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Intangible Capital and Growth – an International Comparison

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I. Introduction

We live in an era of innovation. 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. Innovations have improved producers' efficiency by changing organizational structures.

Innovation, however, is largely ignored in national accounts and corporate financial report because measuring innovation is hard. Indeed, innovation is one of the many assets that are hard to measure and thus are ignored because they are "intangible". Examples of those intangible assets are software, databases, brand equity and human capital.

Intangible assets include computerized information, innovative property and economic competencies[1]. Economists find that developed countries invest substantially in intangible

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[1] According to Corrado, Hulten and Sichel (2005), the three categories of intangible assets include software, databases, R&D, mineral exploration and valuation, copyright and licenses, new products in financial industry, new architectural and engineering designs, brand equity, firm-specific human capital and

assets. In the US, the private sector invested 12.1% of GDP in intangible assets in 2003 (Corrado, Hulten and Sichel, 2005)[2]. In the UK, the private sector invested 10.1% of GDP on intangibles in 2004 (Marrano and Haskel, 2006). In Finland, the private sector invested 9.1% of GDP in intangible assets (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).

Several of the studies above find that intangible assets promote labor productivity. In the US, intangible assets contributed to 0.4 percentage points of the annual growth of labor productivity on average from 1973 to 1995, which increased to 0.8 percentage points from 1995 to 2003. In the UK, Intangible assets increased labor productivity by an average of 0.4 percentage points per year from 1979 to 1995, which increased to 0.6 percentage points per year from 1995 to 2003 (MHW, 2007). In Finland intangible assets increased labor productivity by 0.6 percentage points annually on average from 1995 to 2000, and increased labor productivity by 0.9 percentage points annually on average from 2000 to 2005 (Jalava, Aulin-Ahmavaara and Alanen, 2007).

In this paper, we use the same methodology as CHS (2005) and Morrano, Haskel and Wallis (2007) to measure how much Germany, France, Italy and Spain invested in intangible assets in 2004. We use a wide range of data sources including national accounts, surveys provided by statistical offices, surveys provided by trade associations and corporate financial reports. We estimate that Germany, France, Italy and Spain respectively invested 7.1%, 8.8%, 5.2% and 5.2% of GDP in intangible assets in the market sector in 2004.

From 1995 to 2003, intangible assets contributed to 0.9 percentage points of the annual growth of labor productivity in France, followed by Germany (0.6 percentage points), Italy

organizational capital. This list includes intangible assets that can only be crudely measured at the macro level and may exclude some intangible assets that cannot be measured at the macro level, such as customer relationships.

[2] CHS (2005) provided intangible investment from 1998 to 2000. We requested the estimate of 2003 from them.

(0.4 percentage points) and Spain (0.2 percentage points). We chose the period from 1995 to 2003, to be consistent with CHS (2006) and MHW (2007).

We also carry out growth accounting for 1995-2000 and 2000-2004 for Germany, France, Italy and Spain. The growth rate of labor productivity was higher in the first period, and was lower in the second period. The contribution of intangible assets decreased from the first to the second period.

Spillover effects from intangible assets most likely account for a significant portion of MFP. If no spillover exists, after we include intangible assets in growth accounting, MFP should be uncorrelated with intangible capital deepening. The intangible capital deepening, however, is still strongly correlated with MFP, implying that intangible assets contribute to MFP through spillovers.

The structure of this paper is as follows. Section II estimates how much Germany, France, Italy and Spain invested in intangible assets from 1991 to 2004. Section III carries out growth accounting of labor productivity with and without intangible assets. We compare the results for Germany, France, Italy and Spain with the results for the US and the UK from 1995 to 2003. Moreover, we compare the results before and after 2000. Section IV concludes.

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

Intangible investment in 2004.

Measuring intangible assets is the most difficult part of research on intangible assets. National statistical offices have no data on most intangible assets, so researchers have to find data from less reliable resources. In Hao, Manole and van Ark (2008), we follow the same method as CHS (2005) and MH (2006) to estimate intangible investment in France and Germany. We use a wide range of data sources including national accounts, surveys

provided by statistical offices, surveys provided by trade associations and corporate financial reports. Intangible assets include three major groups—computerized information, innovative property and economic competencies. In this paper, we use similar data sets to expand the estimates to Italy and Spain.

