22	4.47	3.13
Labour Productivity	**1.31**	**3.37**	**6.01**	**3.59**	**4.78**	**7.50**	**-1.71**	**0.67**	**3.58**	**1.55**	**0.29**	**-0.96**
Capital deepening	0.11	0.20	1.38	0.47	2.56	1.40	0.21	0.08	0.83	0.42	1.92	0.17
ICT capital	0.02	0.02	0.06	0.03	0.13	0.07	0.02	0.01	0.16	0.09	0.62	0.24
Non-ICT capital	-0.13	-0.01	0.30	0.13	1.79	1.12	-0.14	0.01	0.23	0.24	0.23	-0.06
Intangible capital	**0.22**	**0.19**	**1.01**	**0.31**	**0.64**	**0.21**	**0.32**	**0.06**	**0.44**	**0.10**	**1.07**	**-0.02**
Labour quality	-0.35	-0.12	0.02	0.11	0.04	0.04	0.05	0.09	-0.08	0.03	-0.06	-0.01
Intermed. input deep.	-0.08	1.78	4.08	2.44	2.01	5.14	-0.69	0.59	1.80	0.68	0.37	-0.30
TFP	1.64	1.51	0.53	0.57	0.17	0.92	-1.28	-0.10	1.03	0.41	-1.94	-0.81

Source: Own calculation.