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Intangible Capital and Growth – an International Comparison

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# Intangible Capital and Growth – an International Comparison

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## I. Introduction

We live in an era of innovation. Firms rapidly innovate in products and processes. These innovations have improved consumer welfare by introducing new goods and services, increasing the quality of existing goods, decreasing the costs of existing goods, and providing a great amount of information about available goods. Moreover, these innovations have improved producers' efficiency by changing organizational structures.

However, measuring innovations at the national level is difficult. Measures of expenditure on research and development (R&D) or use of patents are imperfect proxies of the inputs and output from innovation, respectively. In the US, the National Academy of Science uses surveys and interviews to analyze innovations directly at the firm level, but this is lacking at the national level. In the European Union, the Community Innovation Survey collects information on whether firms innovate, but it lacks data on how much firms spent on innovation.

A significant step in measuring innovation was made by Corrado, Hulten and Sichel (CHS, 2005). They classified expenditure on intangible assets in three categories (computerized information, innovative property and economic competencies), and developed a

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methodology to measure and "capitalize" them, so that they appear as investment rather than expenditure in the national accounts. CHS (2005) find that the US private sector invested 11.7% of GDP or $3,660 billion on intangible assets from 1998 to 2000, 20% more than investment on tangible assets.

Several researchers have used similar methods to measure intangible investment in the UK, Finland, Japan and the Netherlands, and also find that those countries invested substantially in intangibles as well. The UK invested 10.1% of GDP on intangibles in 2004 (Haskel and Marrano, 2006); Finland invested 9.1% of GDP (Jalava, Aulin-Ahmavaara and Alanen, 2007); the Netherlands invested 8.3% of GDP between 2001 and 2004 (van Rooijen-Horsten, van den Bergen and Tanriseven, 2008); and Japan invested 7.5% of GDP from 1995 to 2002 (Fukao, Hamagata, Miyagawa and Tonogi, 2007).

CHS (2006) and MHW (2007) also show how intangible assets promote economic growth. For example, Corrado, Hulten and Sichel (CHS, 2005) have developed an estimate of intangible investment for the past five decades in the United States. They subsequently integrated a measure of intangible capital in the growth accounts of the U.S. (CHS, 2006). They estimated that intangible assets contributed to 0.43 percentage points of the annual growth of labor productivity on average from 1973 to 1995, which increased to 0.84 percentage points from 1995 to 2003 in the US. CHS (2006) was replicated by MHW (2007) for the UK, who estimated that intangible assets contributed on average 0.44 percentage points per year to labor productivity growth from 1979 to 1995, which increased to 0.60 percentage points from 1995 to 2003.

Other research focusing on one or a narrow set of intangible assets, also found that intangible assets promote economic growth. Growth accounting studies, such as Timmer and van Ark (2005) and Inklaar. Timmer and van Ark (2008) look at the contribution of information and communication technology (ICT) to the growth of labour productivity and total factor productivity, respectively. Eicher and Strobel (2008) found that software investment drove the growth of labor productivity from 1991 to 2004 in Germany. Software-intensive industry contributed to 35% of labor productivity growth in the whole

economy from 2000 to 2004. Pianta and Vaona (2006) studied the European countries and showed that product innovation, process innovation and efficient organizational structure drove the growth of labor productivity.

In this paper, we use the same methodology as CHS (2005) and HM (2007) to measure how much Germany, France, Italy and Spain invested in intangible assets in 2004. We estimate that Germany, France, Italy and Spain respectively invested 6.42%, 7.94%, 4.79% and 5.12% of GDP in intangible assets in the market sector (Table 1). Moreover, we measure how much the aggregate economy (i.e., including the public sector) invested in intangible assets. Germany, France, Italy and Spain respectively invested 6.48%, 8.03% 4.89% and 5.28% of GDP in intangible assets for the whole economy in 2004 (Table 2). Finally, we estimate the time series of intangible investment from 1991 to 2004.

Next, we carry out growth accounting and estimate the contribution of intangible assets to GDP growth from 1995 to 2004. From 1995 to 2000, intangible assets contributed 0.62 percentage points to annual GDP growth in Germany, 0.92 percentage points in France, 0.51 percentage points in Italy and 0.60 percentage points in Spain. From 2000 to 2004, intangible assets contributed by 0.42 percentage points to the annual GDP growth in Germany, 0.52 percentage points in France, 0.17 percentage points in Italy and 0.43 percentage points in Spain.

Then we compare the four countries with the US and the UK for the period of 1995-2003. We focus on labor productivity, instead of GDP growth, to be consistent with CHS (2006) and MHW (2007). Intangible assets contributed the most in the US, followed by France, Germany, the UK, Italy and Spain. CHS (2006) and MHW (2007) estimated intangible assets contributed 0.84 percentage points and 0.59 percentage points to the annual growth of labor productivity from 1995 to 2003 in the US and the UK, respectively. We estimated that intangible assets contributed to 0.64 percentage points of the annual growth of labor productivity from 1995 to 2003 in Germany, 0.74 percentage points in France, 0.33 percentage points in Italy and 0.23 percentage points in Spain.

The structure of this paper is as follows. Section II estimates how much Germany, France, Italy and Spain respectively invested in intangible assets in 2004 and compares those countries with the already existing estimates for the US, the UK, the Netherlands and Finland. Section III describes the trends of tangible and intangible investment in Germany, France, Italy and Spain from 1991 to 2004, showing that France and Germany increased the share of intangible investment in total investment, while Italy and Spain showed a decline in the ratio of intangible to tangible investment. Section IV estimates how much intangible assets contributed to GDP growth in Germany, France, Italy and Spain from 1995 to 2004. Our analysis shows that in all four countries, intangible assets contributed substantially to GDP growth from 1995 to 2000, but with a slowdown in contribution from 2000 to 2004. Section V concludes.

## II. Intangible Investment in Germany, France, Italy and Spain.

### 1. Benchmark

This section presents our estimates of how much Germany, France, Italy and Spain invested in intangible assets in the market sector and the whole economy in 2004. We measure three major types of intangible investment—computerized information, innovative property and economic competencies. Within each type of intangible investment, there are more detailed subtypes (CHS, 2005). Computerized information includes software and databases; Innovative property includes R&D, mineral exploration and evaluation, copyright and license costs, development costs in financial industry and new architectural and engineering designs; Economic competencies include brand equity (advertisement and market research), firm-specific human capital and organizational structure (management consulting and own-account organizational structure).

*Spending.* We estimate that Germany, France, Italy and Spain respectively spent 6.82%, 8.82%, 5.23% and 5.39% of GDP on intangible assets in the market sector in 2004 (Table 1). Since those countries have large public sectors, if we ignore the investment in the public sector, we may incorrectly conclude that Germany, France, Italy and Spain invested

lightly in intangible assets. So we measure also how much the whole economy (public and market sectors) spent on intangible assets. We estimate that Germany, France, Italy and Spain respectively spent 7.70%, 9.68%, 5.88% and 6.03% of GDP on intangible assets in the whole economy in 2004 (Table 2).

*Investment.* We construct intangible investment from intangible spending, following the method of CHS (2005) and RBT (2008). CHS (2005) argue that if the benefit of expenditure lasts for more than one year, the expenditure is an investment, and vice versa. Using that standard, CHS (2005) estimate that 60% of expenditure on advertisement, 80% of expenditure on own-account organizational structure and 100% of all the other expenditure qualify as investment. RBT (2008) exclude public investment in R&D, because they assume freely available goods should not be treated as assets. So investment equals spending on all intangible assets except for R&D, advertisement and own-account organizational structure.

We estimate that Germany, France, Italy and Spain respectively invested 6.42%, 7.94%, 4.79% and 5.12% of GDP in intangible assets in the market sector in 2004 (Table 1), roughly 0.4 to 0.9 percentage point lower than spending as a % of GDP. Moreover, we estimate that Germany, France, Italy and Spain respectively invested 6.48%, 8.03%, 4.89% and 5.28% of GDP in intangible assets in the whole economy in 2004 (Table 2).

Our major data sources are EU KLEMS, EUROSTAT, OECD and trade associations. The follow describes the data sources of each type of intangible investment. Please see Appendix for more details on data.

(1) Computerized information

a. *Software*.

For Germany, Italy and Spain, the data source is EU KLEMS. EU KLEMS provides the investment and stocks estimates for 8 types of assets—(1) software, (2) computing

equipment, (3) communications equipment, (4) transport equipment, (5) other machinery and equipment, (6) total non-resident investment, (7) residential structures, and (8) other assets.

For France, the data source of software investment is France National Institute of Statistics and Economic Studies (INSEE). We use INSEE instead of EU KLEMS to estimate software investment for France, because EU KLEMS provides an unpublished preliminary estimate. We compare the two data sources, and find that EU KLEMS provides an estimate that is almost twice as large as what the France National Institute of Statistics and Economic Studies (INSEE) provides.

To estimate how much the market sector invested in software, we exclude public sector investment in software[1]. We use the Input-Output Tables (IO Tables) from EUROSTAT to construct an average ratio of public investment in software. For example, IO Tables for France are available for 1995, 1997, 1999, 2000 and 2001 from which we calculate a simple average percentage which we use for all the years. We estimate that the public sector accounted for 3.88% of all the software investment and that the market sector invested 0.82% of GDP on software in 2004.

Germany, France, Italy and Spain invested 0.81%, 0.82%. 0.69% and 0.75% of GDP in software in the market sector in 2004 respectively (Table 1). In million euros (current prices), Germany, France, Italy and Spain respectively invested 17,919 million euros, 13,660 million euros, 9,537 million euros and 6,271 million euros in software for the whole economy.

b. Databases

We measure investment in databases using the revenues of NACE 72.4 (Database Activities). Our data source is the gross output by industry (1991-2004), provided by EU KLEMS. Database activities include the following four activities (The Encyclopedia for

[1] We define public sector as national and regional governments, the education sector and the health sector.

Classification Codes, 2007): (1) on-line database publishing, (2) on-line directory and mailing list publishing, (3) other on-line publishing, and (4) web search portals. We argue that companies increase their productivity by accessing data online, so we treat the revenues of Database Activities as companies' investment in databases.

To estimate database investment in the market sector, we exclude database investment in the public sector. The USE tables of EUROSTAT provide the percentages of computer services used by the public sector. For example, in France, public spending on the products of Computer and Related Services (NACE 72) accounts for 2.00% of the total use of those products in 2001.

We estimate that Germany, France, Italy and Spain respectively invested 0.02%, 0.04%, 0.01% and 0.02% of GDP in databases in the market sector in 2004. In million euros (current prices), Germany, France, Italy and Spain respectively invested 351 million euros, 710 million euros, 82 million euros and 174 million euros in databases.