Computerized Information.

The major component of computerized information is software. The other component of computerized information is databases. The data source is EU KLEMS (2008). The capital account of EU KLEMS provides the estimates of the investment and stocks of eight 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. The output account of EU KLEMS provides the output of database industry (NACE 724). We approximate database investment with database output.

We estimate that Germany, France, Italy and Spain respectively spent 0.7%, 1.3%, 0.7% and 0.7% of GDP on software in the market sector in 2004. Germany, France, Italy and Spain respectively spent 0.02%, 0.04%, 0.01% and 0.03% of GDP on databases in the market sector in 2004.

Innovative Property.

Innovative property includes both scientific and artistic innovation. The components of innovative property are (1) R&D in natural science and social science, (2) mineral explorations, (3) copyright and license costs, (4) development costs of new products in financial industry, and (5) new architectural and engineering designs. We estimate that Germany, France, Italy and Spain respectively spent 3.5%, 3.1%, 2.3% and 2.5% of GDP on innovative property in 2004.

(1) R&D. The data source is EUROSTAT. We estimate that the market sector of Germany invested 1.7% of GDP, France invested 1.3% of GDP, Italy invested 0.5% of GDP, and Spain invested 0.6% of GDP on R&D in 2004.

(2) Mineral explorations. The data source for German is the national accounts, and the data sources for France, Italy and Spain are financial reports of major oil and gas companies. We estimate that Germany spent as little as 0.005% of GDP on exploring costs, France spent 0.02% of GDP, and Italy and Spain spent 0.04% of GDP.

(3) Copyright and license costs. The data source for Germany is the national accounts, and the data source of France, Italy and Spain is Screen Digest (2005). Screen Digest provides production costs for 59 countries from 2000 to 2005. We approximate copyright and license costs at five times the production costs of movies[3]. We estimate that Germany spent 0.2% of GDP on copyright and licenses in the market sector in 2004, France 0.3%, Italy 0.1% and Spain 0.2%.

(4) Development costs of new products in financial industry were based on the OECD STAN database for Industrial Analysis. STAN provides the intermediate costs of the financial industry. We assume that the financial industry invested 20% of the intermediate costs in developing new products. We estimate that Germany spent 0.7% of GDP on developing new products in the financial sector 2004, France 0.6%, Italy 0.8% and Spain 0.4%.

(5) New architectural and engineering designs. The data source for investment in new architectural and engineering designs is the output measure for new architectural and engineering designs from EU KLEMS, with half of the gross output coming from Architectural, Engineering and Other Technical Activities (NACE 74.2). We estimate that Germany spent 0.9% of GDP on new architectural and engineering costs, France 0.9%, Italy 0.8% and Spain 1.4%.

Economic Competency.

[3] CHS (2005) estimate that the total copyright and license costs are three times the development costs of motion pictures. We modify the threes times to five times, because we find that copyright and license costs are five and a half times the development costs of motion pictures in Germany, and are four and a half times in the UK. We obtained copyright and license costs of the UK and Germany from national accounts.

Economic Competency includes brand equity, firm-specific human capital and organizational capital. We estimate that Germany, France, Italy and Spain respectively invested 3.3%, 5.2%, 2.7% and 2.2% of GDP on economic competency in 2004.

(1) Brand equity. Firms can increase their brand equity by advertising their brands or by researching the market. The data sources for advertisement are EU KLEMS and World Magazine Trends. EU KLEMS provides the gross output of advertising industry (NACE K744) from 1970 to 2004. We exclude half of newspaper advertisement, because it is likely to be classified as advertisement and does not increase brand equity. World Magazine Trends provide the percentages of advertisement on newspapers. The data source of market research is the Structural Business Statistics of EUROSTAT. It provides the turnover of Market Research and Public Opinion Polling (NACE, K7413).