(2) Innovative property

CHS (2005) state that investment in innovative property equals the expenditures that leads to a patent, copyright or license, or the acquisition of new resources. CHS (2005) measure six groups of innovative property: (1) R&D in science and engineering, (2) mineral explorations, (3) copyright and license costs, (4) R&D in social science and humanities, (5) development costs in financial industry, and (6) new architectural and engineering designs. To match data sources in Europe, we use a slightly different grouping of innovative property. We combine R&D in science and engineering with R&D in social science and humanities.

i) R&D

Our data source for R&D is EUROSTAT, which provides R&D expenses from 1981 to 2004 including R&D in both natural science and social science. We exclude R&D in

software industry to avoid double-counting. For example, the software industry in France accounts for 2.18% of total R&D expenses in 2002, 2.40% in 2003, and 2.26% in 2004 (EUROSTAT). We take the average of those three percentages (2.28%) and assume that software accounts for 2.28% of total R&D expenses in 2004.

To measure how much the market sector invested in R&D, we subtract the expenditure made by government and the higher education sector on R&D. EUROSTAT breaks down R&D performance into four categories—business enterprise sector, government sector, higher education sector, and private non-profit sector. Business sector is the major market sector, accounting for 64% of total R&D expenses in France and 70% in Germany in 2004. The private non-profit sector is a small market sector, accounting for less than 3% of R&D expenses in both countries in 2004.

After excluding R&D by the software industry and the public sector, we estimate that Germany, France, Italy and Spain invested 1.69%, 1.32%, 0.52% and 0.55% of GDP in R&D in the market sector respectively in 2004. In million euros (current prices), Germany, France, Italy and Spain respectively invested 37,445 million euros, 21,859 million euros, 7,288 million euros and 4,615 million euros in R&D.

ii) Mineral explorations

We ignored spending on mineral exploration by France, Germany, Italy and Spain. For example, we estimate Germany spent only 0.007% of GDP, France spent only 0.004% of GDP, Italy spent 0.014% of GDP and Spain spent 0.011% of GDP even when we use a method that heavily overstates exploration costs. See Appendix 1 for more details.

iii) Copyright and license costs

We follow the method of CHS (2005) to measure copyright and license costs. CHS (2005) proxy copyright and license costs with the development costs of motion pictures and that of radio, television, sound recording and book publishing. CHS (2005) find data on motion pictures, but no data on radio, television, sound recording and book publishing, so they

assume that the development costs in radio, television, sound recording and book publishing industries are double the development costs of motion pictures.

Our data source of the development costs of motion pictures is Screen Digest (2005), a London-based research institute on audiovisual media. Screen Digest provides the production costs for 59 countries from 2000 to 2005. After excluding the software industry, we estimate that Germany, France, Italy and Spain respectively invested 0.11%, 0.19%, 0.06% and 0.11% of GDP in copyright and licenses in the market sector in 2004. In million euros (current prices), Germany, France, Italy and Spain respectively invested 2,395 million euros, 3,144 million euros, 853 million euros and 946 million euros in copyright and licenses.

iv) New Product Development Costs in Financial Industries

We measure development costs, using 20 % of the intermediate inputs in the financial industry. Our data source is the OECD STAN database for Industrial Analysis. STAN provides the intermediate costs of the financial industry from 1991 to 2003 for Germany, from 1978 to 2003 for France, from 1970 to 2003 for Italy and from 1995 to 2003 for Spain. Financial industry in our data has three sub-industries—financial intermediation (except insurance and pension funding), insurance and pension funding (except compulsory social security) and activities related to financial intermediation. Data is unavailable for 2004. We estimate the data for 2004, assuming that the fraction of intermediate inputs to gross output remains the same from 2003 to 2004.

A problem is that we may be double-counting some intangible investment, as we have already included software investment as an intangible investment, and in the following sections we will include management consulting, market research, architectural and engineering, and advertising, while the intermediate inputs of financial industry include products/services of those industries. To avoid doubling counting, we therefore excluded intermediate inputs from Computer and Related Services (NACE 72) and Other Business Services (NACE 74).

We assume that 20% of the adjusted intermediate costs equal the costs to develop new products. We estimate that Germany, France, Italy and Spain invested 0.70%, 0.58%, 0.79% and 0.35% of GDP respectively in developing new products in the financial sector in 2004. In million euros (current prices), Germany, France, Italy and Spain respectively invested 15,544 million euros, 9,666 million euros, 11,001 million euros and 2,929 million euros in developing new products in the financial sector.

v) New Architectural and Engineering Designs

The data source of new architectural and engineering designs is the gross output of Architectural, Engineering and Other Technical Activities (NACE 74.2), provided by EU KLEMS. We measure the investment on new architectural and engineering designs with half of the revenues of those industries. To avoid double-counting of intangible investment we exclude the inputs from software, advertising and consulting in these industries. For example, we excluded 53% of the intermediate inputs for France and 49% of the intermediate inputs for Germany.

We estimate that Germany, France, Italy and Spain respectively invested 0.87%, 0.90%, 0.80% and 1.39% of GDP in new architectural and engineering designs in the market sector in 2004. In million euros (current prices), Germany, France, Italy and Spain respectively invested 19,198 million euros, 14,927 million euros, 11,167 million euros and 11,712 million euros in new architectural and engineering designs.

(3) Economic competencies

i) Brand equity

a. Advertisement

Our measure of advertisement is the gross output of advertising industry (NACE xx), provided by EU KLEMS. To estimate advertisement investment, we adjust advertisement spending in three ways. First, we exclude classified advertisement, which is not brand-creating. Following RBT (2007), we assume that classified advertisement equals 50% of the advertisement in newspapers. Second, we exclude advertisement in newspapers. World Magazine Trends provides the share of advertisement in newspapers from 1994 to 2003. For example, 21% of advertisement is on newspapers in France in 2003. We estimate a time trend of the share of newspaper advertisement and predict the shares for 2004. Third, we assume investment equals 60% of the rest of the spending, following CHS (2005). We estimate that Germany, France, Italy and Spain respectively invested 0.71%, 1.24%, 0.91% and 0.34% of GDP in advertisement in 2004. In million euros (current prices), Germany, France, Italy and Spain respectively invested 9,406 million euros, 12,331 million euros, 7,596 million euros and 1,697 million euros in advertisement.

b. Market Research

Our data source of market research (MR) is the turnover of Market Research and Public Opinion Polling (NACE, K7413), provided by the Structural Business Statistics of Eurostat. Those are estimates of purchased market research. For own-account MR, we follow the assumption in CHS (2005) that own-account market research equals purchased MR. Therefore we estimate that Germany, France, Italy and Spain respectively invested 0.15%, 0.27%, 0.28% and 0.25% of GDP in MR in 2004. In million euros (current prices), Germany, France, Italy and Spain respectively invested 3,249 million euros, 4,444 million euros, 3,861 million euros and 2,105 million euros in MR.

ii) Firm-specific human capital.

We measure how much firms invested in human capital, using spending on continuing vocational training. Our major data sources of continuing vocational training are (1)

Continuing Vocational Training Survey (CVTS) 2005, (2) Labor Cost Survey (LCS) 2004, provided by EUROSTAT, provided by EUROSTAT, and (3) labor compensations, provided by EU KLEMS. CVTS 2005 provides the direct and indirect costs of continuing vocational training as a percentage of total labor costs in 2005. It includes training courses, training at work places, training through job rotation, self-learning and learning at conferences, lectures and workshops. It excludes training financed by firms with less than 10 employees (European Union, 2000), and excludes training in the public sector—public administration and social security, education and health and social work activities (RBT, 2008). EU KLEMS provides labor compensation, and LCS 2004 provides labor compensation as a percentage of labor costs. Using those two data sets, we calculate labor costs in France, Germany, Italy and Spain.

Then we break down the continuing training costs into direct costs and indirect costs. Indirect costs are workers' forgone hours. Direct costs are (1) traveling and boarding costs of trainees, (2) costs of training centers, materials and equipments, (3) labor costs of internal trainers, (4) payments to external trainers, (5) levies and grants. Direct costs exclude workers' forgone hours.

We estimate that Germany, France, Italy and Spain respectively invested 0.67%, 1.25%, 0.69% and 0.73% of GDP in firm-specific human capital in 2004. In million euros (current prices), Germany, France, Italy and Spain respectively invested 14,894 million euros, 20,747 million euros, 9,589 million euros and 6,109 million euros in firm-specific human capital. Direct cost is 6,874 million euros in Germany, 12,629 million euros in France, 6,487 million euros in Italy and 2,240 million euros in Spain.

iii) Organizational structure

a. Purchased organizational structure.

Investment in organizational structure (OS) includes investment in purchased OS and own-account OS. We measure purchased OS with the revenues of management consulting

industry. The data source is the 2004 Annual Survey of the European Management Consultancy Market, provided by the European Federation of Management Consultancies Associations (FEACO). The survey covers five classes of management consultancy—operations management, information technology, corporate strategy services, human resources management and outsourcing services—for eleven private sectors and four public sectors (non-profit and government sector, the European Union, aerospace and defense sector, and healthcare and pharmaceuticals).

To estimate how much the market sector spent on MC, we exclude how much the public sector expenditure. After excluding the public sector, we estimate that Germany, France, Italy and Spain respectively invested 0.50%, 0.31%, 0.22%, 0.25% of GDP in MC in 2004. In million euros (current prices), France, Italy and Spain respectively invested 11,077 million euros, 5,127 million euros, 1597 million euros and 2,103 million euros in MC.

b. Own-account Organizational Structure

We measure investment in own-account OS, using 20% of managers' compensation. The data sources are labor compensation, provided by EU KLEMS, and the Structure of Earnings Survey (SES) 2002, provided by EUROSTAT. EU KLEMS provides labor compensation from 1970 to 2004. SES provides the earnings and the number of employees of 9 occupational categories in 2002. For managers we use the category "Legislators, Senior Officials and Managers". On this basis, we estimate that Germany, France, Italy and Spain respectively invested 0.59%, 1.90%, 0.48% and 0.66% of GDP in own-account organizational structure in 2004. In million euros (current prices), Germany, France, Italy and Spain respectively invested 10,446 million euros, 25,277 million euros, 4,087 million euros and 4,430 million euros in own-account organizational structure.

## 2. Comparing intangible investment across countries.

Figure 1 shows how much the market sector invested in tangible and intangible assets in eight countries. As the estimates are expressed in U.S. dollars, using official exchange rates, a direct comparison of absolute numbers is not very useful. However, it is striking to see that intangible investment exceeded tangible investment in the US, the UK and the Netherlands. In the US, the Netherlands, and the UK, intangible investment is respectively 37%, 33% and 11% larger than tangible investment. In Germany, France and Finland, intangible investment is slightly lower than tangible investment at 75%, 92% and 89% of tangible, respectively. Intangible investment is much lower than tangible investment in Italy and Spain. In Italy, intangible investment is only 28% of tangible investment, and in Spain, intangible investment is only 40% of tangible investment.