Some of the advertising expenditure increases the current sales but not the sales after one year, so part of the advertising costs is not investment. We estimate investment in brand equity as 60% of spending on advertisement and 100% of spending on market research. We estimate that Germany, France, Italy and Spain respectively invested 0.8%, 1.5%, 1.2% and 0.6% of GDP on brand equity.

(2) Firm-specific human capital. We measure how much firms spent on firm-specific human capital, using spending on initial vocational training and continuing vocational training. Initial vocational training relates to apprentice training (AT),whereas continuing vocational training (CVT) includes training courses, training at work places, training through job rotation, self-learning and learning at conferences, lectures and workshops.[4]

Our major data sources of AT and CVT are the Labor Cost Survey (LCS) 2004 provided by EUROSTAT, Continuing Vocational Training Survey (CVTS) 2005 provided by EUROSTAT, and labor compensations provided by EU KLEMS. We

[4] Initial vocational training includes apprentice training and full-time schooling. Since firms do not pay for full-time schooling, we exclude it.

estimate that Germany spent 1.3% of GDP on firm-specific human capital, France 1.5%, Italy 1.0% and Spain 0.8%.

(3) Organizational structure. There are two major ways to improve organizational structure. Managers spend time on making the firms more efficient, or firms purchase management consultancy to solve problems of organizational structure. We assume that managers spend 20% of their time on improving organizational structures. Following CHS (2005), we assume that 4 percentage points of those efforts improve current organizational structure and 16 percentage points of those efforts improve future organizational structure. So we measure investment in organizational structures at 16% of managers' compensation and 100% of the revenues of the management consulting industry.

The data sources for managers' compensation are EU KLEMS and the Structure of Earnings Survey (SES) 2002 from EUROSTAT. The data source of management consultancy is the 2004 Annual Survey of the European Management Consultancy Market, provided by the European Federation of Management Consultancies Associations (FEACO). We estimate that Germany, France, Italy and Spain respectively invested 1.1%, 2.2%, 0.5% and 0.8% of GDP in organizational structure.

We stress that these are still relatively crude measures of intangible investment. A major difficulty in studying intangible assets is that since it is a new research field, statistical offices and other agencies do not have data on most intangible assets, and research is scarce on most intangible assets. First, we have no data on imports and exports of intangible assets. Jalava, Ahmavaara and Alanen (2007) use imports, exports, fixed investment in R&D to adjust the R&D spending of BERD for Finland in 2005. They estimate that Finland invested 4275 million Euros in R&D in 2005, 399 million Euros larger than our unadjusted estimation. Second, the CHS (2005) method has its own shortcomings. For example, CHS (2005) crudely assume that the financial industry spend 20% of their intermediate costs on developing new products and that managers spent 20% of their time improving

organizational structure. We have no corroborating evidence that those percentages would hold in Germany, France, Italy and Spain.

International Comparison.

Below we compare how much Germany, France, Italy and Spain invested in intangible assets relative to the U.S. and the UK as a percentage of GDP, and how intangible investment compare in relative terms with tangible investment in the same country.

Countries differ in how much they invested in intangible assets (Figure 1). In the U.S. intangible investment was 37% larger than tangible investment from 1998 to 2000, in France 24% in 2004, and in the UK 11% in 2004. In Germany intangible investment was 9% lower than tangible investment, in Italy intangible investment was 69% less than tangible investment, and in Spain intangible investment was 54% less than tangible investment. Countries also differed in how much they invested in intangible assets as a percentage of GDP (Table 1). In 2004, the U.S. invested in the most in intangible assets (11.7% of GDP), followed by the UK (10.1%), France (8.8%), Germany (7.1%), Italy (5.2%) and Spain (5.2%).

Countries varied in the composition of intangible assets (Table 2 and Figure 2). In all six countries, computerized information is the smallest part of intangible investment, ranging from 10% (in Germany) to 17% (in the UK) of total intangible investment. In the US, the UK and France, innovative property is the second largest component of intangible investment in the US, the UK and France ranging from 32% to 39%. Economic competency is the largest part of intangible investment at between about 47% and 51%. In Germany, Italy and Spain, economic competency is the second largest part of intangible investment ranging from 38% to 43%. Innovative property is the largest part of intangible investment ranging from 44% to 49% of total intangible investment.

When comparing the more detailed types of intangible spending, the difference among the countries is 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, Italy and Spain spent less than 0.8% of GDP. As to R&D, the US spent 2.1% of GDP on R&D, while Italy and Spain respectively spent only 0.5% and 0.6% of GDP. As to advertisement, the US spent 2.3% of GDP on advertisement, while Spain spent only 0.3% of GDP and Germany spent only 0.7% of GDP. As to firm-specific human capital, the UK spent at least twice as much as the other countries. The UK spent 2.5% of GDP on firm-specific human capital, while Spain spent only 0.8% of GDP. As to own-account organizational capital, the US spent 2.3% of GDP, while Germany, Italy and Spain spent less than 0.6% of GDP.

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

A problem of comparing intangible investment across countries is that different authors have used different data sources. For example, in this paper we make intensive use of data from trade associations because many data are unavailable in national accounts, while in particular MH (2006) for the UK and RBT (2007) for the Netherlands rely heavily on the data from national accounts. It should be noted that the U.S. estimates also rely more strongly on trade association sources, because the U.S. National Income and Product Accounts often did not have the relevant data directly included either.

We have compared our data sources to estimate intangible spending in the UK and the Netherlands with those of MH (2006) for the UK and RBT (2007) for the Netherlands. On this basis we estimate that the UK invested 10.1% of GDP on intangible assets in 2004, 0.8

percentage points of GDP less than what MH (2006) estimate (Table A2). We estimate that the Netherlands invested 10.5% of GDP on intangible assets in 2004, 1.2 percentage points more than what RBT (2007) estimate (Table A2).

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 Netherlands, respectively.

Intangible investment from 1991 to 2004.

All four countries expanded intangible investment from 1991 to 2004 (Figure 3)[5]. Germany increased intangible investment from 6.9% of GDP in 1991 to 7.1% of GDP in 2004; France expanded intangible investment from 8.0% to 8.8% of GDP; Italy expanded intangible investment from 3.2% to 5.2% of GDP; Spain expanded intangible investment from 4.0% to 5.2% 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.

The composition of intangible investment changed from 1991 to 2004 (Table 2). The share of computerized information and the share of innovative property in total intangible investment increased in all countries. The share of economic competencies decreased in all countries. The share of computerized information increased from 8.5% to 10.1% of total intangible investment in Germany, from 8.6% to 14.9% of intangible investment in France, from 12.6% to 12.9% in Italy, and from 11.3% to 14.3% in Spain. The share of innovative property increased from 44.1% to 49.1 % of intangible investment in Germany, from 42.4% to 43.8% in Italy, and from 39.0% to 48.2% in Spain, and remained 35.5% in France. The share of economic competencies decreased from 47.4% to 40.8% of intangible investment in

[5] For more details on the time series, please see Appendix 1.

Germany, from 56.0% to 55.0% in France, from 45.0% to 43.3% in Italy, and from 49.7% to 37.6% in Spain.

Germany and France shifted from tangible to intangible investment, while Italy and Spain seemed to prefer tangible to intangible investment. Germany and France decreased tangible investment as a percentage of GDP from 1991 to 2004 (Figure 4). In Germany tangible investment fell from 12.4% of GDP in 1991 to 7.8% of GDP in 2004 and in France from 9.6% of GDP in 1991 to 7.1% of GDP in 2004. Italy and Spain expanded intangible investment much less than tangible investment. Italy and Spain expanded intangible investment by 2.0% and 1.2% of GDP respectively from 1991 to 2004, while they expanded tangible investment by 2.8% and 2.0% of GDP respectively from 1991 to 2004.

III. Intangible Assets Contribute to Labor Productivity.

Intangible assets contribute substantially to labor productivity in recent years in the US and the UK (CHS, 2006 and MHW, 2007). Do intangible assets contribute to labor productivity in Germany, France, Italy and Spain? To answer this question, we carry out growth accounting of the market sector using our estimates of intangible assets.