Table 1 lists how much the market sector spent and invested in intangible assets in eight countries as a % of GDP. As to spending in 2004, the US spent the most in intangible assets, while Italy spent the least, i.e. 13.13% of GDP in the US compared to 5.23% of GDP in Italy. As to investment, the US invested 11.7% of GDP in intangible assets, and Italy invested 4.79% of GDP. The UK is the second largest investor in intangible assets (10.1% of GDP in 2004), followed by Finland (9.36% of GDP in 2005), France (7.94% of GDP in 2004), the Netherlands (7.5% of GDP in 2004), Germany (6.42% of GDP in 2004), Spain (5.12% of GDP in 2004) and Italy.

The composition of intangible assets shows fairly substantial differences between countries (Table 4 and Figure 2). Computerized information is the smallest part of intangible investment, ranging from 9.5% (in Finland) to 15.6% (in the UK) of total intangible investment. Economic competency is the largest part of intangible investment, at between about 45 and 55% except for Germany (38.4%) and Spain (41.2%). Innovative property is the largest component of intangible investment for Germany (49%) and Spain (45%), and is the second largest component for the other countries.

When comparing the more detailed types of intangible spending, the differences between countries are even larger. Countries varied the most on how much they spent on software, R&D, advertisement, firm-specific human capital and own-account organizational structure (Table 1). As to software, the UK and the US spent around 1.7% of GDP on software, while Germany, France, Italy and Spain spent less than 0.9% of GDP. As to R&D, the US spent 2.06% of GDP on R&D, while Italy and Spain respectively spent only 0.52% and 0.55% of GDP. As to advertisement, the US and the Netherlands spent 2.3% of GDP on advertisement, while Spain spent only 0.34% of GDP and Germany spent only 0.71% of GDP. As to firm-specific human capital, the UK spent at least twice as much as the other countries. The UK spent 2.45% of GDP on firm-specific human capital, the US and France both spent 1.25% of GDP, and Germany spent only 0.67% of GDP. As to own-account organizational capital, the US spent 2.26% of GDP, while Germany, Italy and Spain spent less than 0.7% of GDP.

Why do countries spent so differently on intangible assets? While beyond the scope of this paper, it seems clear that the historical path of technological development and institutional change let to differences in the national innovation systems of individual countries (Lundvall, 1992; OECD, 1997). This might have led to different proportions of R&D, firm-expenditure on human capital and organizational change, which warrant further research. Hence these estimates are very useful in their own right to evaluate the effectiveness of different national innovation systems.

**3. Comparability of intangible investment across countries**

The development of comparable estimates for intangible investment across countries is complicated by the fact that different authors have used different data sources. For example, while we use many data from trade associations, in particular MH (2007) and RBT (2007) for the United Kingdom and the Netherlands respectively rely heavily on the data from national accounts. It should be noted that the U.S. estimates also rely more strongly on trade source data, because the U.S. National Income and Product Accounts often did not have the relevant data included either.

To find out how much different data sources cause different estimated values, we have used our data sources to estimate intangible spending in the UK and the Netherlands, and then compare our estimates with those of MH (2007) and RBT (2007). On this basis we estimate that the UK invested only 9.14% of GDP on intangible assets in 2004, which is 1.74%-points of GDP less than what MH (2007) estimate (Table A1)[2]. We estimate that the Netherlands invested 10.13% of GDP on intangible assets in 2004, which was 0.79 %-points more than what RBT (2007) estimate (Table A1).

We have examined the data sources of each detailed type of intangibles to analyze the differences further. The differences for investment in software and R&D are small, since we also directly measure those using national accounts. But our estimates for investment in copyright and licenses and investment in advertisement are generally lower than those provided by MH (2007) and RBT (2007) for the UK and the respectively.

## III. Investment in Tangible and Intangible Assets, 1991-2004.

This section analyzes the trends of tangible and intangible investment in Germany, France, Italy and Spain from 1991 to 2004, showing that Germany and France raised intangible investment as a % of GDP in recent years, while Italy and Spain showed a slowdown in that ratio in recent years. The data source of intangible investment is based on our estimates, and the data source of tangible investment is EU KLEMS. EU KLEMS provides the investment and stocks of 8 types of assets—(1) software, (2) computing equipment, (3) communications equipment, (4) transport equipment, (5) other machinery and equipment, (6) total non-resident investment, (7) residential structures, and (8) other assets. Using EU KLEMS, we construct three large groups of tangible assets - ICT tangible assets, non-residential buildings and other tangible assets. ICT tangible assets include (2) computing equipment and (3) communications equipment. Non-residential buildings are (6) total non-resident investment. Other tangible assets include (4) transport equipment, (5) other

[2] We focus in this Appendix on how much the market sector invests in intangibles.

machinery and equipment and (8) other assets. We exclude (7) residential structures, because they are not used in production.

All four countries expanded intangible investment from 1991 to 2004 (Figure 3). Germany increased intangible investment from 6.14% of GDP in 1991 to 6.43% of GDP in 2004; France expanded intangible investment from 7.45% to 7.99% of GDP; Italy expanded intangible investment from 2.88% to 4.80% of GDP; Spain expanded intangible investment from 3.84% to 5.10% of GDP. In 1991, Italy and Spain invested much less in intangible assets than Germany and France. Partly because of that, from 1991 to 2004, Italy and Spain expanded intangible investment more rapidly than Germany and France. Still, Italy and Spain invested a smaller amount of GDP in intangible assets in 2004.

The composition of intangible investment changed from 1991 to 2004 (Figures 4-6). The share of computerized information in total intangible investment increased in all countries except Italy. The share of computerized information increased from 11% to 13% of total intangible investment in Germany, from 6% to 11% of intangible investment in France, from 14% to 16% of intangible investment in Spain. It was 14% of intangible investment in Italy in 1991 and in 2004. The share of innovative property increased from 48% to 52% of intangible investment in Germany, increased from 38% to 47% of intangible investment in Spain, stayed around 37% of intangible investment in France, and around 45% of intangible investment in Italy. The share of economic competencies decreased in all countries except Italy. The share of economic competencies decreased from 41% to 34% of intangible investment in Germany, decreased from 56% to 51% of intangible investment in France, decreased from 49% to 36% of intangible investment in Spain, and stayed around 40% of intangible investment in Italy.

Germany and France showed a decline in tangible investment as a % of GDP from 1991 to 2004 (Figure 7). In Germany it fell from 13.1% of GDP in 1991 to 11.7% of GDP in 2004, and in France from 11.2% of GDP in 1991 to 10.6% of GDP in 2004.

Italy and Spain expanded intangible investment much less than tangible investment. Italy and Spain expanded intangible investment by 1.1% and 1.3% of GDP respectively from 1991 to 2004, while they expanded tangible investment by 10% and 6% of GDP respectively from 1991 to 2004. Italy and Spain expanded investment in all kinds of tangible assets—ICT capital, non-residential buildings and other tangible capital. Italy invested 0.77% of GDP in ICT capital in 1991, and invested 2.95% of GDP in ICT capital in 2004. Spain invested 0.88% of GDP in ICT capital in 1991, and invested 3.48% of GDP in ICT capital in 2004. Moreover, Italy and Spain increased investment in non-residential building by 1% of GDP from 1991 to 2004. Compared with tangible investment, intangible investment in Italy and Spain is still relatively small.

## IV. Growth Accounting

This section estimates how much intangible assets contributed to GDP growth in Germany, France, Italy and Spain from 1995 to 2000 and from 2000 to 2004. We focus on the market sector.

### 1. Model and Data

We use a Cobb-Douglass production function, $Y = AK^a L^b$. $K$ is tangible capital stock, and $L$ is labor input. That production function excludes intangible assets, as conventional growth accounting does. Unlike the conventional growth accounting, we include intangible assets in the production function, $Y = AK^\alpha R^\beta L^\gamma$. $R$ is intangible capital stock. The equations of growth accounting are: (We suppress the time subscripts for now.)

Without intangible assets:

$$\ln Y = A + a \ln K + b \ln L$$

With intangible assets:

$$\ln Y = A + \alpha \ln K + \beta \ln R + \gamma \ln L$$

We carry out growth accounting using $i$ types of tangible capital and $j$ types of intangible capital, and the above equations become:

Without intangible assets:

$\ln Y = A + \sum_i a_i \ln K_i + b \ln L$, $i$ denotes a certain type of tangible capital.

With intangible assets:

$\ln Y = A + \sum_i \alpha_i \ln K_i + \sum_i \beta_i \ln R_i + \gamma \ln L$

$i$ denotes a certain type of tangible capital, and $j$ denotes a certain type of intangible capital.

We estimate the values of $a_i$, $b$, $\alpha_i$, $\beta_i$ and $\gamma$, following the method of CHS (2006) and Hulten (2005). $a_i$, $b$, $\alpha_i$, $\beta_i$ and $\gamma$ are the shares of returns to each type of inputs. The return to each type of inputs is unavailable in national accounts, so we have to estimate those returns, using the following equation from Hulten (2005).

$$S = \sum_{i=1}^{N} P_i^K K_i = \sum_{i=1}^{N} [r - \rho_i + (1+\rho_i)\delta_i] P_i^I K_i$$

$S$ is the operating surplus, which is value added minus labor compensation. $P_i^K$ is the user cost of asset $i$. $K_i$ is the stock of (tangible or intangible) capital $i$. $P_i^K K_i$ is the return to capital $i$. $S = \sum_{i=1}^{N} P_i^K K_i$ means that value added equals returns to labor and returns to capital. $r$ is the rate of return, $\rho_i$ is the rate of asset price revaluation of a certain capital, $\delta_i$ is the rate of depreciation of a certain capital, and $P_i^I$ is the acquisition price of a certain capital.

We estimate $r$ for each year, calculate $P_i^K K_i$, and then estimate the share of return to each type of capital as $P_i^K K_i / S$. We estimate $r$ by plugging the values of $S$, $\rho_i$, $\delta_i$, $P_i^I$ and $K_i$. For $\rho_i$, we use the three-year moving average of price deflators of each type of capital, $P_i^I$.

We use perpetual inventory method to estimate the stock of intangible capital[3].

$$R_{j,t} = (1-\delta_j) R_{j,t-1}$$

Table 5 lists the data sources of variables in growth accounting. Our data sources are EU KLEMS, EUROSTAT, CHS (2006) and our estimation of intangible assets. EU KLEMS provides value-added by industry, labor compensation by industry, labor composition by industry, flow and stock of software and 7 types of tangible capital, the deflators of value-added by industry, the deflators of software by industry, and the deflators of 7 types of tangible capital by industry. EUROSTAT provides GDP. CHS (2006) provides the depreciation rates of intangible assets. We examine the market sector only, so all the variables are the values for the market sector.

**2. Contribution to GDP growth, 1995-2000 and 2000-2004.**

We carry out two sets of growth accounting for the market sector—growth accounting without intangible assets, and growth accounting with intangible assets. The periods we cover are 1995-2000 and 2000-2004.[4]

(1) GDP with and without intangible assets.

National accounts treat most intangible investment as an intermediate input, not as capital formation, except for software investment. As a result, GDP excludes intangible

[3] Our data source provides the stock of tangible capital.
[4] We would like to analyze the periods before 1995, but we have no data forthe stock of intangible capital.

investment except for software investment. After we include intangible investment in GDP, the level of GDP increases as well. The growth rates of GDP increased only slightly, partly because intangible investment as a percentage of GDP remained almost constant for Germany and France, and was a small percentage for Italy and Spain. We use Germany as an example. Figure 8 shows that the GDP of Germany increased by 140 billion euros (current prices) if we include intangible investment. Figure 9 shows that including intangible investment slightly increases the growth rates of the GDP of Germany.

(2) Growth accounting without intangible assets.

GDP in the market sector (GDP for short afterwards) grew rapidly from 1995 to 2000, and slowed down from 2000 to 2004 in all four countries (Figure 10). Spain had the highest growth rate both before and after 2000. From 1995 to 2000 the GDP of Spain grew at 4.06% per year on average, and from 2000 to 2004 the GDP of Spain grew at 3.14% per year. Germany had the lowest growth rate before 2000 (1.13% per year on average from 1995 to 2000), and had the second lowest growth rate after 2000 (0.40% per year on average). Italy had the second highest growth rate before 2000 (3.96% per year on average from 1995-2000), but the lowest growth rate after 2000 (0.39% per year on average). France grew at 3.00% per year on average from 1995 to 2000, and grew at 1.59% per year on average from 2000 to 2004.

We break down GDP growth into the contribution of ICT capital, non-ICT capital, hours worked, labor quality and TFP (Table 6, Figure 11 and Figure 12). From 1995 to 2000 *ICT capital* contributed to 0.40% of the annual GDP growth on average in Germany, 0.25% of the annual GDP growth in France, 0.29% of the annual GDP growth in Italy, and 0.49% of the annual GDP growth in Spain. *Non-ICT capital* contributed to 0.90% of the annual GDP growth on average in Germany, 0.70% of the annual GDP growth in France, 0.79% of the annual GDP growth in Italy, and 1.92% of the annual GDP growth in Spain. *Hours worked* slowed down GDP growth in Germany, but contributed strongly to GDP growth in Spain. Hours worked contributed to 2.43% of the annual GDP growth on average in Spain, 0.65% of the annual GDP growth in Italy, 0.39% of the annual GDP

growth in France, and -0.05% of the annual GDP growth in Germany. *Labor quality* slowed down GDP growth by 0.06% annually on average in Germany, contributed to 0.44% of the annual GDP growth on average in France, 0.14% of the annual GDP growth in Italy, and 0.59% of GDP growth in Spain. The residual, *TFP*, varied across countries. We over-explained 0.06% of annual GDP growth in Germany and 1.37% of GDP growth in Spain. We cannot explain 1.22% of annual GDP growth in France and 2.09% of GDP growth in Italy.

From 2000 to 2004 GDP growth slowed down and the contribution of most inputs decreased. *ICT capital* contributed to 0.19% of the annual GDP growth on average in Germany, 0.15% of the annual GDP growth in France, 0.10% of the annual GDP growth in Italy, and 0.22% of the annual GDP growth in Spain. *Non-ICT capital* still contributed strongly to GDP growth. Non-ICT capital contributed to 0.44% of the annual GDP growth in Germany, 0.88% of the annual GDP growth in France, 1.02% of the annual GDP growth in Italy and 1.98% of the annual GDP growth in Spain. *Hours worked* slowed down the annual GDP growth by 0.64% in Germany, contributed to 0.88% of the annual GDP growth in France, 1.02% of the annual GDP growth in Italy, and 1.98% of the annual GDP growth in Spain. *Labor quality* improved in all countries. Labor quality contributed to 0.23% of the annual GDP growth in Germany, 0.21% of the annual GDP growth in France, 0.17% of the annual GDP growth in Italy, and 0.51% of the annual GDP growth in Spain.

The residual, *TFP*, varied across countries. We cannot explain 0.17% of the annual GDP growth in Germany and 0.28% of the annual GDP growth in France from 2000 to 2004. We over-explained 1.65% of the annual GDP growth in Italy and 1.17% of the annual GDP growth in Spain from 2000 to 2004, possibly because growth accounting considers the growth in investment and ignores the returns to investment, so negative returns add to the residual, TFP. In Spain, the growth rate of investment in non-residential buildings remained above 5%, while the growth rate of GDP slowed down from 5.22% in 2000 to 3.47% in 2004. In Italy, the growth rate of non-residential buildings remained above 5%, while the growth rate of GDP slowed down from 3.52% in 2000 to 0.22% in 2002. Growth accounting theoretically assumes that that 5% growth rate of non-residential

buildings contributes to GDP growth, despite the fact that GDP slowed down its growth during the same period.

(2) Growth accounting with intangible assets.

After we include intangible investment in GDP from 1995 to 2000, GDP growth rate increased for all countries, compared to GDP growth rate without intangible investment. For example, in Germany, annual GDP growth rate increased from 1.13% to 1.35%. After we include intangible assets in growth accounting of 1995-2000, the contribution of all the other factors decreased slightly in all countries (Table 7). For example, the contribution of non-ICT capital decreased by 0.52% of the annual GDP growth in Spain, by 0.20% in Italy, by 0.25% in France and by 0.27% in Germany. From 1995 to 2000, intangible assets contributed to 0.62% of the annual GDP growth in Germany, 0.92% of the annual GDP growth in France, 0.51% of the annual GDP growth in Italy and 0.60% of GDP growth in Spain. We define the contribution of knowledge as the contribution of intangible assets, ICT capital and labor quality. From 1995 to 2000, knowledge contributed to 0.92% of the annual GDP growth in Germany, 1.54% of the annual GDP growth in France, 0.91% of the annual GDP growth in Italy and 1.60% of the annual GDP growth in Spain.

We break down the contribution of intangible assets into the contribution of three types of intangible assets (Table 7, Figure 13 and Figure 14). Computerized information contributed to 0.12 % of annual GDP growth in Germany, 0.16% in France, 0.08% in Italy and 0.14% in Spain. Innovative property contributed by 0.43% to the annual GDP growth in Germany, by 0.39% in France, by 0.20% in Italy and 0.36% in Spain. Economic competency contributed by 0.07% in Germany, 0.37% in France, 0.23% in Italy and 0.10% in Spain.

From 2000 to 2004, after we include intangible assets in GDP, the annual growth of GDP declined for France, Italy and Spain. For example, for Spain the annual growth rate of GDP declined from 3.14% to 3.05%. Including intangible investment decreased the growth rate of GDP, because the growth rate of intangible investment is lower than the

growth rate of GDP. After we include intangible assets in the growth accounting of 2000-2004, the contribution of most other inputs decreased. For example, the contribution of ICT capital decreased by 0.02% of annual GDP growth in Germany, France and Spain. Intangible assets contributed to 0.42% of annual GDP growth in Germany, 0.52% of annual GDP growth in France, 0.17% of annual GDP growth in Italy and 0.43% of annual GDP growth in Spain. Knowledge (intangible capital, ICT capital and labor quality) contributed to 0.81% of annual GDP growth in Germany, 0.84% of annual GDP growth in France, 0.43% of annual GDP growth in Italy and 1.11% of annual GDP growth in Spain.

We break down the contribution of intangible assets into the contribution of three types of intangible assets (Table 3 and Figure 10). Computerized information contributed to 0.09 % of the annual GDP growth in Germany, 0.09% in France, 0.04% in Italy and 0.09% in Spain. Innovative property contributed to 0.29% of the annual GDP growth in Germany, contributed to 0.30% in France, contributed to 0.14% in Italy and 0.34% in Spain. Economic competency contributed to 0.04% in Germany, 0.13% in France, -0.01% in Italy and 0% in Spain.

### 3. Contribution to the growth of labor productivity, 1995-2003.

In this section, we compare the four countries with the US and the UK. For the US and the UK, CHS (2006) and MHW (2007) estimated how much intangible assets contributed to labor productivity from 1995 to 2003. To be consistent with CHS (2006) and MHW (2007), we estimate how much intangible assets contributed to labor productivity from 1995 to 2003 in Germany, France, Italy and Spain.

Labor productivity measures how much an employee produces per hour on average. For example, labor productivity was 37.2 in the US in 2003, meaning one hour of work produced $37.2 of value-added on average (2000 constant prices). Labor productivity may increase if producers use better tangible and intangible capital or if workers are of better quality.

The upper panel of Table 8 explains why labor productivity increased in the six countries from 1995 to 2003, ignoring intangible assets. The US had the largest increase in labor productivity, followed by the UK, France, Germany, Italy and Spain. Labor productivity increased by 2.78% annually on average from 1995 to 2003 in the US, 2.59% in the UK, 2.00% in France, 1.41% in Germany, 1.33% in Italy and 0.15% in Spain. ICT tangible capital is the largest contributor to labor productivity in the US and the UK, while non-ICT tangible capital is the largest contributor to labor productivity in Germany, France, Italy and Spain. In the US, ICT tangible capital contributed to 0.70 percentage points of the annual labor productivity growth, while non-ICT tangible capital contributed to 0.28 percentage points. In the UK, ICT tangible capital contributed to 1.13 percentage points of the annual labor productivity growth, while non-ICT tangible capital contributed to 0.51 percentage points. In contrast, in Germany, ICT tangible capital contributed to 0.33 percentage points of the annual labor productivity growth, while non-ICT tangible capital contributed to 1.02 percentage points. Similarly, in France, Italy and Spain, non-ICT tangible capital contributed more to labor productivity than ICT tangible capital did.

The lower panel of Table 8 includes intangible assets in the growth accounting. The growth rates of labor productivity in the lower panel are different from those in the upper panel, because we include intangible investment as part of the output. After we include intangible assets, the contribution of the other factors decreases. For example, the contribution of non-ICT tangible capital in Germany decreases from 1.02 percentage points to 0.72 percentage points.

Intangible assets increased labor productivity in all six countries. Intangible assets contributed to labor productivity the most in the US, followed by France, Germany, the UK, Italy and Spain. Intangible assets contributed to 0.84 percentage points of the annual growth rate of labor productivity from 1995 to 2003 in the US, 0.74 percentage points in France, 0.64 percentage points in Germany, 0.59 percentage points in the UK, 0.33 percentage points in Italy and 0.23 percentage points in Spain.

Knowledge is the major driver of labor productivity from 1995 to 2003 in all six countries. We define the contribution of knowledge as that of ICT tangible capital, intangible capital and labor quality. Knowledge contributed to 1.77 percentage points of the annual growth of labor productivity in the US from 1995 to 2003, 1.92 percentage points in the UK, 0.98 percentage points in Germany, 1.19 percentage points in France, 0.66 percentage points in Italy and 0.97 percentage points in Spain. We are indeed in a knowledge economy.