1. Methodology

(1) Equation of Growth Accounting with Intangible Assets.

Growth accounting relates the growth of output to the growth of inputs. We use a Cobb-Douglass production function of constant returns to scale.

$$Y = AK^{\alpha}R^{\beta}(L \cdot L^{QA})^{\gamma}, \text{ where } \alpha + \beta + \gamma = 1. \quad (1)$$

Y is the value-added of the market sector. A is total-factor productivity. K is tangible capital stock. R is intangible capital stock. L is labor input. L^{QA} is labor quality. We divide

both sides with L. So labor productivity (Y/L) is determined by tangible capital deepening (K/L), intangible capital deepening (R/L), labor quality (L^{QA}) and MFP (A).

$$(Y/L) = A(K/L)^{\alpha}(R/L)^{\beta}(L^{QA})^{\gamma}, \text{ where } \alpha+\beta+\gamma=1.$$

$$\Delta \ln A = \Delta \ln(Y/L) - \alpha\Delta \ln(K/L) - \beta\Delta \ln(R/L) - \gamma\Delta \ln(L^{QA})$$

There are i types of tangible capital and j types of intangible capital, and our equation of growth accounting with intangible assets becomes the following.

$$\Delta \ln A = \Delta \ln(Y/L) - \sum_i \alpha_i \Delta \ln(K_i/L) - \sum_j \beta_j \Delta \ln(R_j/L) - \gamma\Delta \ln(L^{QA}),$$
$$\text{where } \sum_i \alpha_i + \sum_j \beta_j + \gamma = 1.$$

We also carry out growth accounting without intangible assets. The equation without intangible assets is the following.

$$\Delta \ln A' = \Delta \ln(Y/L) - \sum_i a_i \ln(K/L) - b\Delta \ln(L^{QA}),$$
$$\text{where } \sum_i a_i + b = 1.$$

(2) Estimating the shares of tangible capital, intangible capital and labor.

We calculate the values of α_i and β_j, following the method of CHS (2006). In an economy of constant returns to scale and perfect competition, α_i is the share of compensation of tangible capital i in value-add. β_j is the share of compensation of intangible capital j in value-added. γ is the share of labor compensation in value-added. The compensation of tangible capital i is the rental price of tangible capital i, P_i^K, multiplied by the stock of

tangible capital i, K_i. The compensation of intangible capital is the rental price of tangible capital j, P_j^R, multiplied by the stock of intangible capital j, K_j.

$$Y = \sum_i P_i^K K_i + \sum_j P_j^R R_j + wL. \tag{2}$$

$$\alpha_i = \frac{P_i^K K_i}{Y} \tag{3}$$

$$\beta_j = \frac{P_j^R R_j}{Y} \tag{4}$$

$$\gamma = \frac{wL}{Y}$$

To calculate the values of α_i and β_j, we need the values of P_i^K and P_j^R. The following equations determine the values of P_i^K and P_j^R.

$$P_i^K = [r - \rho_i + (1+\rho_i)\delta_i]P_i^{IK} \tag{5}$$

$$P_j^R = [r - \rho_j + (1+\rho_j)\delta_j]P_j^{IR} \tag{6}$$

In equilibrium, the cost of buying an asset equals the cost of renting the asset. P_i^{IK} is the acquisition price of tangible capital i. r is the economy-wide rate of return. ρ_i is capital gains of tangible capital i. δ_i is the depreciation rate of tangible capital i. P_j^{IR} is the acquisition price of intangible capital j. ρ_j is capital gains of intangible capital j. δ_j is the depreciation rate of intangible capital j.

We do not know the value of r, but we know the value of the other variables. We plug equations (5) and (6) into equation (2) and solve for r.

$$Y = \sum_i [r - \rho_i + (1+\rho_i)\delta_i]P_i^{IK} K_i + \sum_j [r - \rho_j + (1+\rho_j)\delta_j]P_j^{IR} R_j + wL$$

$$r = \frac{(Y - wL) - \sum_i [-\rho_i + (1+\rho_i)\delta_i]P_i^{IK} K_i - \sum_j [-\rho_j + (1+\rho_j)\delta_j]P_j^{IR} R_j}{\sum_i P_i^{IK} K_i + \sum_j P_j^{IR} R_j}$$

We plug the value of r into equation (5) and equation (6) to estimate P_i^K and P_j^R, and then plug the values of P_i^K and P_j^R into equation (3) and equation (4) to get the values of α_i and β_j.