## V. Conclusion

We estimate that Germany, France, Italy and Spain respectively invested 6.42%, 7.94%, 4.79% and 5.12% of their GDP in intangible assets in 2004. We compare intangible investment in eight countries—Germany, France, Italy, Spain, the Netherlands, Finland, the UK and the US. The US invested the most in intangible assets (11.7% of GDP), while Italy and Spain invested the least in intangible assets (4.79% and 5.12% of GDP, respectively). Not all countries invested heavily in intangible assets.

We carry out growth accounting for GDP growth from 1995 to 2004, comparing the results with and without intangible assets. We find that if we ignore intangible assets, we over-estimate the contribution of tangible assets and labor to GDP growth. We found that intangible assets contributed to GDP growth in Germany, France, Italy and Spain. Then we carry out growth accounting for labor productivity from 1995 to 2003, and compare the four countries with the US and the UK. We find that intangible capital contributed substantially to labor productivity in all six countries, and that knowledge (ICT tangible capital, intangible capital and labor quality) was the major driver of labor productivity in all six countries.

In the future, we aim to measure intangible investment at the *industry* level and carry out growth accounting. We aim to answer the following questions: How much did intangible assets contribute to economic growth in different industries across countries? Did intangible assets change the comparative advantage of industries across countries?

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## Table 1: Private Spending on Intangible Assets in Eight Countries (% GDP)

| Type of Expenditure | France 2004 | Germany 2004 | Italy 2004 | Spain 2004 | Finland[1] 2005 | Netherlands (2001-2004) | UK 2004 | US (1998-2000) |
|---|---|---|---|---|---|---|---|---|
| 1. Computerized information | **0.87** | **0.83** | **0.69** | **0.77** | **1.01** | **1.2** | **1.7** | **1.65** |
| a) Software | 0.82 | 0.81 | 0.69 | 0.75 | | | | |
| b) Databases | 0.04 | 0.02 | 0.01 | 0.02 | | | | |
| 2. Innovative property | **2.99** | **3.37** | **2.18** | **2.40** | **4.30** | **2.44** | **3.23** | **4.57** |
| a) R&D, including social sciences and humanities | 1.32 | 1.69 | 0.52 | 0.55 | 2.72 | 1.52 | 1.09 | 2.06 |
| b) Mineral exploration and evaluation | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.02 | 0.04 | 0.19 |
| c) Copyright and license costs | 0.19 | 0.11 | 0.06 | 0.11 | 0.14 | 0.14 | 0.21 | 0.81 |
| d) Development costs in financial industry | 0.58 | 0.70 | 0.79 | 0.35 | 0.32 | 0.02 | 0.69 | 0.79 |
| e) New architectural and engineering designs | 0.90 | 0.87 | 0.80 | 1.39 | 1.09 | 0.73 | 1.2 | 0.73 |
| 3. Economic competencies | **4.97** | **2.62** | **2.36** | **2.22** | **5.39** | **4.62** | **5.95** | **6.91** |
| a) Brand equity | 1.51 | 0.86 | 1.19 | 0.59 | 2.89 | 2.59 | 1.59 | 2.53 |
| Advertising expenditure | 1.24 | 0.71 | 0.91 | 0.34 | | 2.34 | 1.2 | 2.33 |
| Market research | 0.27 | 0.15 | 0.28 | 0.25 | | 0.24 | 0.39 | 0.2 |
| b) Firm-specific human capital | 1.25 | 0.67 | 0.69 | 0.73 | 1.18 | 0.81 | 2.45 | 1.25 |
| c) Organizational structure | 2.21 | 1.09 | 0.47 | 0.91 | 1.32 | 1.22 | 1.92 | 3.13 |
| Purchased | 0.31 | 0.50 | 0.22 | 0.25 | 0.41 | 1.22 | 0.6 | 0.87 |
| Own account | 1.90 | 0.59 | 0.48 | 0.66 | 0.91 | -- | 1.31 | 2.26 |
| Total Spending | **8.82** | **6.82** | **5.23** | **5.39** | **10.70** | **8.26** | **10.88** | **13.13** |
| Total Investment | **7.94** | **6.42** | **4.79** | **5.12** | **9.36** | **7.5** | **10.1** | **11.7** |

Source: CHS (2005), MH (2007), JAA (2007), RBT (2008) and authors estimation.
Note: JAA (2007) excludes development costs in financial industry. We added it back.

## Table 2: Public and Private Spending on Intangible Assets in Six Countries (% GDP)

| Type of Expenditure | France 2004 | Germany 2004 | Italy 2004 | Spain 2004 | Netherlands (2001-2004) | Japan |
|---|---|---|---|---|---|---|
| 1. Computerized information | **0.90** | **0.87** | **0.76** | **0.84** | **1.35** | **2.0** |
| a) Software | 0.86 | 0.85 | 0.76 | 0.81 | | 1.8 |
| b) Databases | 0.04 | 0.02 | 0.01 | 0.03 | | 0.2 |
| 2. Innovative property | **3.76** | **4.12** | **2.73** | **2.89** | **3.07** | **3.7** |
| a) R&D, including social sciences and humanities | 2.09 | 2.44 | 1.08 | 1.03 | 1.91 | |
| b) Mineral exploration and evaluation | | 0.00 | 0.00 | | 0.06 | |
| c) Copyright and license costs | 0.19 | 0.11 | 0.06 | 0.11 | 0.14 | |
| d) Development costs in financial industry | 0.58 | 0.70 | 0.79 | 0.35 | 0.02 | |
| e) New architectural and engineering designs | 0.90 | 0.87 | 0.80 | 1.39 | 0.97 | |
| 3. Economic competencies | **5.01** | **2.72** | **2.38** | **2.30** | **5.15** | **2.5** |
| a) Brand equity | 1.51 | 0.86 | 1.19 | 0.59 | 2.70 | 1.0 |
| Advertising expenditure | 1.24 | 0.71 | 0.91 | 0.34 | 2.45 | |
| Market research | 0.27 | 0.15 | 0.28 | 0.25 | 0.26 | |
| b) Firm-specific human capital | 1.25 | 0.67 | 0.69 | 0.73 | 1.17 | 0.3 |
| c) Organizational structure | 2.26 | 0.31 | 0.47 | 0.99 | 1.28 | 1.2 |
| Purchased | 0.36 | 0.36 | 0.22 | 0.33 | 1.28 | |
| Own account | 1.90 | 1.19 | 0.51 | 0.66 | | |
| Total Spending | **9.68** | **7.70** | **5.88** | **6.03** | **9.57** | |
| Total Investment | **8.03** | **6.48** | **4.89** | **5.28** | **8.30** | **8.3** |

Source: RBT (2008), Fukao et al. (2007) and authors estimation

## Table 3: Private Investment on Intangible Assets in Germany, France, Italy and Spain (Million euros, current prices)

| | France | Germany | Italy | Spain |
|---|---|---|---|---|
| 1. Computerized information | 14369 | 18270 | 9619 | 6445 |
| a) software | 13660 | 17919.12 | 9537 | 6271 |
| b) databases | 710 | 351 | 82 | 174 |
| 2. Innovative property | 49596 | 74582 | 30309 | 20202 |
| a) R&D, including social sciences and humanities | 21859 | 37445 | 7288 | 4615 |
| b) Mineral exploration and evaluation | | | | |
| c) Copyright and license costs | 3144 | 2395 | 853 | 946 |
| d) Development costs in financial industry | 9666 | 15544 | 11001 | 2929 |
| e) New architectural and engineering designs | 14927 | 19198 | 11167 | 11712 |
| 3. Economic competencies | 67926 | 49072 | 26730 | 16443 |
| a) Brand equity | 16775 | 12655 | 11457 | 3802 |
| Advertising expenditure | 12331 | 9406 | 7596 | 1697 |
| Market research | 4444 | 3249 | 3861 | 2105 |
| b) Firm-specific human capital | 20747 | 14894 | 9589 | 6109 |
| Direct costs | 12629 | 6874 | 6487 | 2240 |
| Indirect costs | 8118 | 8020 | 3102 | 3869 |
| c) Organizational structure | 30404 | 21523 | 5684 | 6533 |
| Purchased | 5127 | 11077 | 1597 | 2103 |
| Own account | 25277 | 10446 | 4087 | 4430 |
| Total Investment | 131891 | 141924 | 66659 | 43090 |

Source: Please see Appendix 1.

## Table 4: Composition of Intangible Investment (% of total intangible investment)

| | France | Germany | Italy | Spain | Finland | Netherlands | UK | US |
|---|---|---|---|---|---|---|---|---|
| Computerized information | 9.81% | 12.11% | 13.22% | 14.22% | 9.45% | 14.53% | 15.63% | 12.57% |
| Innovative property | 33.87% | 49.46% | 41.67% | 44.57% | 40.22% | 29.54% | 29.69% | 34.81% |
| Economic competencies | 56.32% | 38.43% | 45.11% | 41.21% | 50.33% | 55.93% | 54.69% | 52.63% |

Source: Please see section II of text.

## Table 5: Data Sources of Growth Accounting

| Variable | Data Sources |
|---|---|
| $Y$, GDP. | EU KLEMS and EUROSTAT |
| $K_i$, different types of tangible capital stock. | EU KLEMS |
| $R_j$, different types of intangible capital stock. | Our estimation. |
| $L$, hours worked. | EU KLEMS |
| Labor composition | EU KLEMS |
| $\delta_i$, depreciation rates | |
| Tangible capital and software | EU KLEMS |
| Intangible capital | CHS (2006) |
| $P_i^I$, acquisition price of a certain capital | |
| Tangible capital | EU KLEMS. The price deflators of each type of tangible capital. |
| Software | EU KLEMS. The price deflator of software. |
| Other Intangible Capital | GDP deflator. |
| $\rho_i$, the rate of asset price revaluation | The three-year moving average of the price deflator of that capital. |

## Table 6: Growth Accounting without Intangible Assets, 1995-2000 and 2000-2004

| | 1995-2000 | | | | 2000-2004 | | | |
|---|---|---|---|---|---|---|---|---|
| | Germany | France | Italy | Spain | Germany | France | Italy | Spain |
| Annual GDP growth rate of the Market sector | 1.13% | 3.00% | 3.96% | 4.06% | 0.40% | 1.59% | 0.39% | 3.14% |
| Contribution of Inputs | | | | | | | | |
| ICT tangible capital | 0.40% | 0.25% | 0.29% | 0.49% | 0.19% | 0.15% | 0.10% | 0.22% |
| Non-ICT tangible capital | 0.90% | 0.70% | 0.79% | 1.92% | 0.44% | 0.88% | 1.02% | 1.98% |
| Labor | -0.05% | 0.39% | 0.65% | 2.43% | -0.64% | 0.08% | 0.75% | 1.60% |
| Labor Quality | -0.06% | 0.44% | 0.14% | 0.59% | 0.23% | 0.21% | 0.17% | 0.51% |
| TFP | -0.06% | 1.22% | 2.09% | -1.37% | 0.17% | 0.28% | -1.65% | -1.17% |

Source: EU KLEMS, EUROSTAT, CHS (2005) and authors' estimation of intangible assets.

## Table 7: Growth Accounting with Intangible Assets, 1995-2000 and 2000-2004

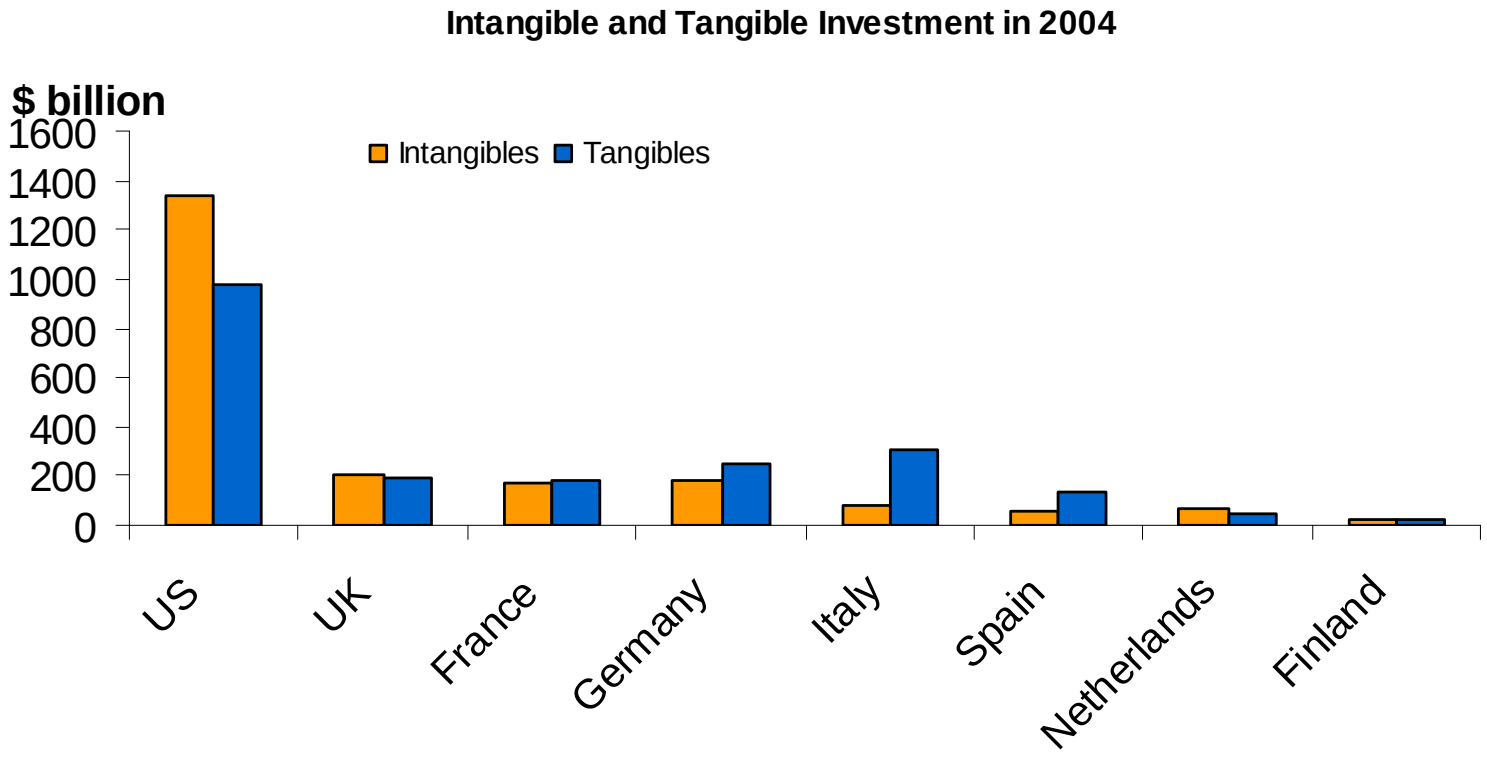
| | 1995-2000 | | | | 2000-2004 | | | |
|---|---|---|---|---|---|---|---|---|
| | Germany | France | Italy | Spain | Germany | France | Italy | Spain |
| Annual GDP growth rate of the Business sector | 1.35% | 3.29% | 4.04% | 4.28% | 0.45% | 1.57% | 0.37% | 3.05% |
| Contribution of Inputs | | | | | | | | |
| ICT tangible capital | 0.36% | 0.22% | 0.27% | 0.45% | 0.17% | 0.13% | 0.10% | 0.20% |
| Non-ICT tangible capital | 0.63% | 0.45% | 0.59% | 1.40% | 0.26% | 0.54% | 0.75% | 1.47% |
| Intangible Capital | 0.62% | 0.92% | 0.51% | 0.60% | 0.42% | 0.52% | 0.17% | 0.43% |
| Labor | -0.05% | 0.35% | 0.62% | 2.29% | -0.59% | 0.07% | 0.71% | 1.51% |
| Labor Quality | -0.06% | 0.40% | 0.13% | 0.55% | 0.22% | 0.19% | 0.16% | 0.48% |
| TFP | -0.16% | 0.94% | 1.92% | -1.02% | -0.02% | 0.12% | -1.51% | -1.04% |
| | | | | | | | | |
| Software | 0.12% | 0.16% | 0.08% | 0.14% | 0.09% | 0.09% | 0.04% | 0.09% |
| Innovative Property | 0.43% | 0.39% | 0.20% | 0.36% | 0.29% | 0.30% | 0.14% | 0.34% |
| Economic Competency | 0.07% | 0.37% | 0.23% | 0.10% | 0.04% | 0.13% | -0.01% | 0.00% |

Source: EU KLEMS, EUROSTAT, CHS (2005) and authors' estimation of intangible assets.

## Table 8: Annual Change in Labor Productivity in the Market Sector, 1995-2003

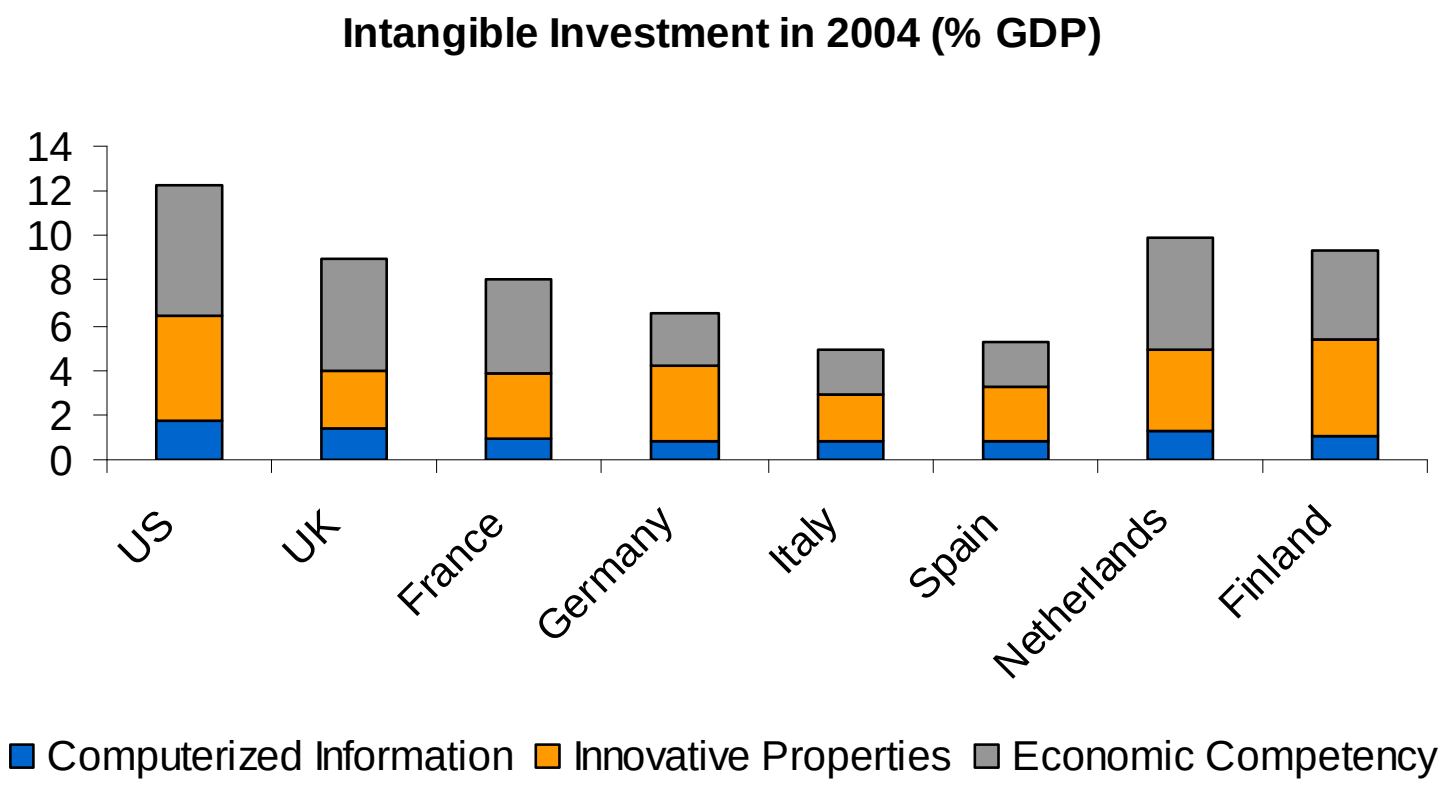
| | US | UK | Germany | France | Italy | Spain |
|---|---|---|---|---|---|---|
| | Excluding Intangible Capital (%) | | | | | |
| Labor productivity growth | 2.78 | 2.59 | 1.41 | 2.00 | 1.33 | 0.15 |
| Contribution of Inputs | | | | | | |
| ICT tangible capital | 0.70 | 1.13 | 0.33 | 0.20 | 0.18 | 0.25 |
| Non-ICT tangible capital | 0.28 | 0.51 | 1.02 | 0.66 | 0.38 | 0.45 |
| Labor Quality | 0.38 | 0.36 | 0.04 | 0.30 | 0.17 | 0.53 |
| TFP | 1.42 | 0.58 | 0.01 | 0.84 | 0.59 | -1.09 |
| | Including Intangible Capital (%) | | | | | |
| Labor productivity growth | 3.09 | 2.93 | 1.58 | 2.17 | 1.38 | 0.21 |
| Contribution of Inputs | | | | | | |
| ICT tangible capital | 0.60 | 1.02 | 0.30 | 0.18 | 0.17 | 0.23 |
| Non-ICT tangible capital | 0.24 | 0.52 | 0.72 | 0.38 | 0.23 | 0.22 |
| Intangible Capital | 0.84 | 0.59 | 0.64 | 0.74 | 0.33 | 0.23 |
| Labor Quality | 0.33 | 0.31 | 0.04 | 0.27 | 0.16 | 0.51 |
| TFP | 1.08 | 0.48 | -0.12 | 0.60 | 0.50 | -0.97 |
| Software | 0.27 | 0.18 | 0.12 | 0.13 | 0.05 | 0.08 |
| Innovative Property | 0.22 | 0.14 | 0.43 | 0.35 | 0.15 | 0.23 |
| Economic Competency | 0.35 | 0.26 | 0.09 | 0.26 | 0.13 | -0.09 |