(3) Labor Quality.

Hours worked (L) is comprised of hours worked of high-skilled (L_h), medium-skilled (L_m) and low-skilled labor (L_l).

$$L = L_h + L_m + L_l$$

We break down the contribution of labor into the contribution of hours worked ($\Delta \ln(L)$) and the contribution of labor quality ($\Delta \ln(L^{QA})$).

$$\Delta \ln(L \cdot L^{QA}) = \Delta \ln(L) + share_h \Delta \ln(L_h / L) + share_m \Delta \ln(L_m / L) + share_l \Delta \ln(L_l / L),$$

where $share_h = \dfrac{w_h L_h}{w_h L_h + w_m L_m + w_l L_l}$,

$share_m = \dfrac{w_m L_m}{w_h L_h + w_m L_m + w_l L_l}$, and

$share_l = \dfrac{w_l L_l}{w_h L_h + w_m L_m + w_l L_l}$.

(4) Constructing Variables of the Market Sector.

A problem of aggregating industries of the market sector is that we cannot simply add up the real values of the value-added, investment and capital stock across industries. Suppose the market sector Z is made of two industries, X and Y. The nominal value of Z equals the nominal values of X and Y, but the real value of Z may not equal the real values of X and Y.

$$P_z Z = P_x X + P_y Y.$$

$$Z \neq X + Y$$

To estimate the real values of Z, we use the following equation.

$$\Delta \ln(Z) = \frac{P_x X}{P_x X + P_y Y} \Delta \ln(X) + \frac{P_y Y}{P_x X + P_y Y} \Delta \ln(Y)$$

Then we estimate the deflator of the market sector, dividing the nominal value by the estimated real value.

$$deflator_Z = (P_x X + P_y Y) / Z.$$

2. Data sources.

Value-added and labor input. EU KLEMS provides the value-added and labor input by industry. Eight variables of labor input are available—(1) total hours worked, (2) hours worked of high-skilled labor, (3) hours worked of medium-skilled labor, (4) hours worked of low-skilled labor, (5) total labor compensation, (6) compensation of high-skilled labor, (7) compensation of medium-skilled labor and (8) compensation of low-skilled labor.

Investment and stock of tangible assets. EU KLEMS provides the investment and stocks of six tangible assets—(1) computing equipment (IT), (2) communications equipment (CT), (3) transport equipment, (4) other machinery and equipment, (5) total non-resident investment and (6) other assets. We construct three large groups of tangible assets - ICT tangible assets, non-residential buildings and other tangible assets. ICT tangible assets include computing equipment and communications equipment. Non-residential buildings are the EU KLEMS variable of total non-resident investment. Other tangible assets include transport equipment, other machinery and equipment and other assets. We exclude residential structures, because they are not used in production.

Investment and stock of intangible assets. The data source of intangible investment is our estimate. We extend our estimation back to the 1970s, and estimate the stock of each

intangible asset using the perpetual inventory method. An exception is software. EU KLEMS provides the investment and stock data for software.

Deflators and Capital Gains. EU KLEMS provides the deflator of tangible assets. We use the deflator of value-added as the deflator of intangible assets, following CHS (2005). Also following the method of CHS (2006), we use a three-year average of deflators to calculate the capital gains of each asset.

Depreciation rates. EU KLEMS provides the depreciation rates of tangible assets, software and databases. CHS (2005) provides the depreciation rates of intangible assets except software and databases. Table 3 lists the values of depreciation rates.

3. Intangible Assets and Labor Productivity, 1995-2003.

In this section, we carry out growth accounting of the market sector in Germany, France, Italy and Spain, and compare our results with the results of the US and the UK. 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. Market sector is the whole economy excluding public administration, education, health and real estate activities (EU KLEMS, 2008).