**Figure 1**



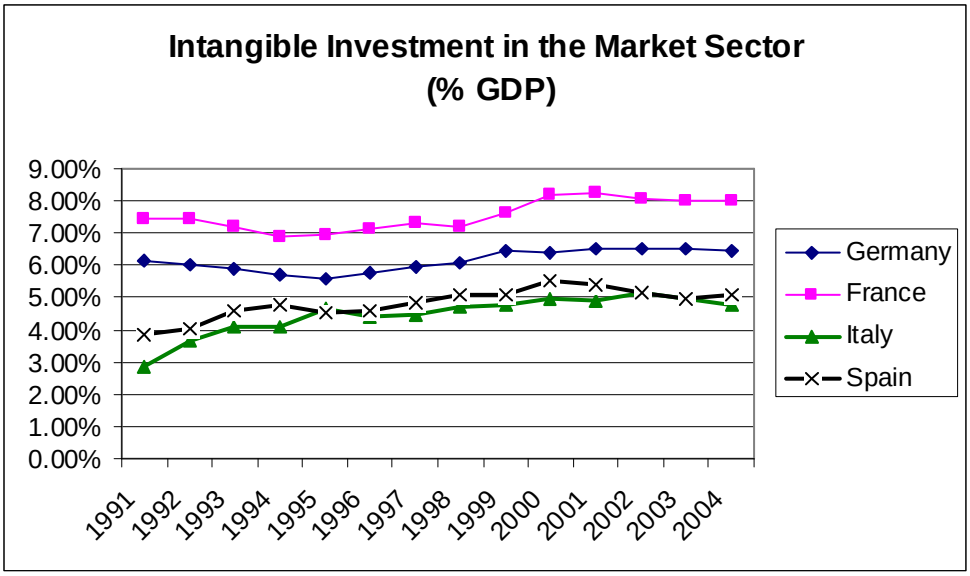

Source: CHS (2005), MH (2007), JAA (2007), RBT (2008) and our estimation.
Note: The values are in current dollars. Estimates of the US is on average from 1998 to 2000, and those of Finland for 2005.

**Figure 2**



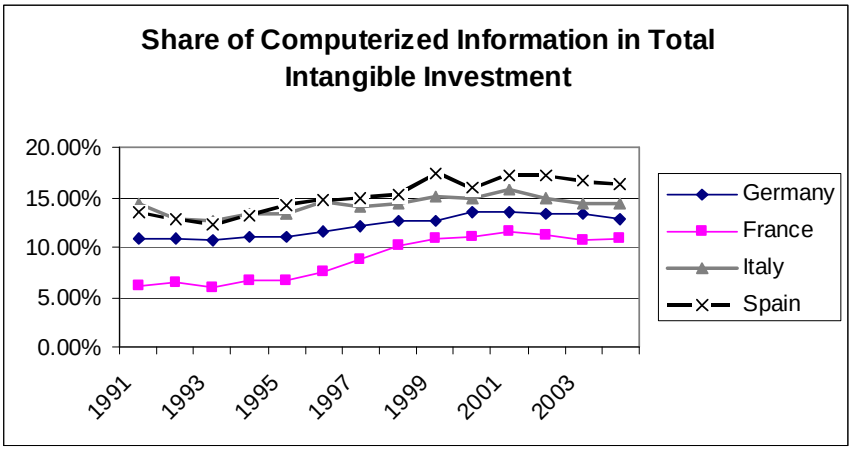

Source: CHS (2005), MH (2007), JAA (2007), RBT (2008) and our estimation.
Note: The values are in current dollars. Estimates of the US are on average from 1998 to 2000, and those of Finland for 2005.

## Figure 3



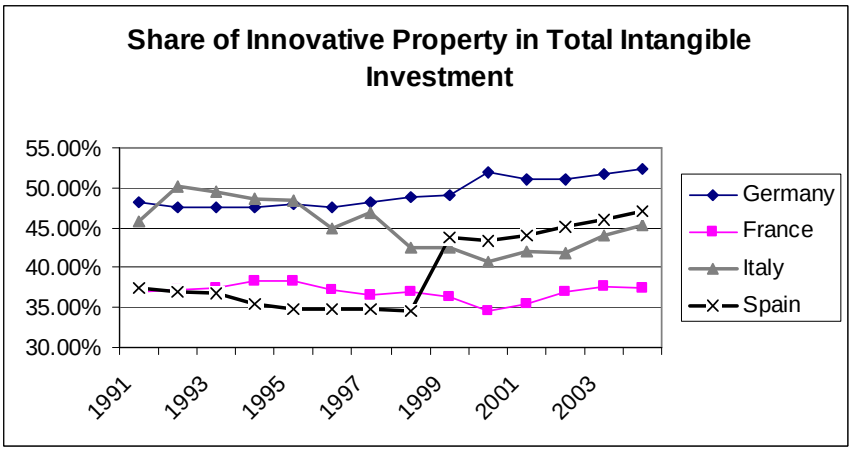

Source: Please see Section II of text.

## Figure 4



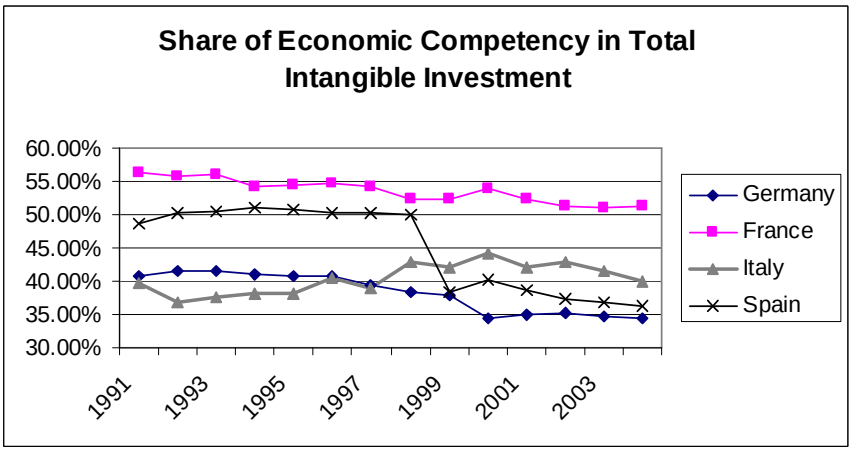

Source: Please see Section II of text.

## Figure 5



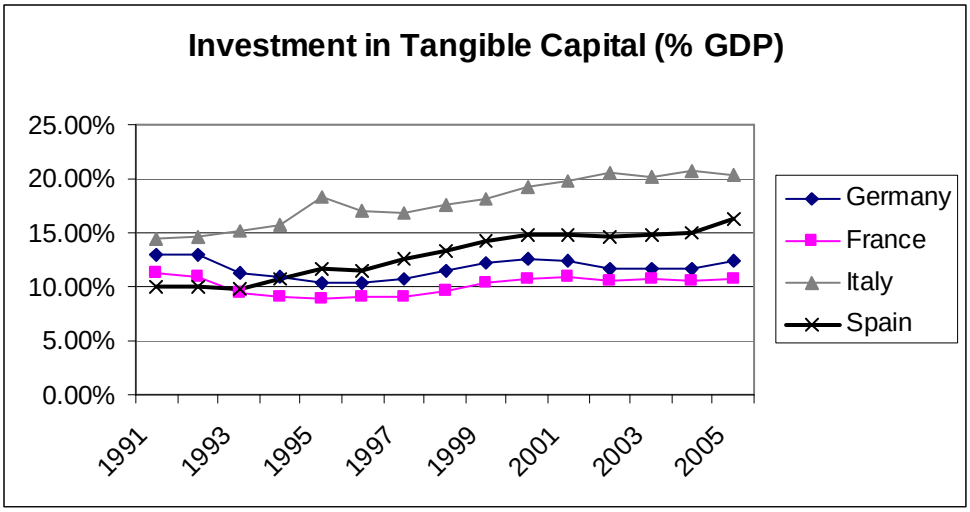

Source: Please see Section II of text.

## Figure 6



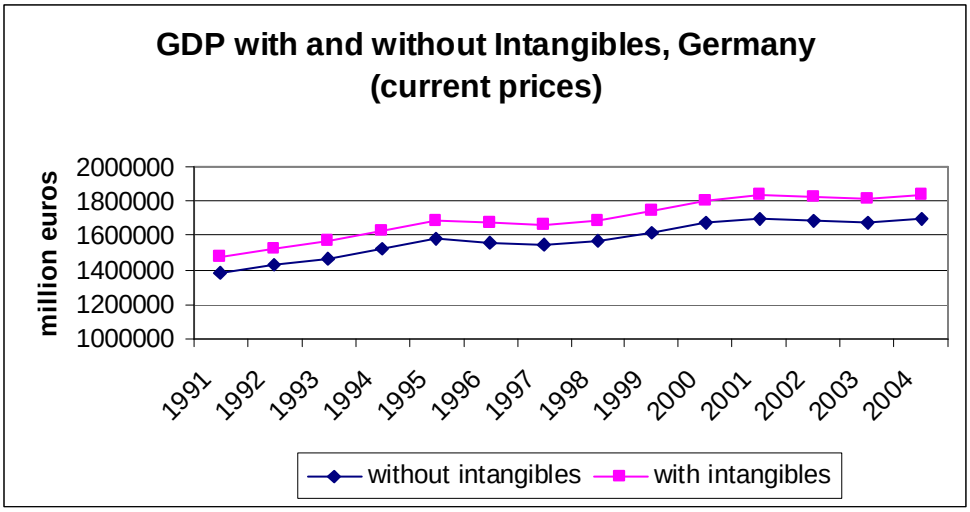

Source: Please see Section II of text.

## Figure 7



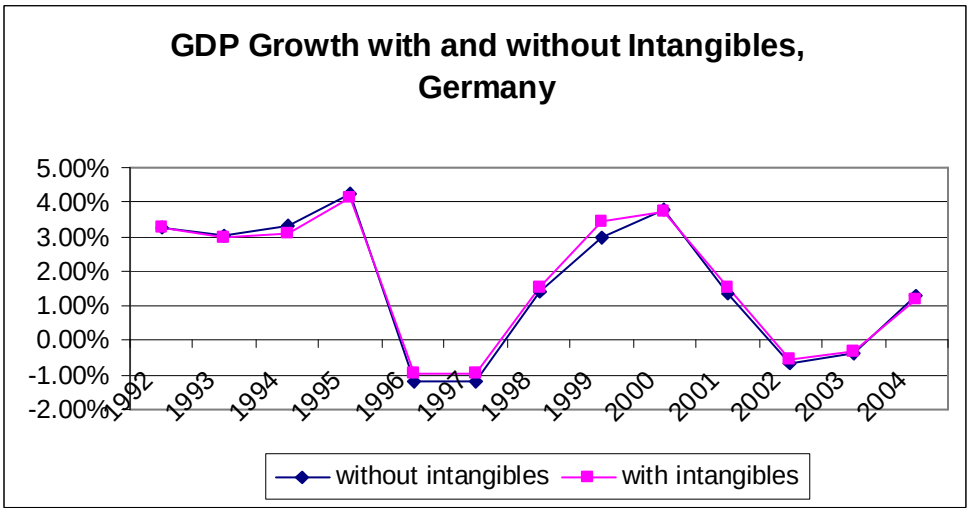

Source: EU KLEMS.

## Figure 8



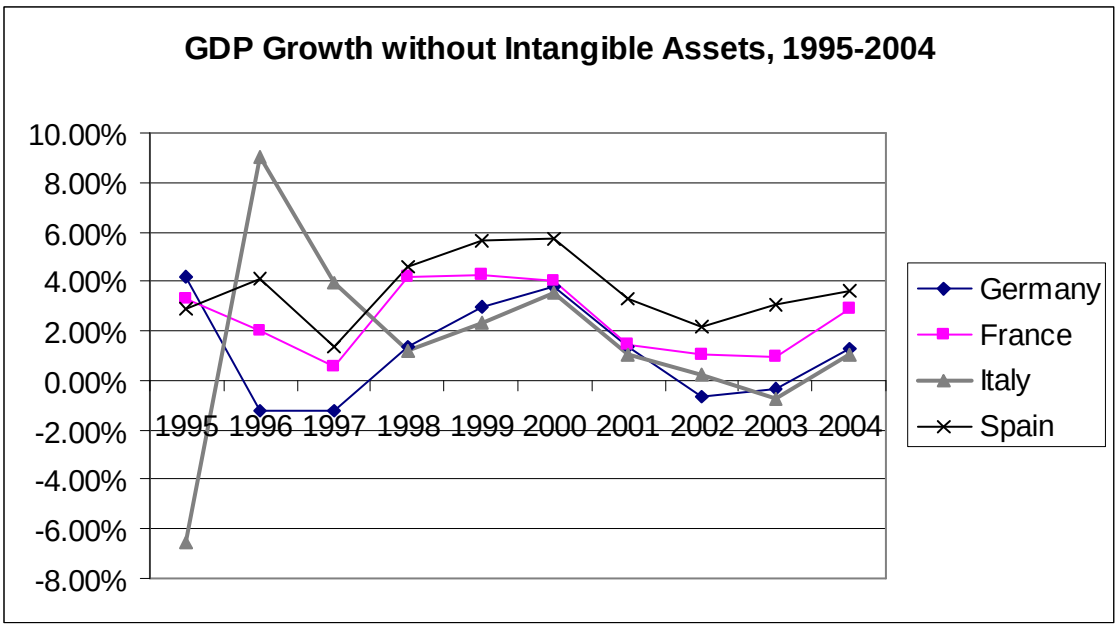

Source: EU KLEMS and authors' estimation of intangible assets.

## Figure 9



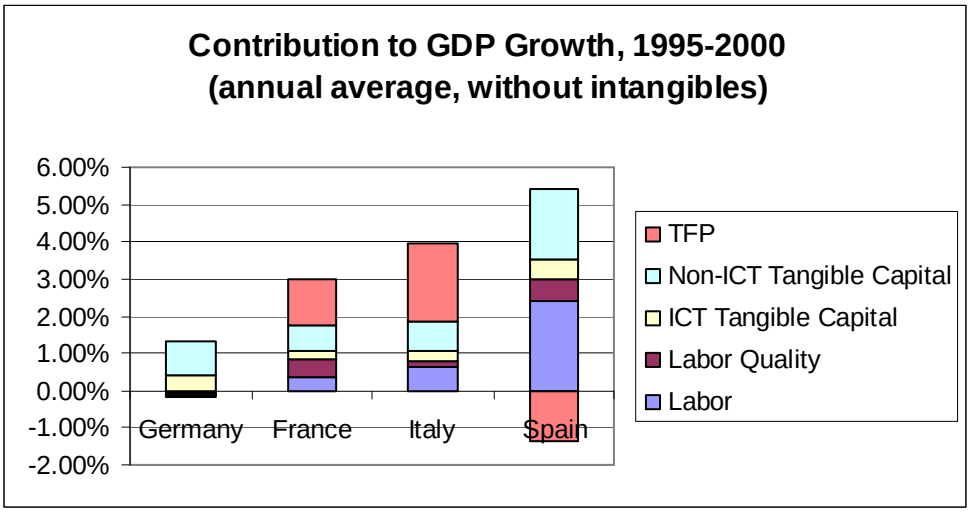

Source: EU KLEMS and authors' estimation of intangible assets.

## Figure 10



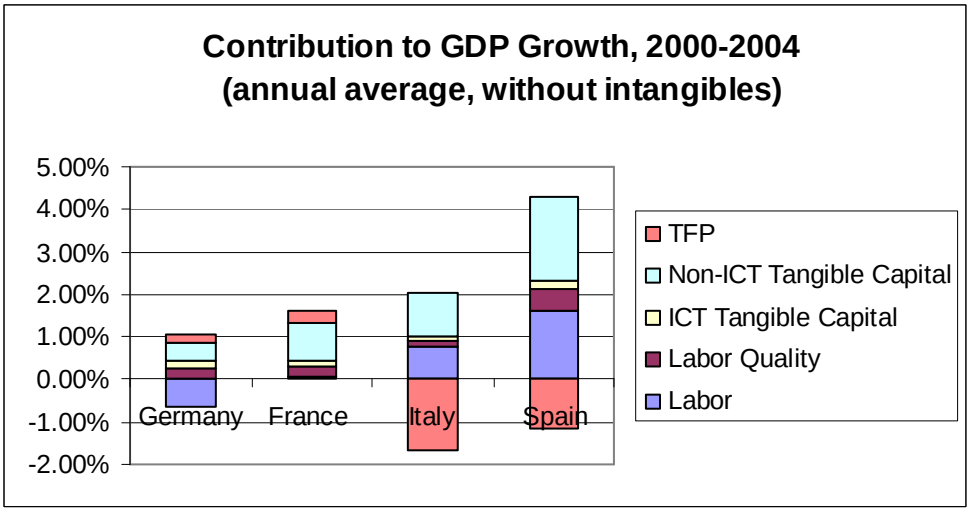

Source: EU KLEMS and authors' estimation of intangible assets.

## Figure 11



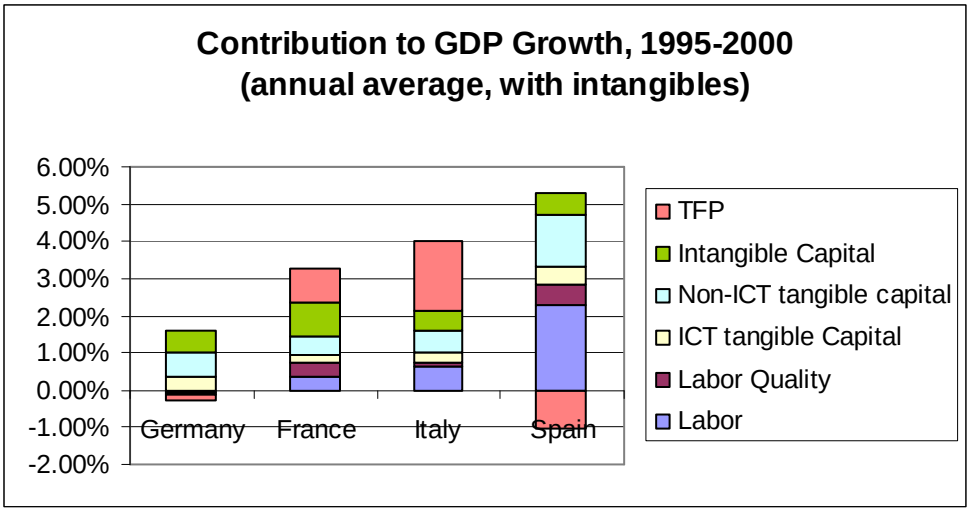

Source: EU KLEMS, EUROSTAT, CHS (2005) and authors' estimation of intangible assets.

## Figure 12



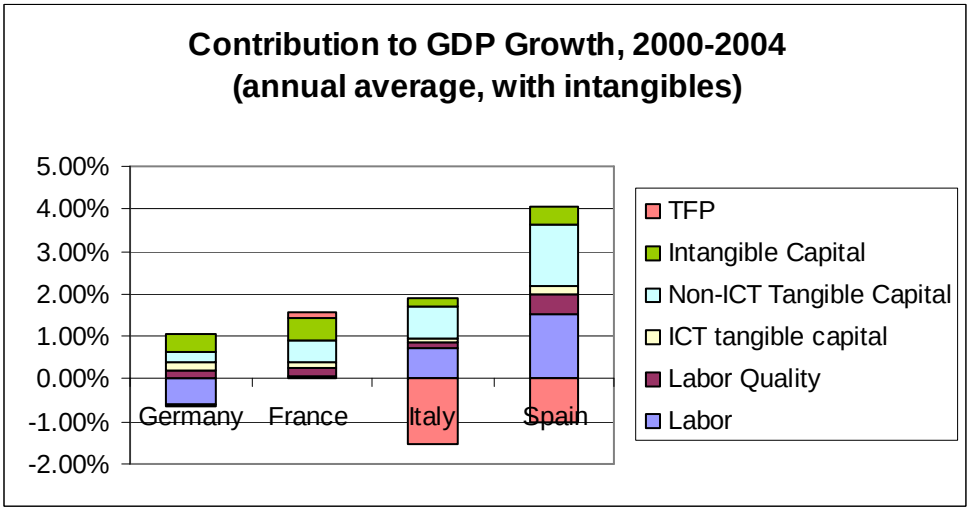

Source: EU KLEMS, EUROSTAT, CHS (2005) and authors' estimation of intangible assets.

## Figure 13




Source: EU KLEMS, EUROSTAT, CHS (2005) and authors' estimation of intangible assets.

## Figure 14




Source: EU KLEMS, EUROSTAT, CHS (2005) and authors' estimation of intangible assets.