(1) Why we include intangible assets.

Including intangible assets is necessary for growth accounting. If we ignore intangible assets, we will under-estimate labor productivity, and over-estimate the contribution of MFP, tangible capital and labor quality to labor productivity. Adding intangible assets increases labor productivity, because intangible investment adds to value-added. Adding intangible assets decreases the contribution of MFP, because the contribution of intangible assets is no longer hidden in MFP. Adding intangible assets decreases the contribution of tangible

capital and labor decreases because their compensation shares decreases. The shares of tangible capital, intangible capital and labor add up to one.

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 higher-skills.

National accounts treat most intangible investment as an intermediate input, not as capital formation. As a result, value-added with intangible investment is usually larger than value-added without intangible investment. Labor productivity is value-added divided by hours worked, so including intangible investment usually increases labor productivity.

From 1995 to 2003, including intangible assets increases the growth rates of labor productivity in the US, the UK, Germany, France, Italy and Spain. The growth rate increases from 2.8% to 3.1% per years in the US (CHS, 2006), increases from 2.6% to 2.9% per year in the UK (MHW, 2007), increases from 1.7% to 1.9% per year in Germany, increases from 2.1% to 2.4% per year in France, increases from 0.4% to 0.6% per year in Italy, increases from 0.2% to 0.3% per year in Spain (Table 4).

From 1995 to 2003 including intangible assets changes MFP growth, and decreases the contribution of tangible capital and labor to productivity growth. MFP growth decreases by 0.3 percentage points in the US (CHS, 2006), 0.1 percentage points in the UK (MHW, 2007), 0.3 percentage points in Germany, 0.4 percentage points in France. It changed from -0.3 percentage points to -0.4 percentage points per year in Italy and changed from -1.00 percentage points to -0.98 percentage points per year in Spain. The contribution of tangible capital (ICT and non-ICT tangible capital) decreases by 0.1 percentage points in the US, 0.1 percentage points in the UK, 0.1 percentage points in Germany, 0.1 percentage points in France, 0.04 percentage points in Italy and 0.1 percentage points in Spain. The contribution of labor quality decreases by 0.05 percentage points in the US, the UK and France, decreased by 0.02 percentage points in Italy, and decreased by 0.03 percentage points in Spain.

To sum up, if growth accounting ignores intangible assets, its results are biased.

(2) International comparison (with intangible assets).

From 1995 to 2003 labor productivity grew the fastest in the US, 3.1% per year on average, followed by the UK (2.9%), France (2.4%), Germany (1.9%), Italy (0.6%) and Spain (0.3%).

Intangible assets contributed substantially to the growth of labor productivity in all six countries. It contributed to 0.9 percentage points in France, 0.8 percentage points in the US, 0.6 percentage points in the UK and Germany, 0.4 percentage points in Italy and 0.2 percentage points in Spain. Economic competency contributes more than software and innovative property to labor productivity in the US and the UK, while innovative property contributes the most to labor productivity in Germany, France, Italy and Spain.

Tangible capital (ICT and non-ICT tangible capital) contributed the most in the UK (1.5 percentage points), followed by Germany (0.9 percentage points), the US (0.8 percentage points), France (0.6 percentage points), Spain (0.6 percentage points) and Italy (0.5 percentage points). Tangible capital contributed to labor productivity mostly because of ICT capital in the US and the UK and mostly because of non-ICT capital in Germany, France, Italy and Spain.

Labor quality contributed the most in Spain (0.5 percentage points), followed by France (0.4 percentage points), the US (0.3 percentage points), the UK (0.3 percentage points), Italy (0.2 percentage points) and Germany (0.1 percentage points). Spain benefited the most from labor quality possible because Spain started with many low-skilled workers and the share of low-skilled workers dropped from 1995 to 2003. In 1995, 69.6% of the labor force (hours worked) of Spain was low-skilled, and in 2003 the share of low-skilled labor dropped to 57%. In contrast, Germany benefited the least from labor quality possibly because Germany had a small number of low-skilled workers in 1995 and the room to decrease the number of

low-skilled workers was small. In 1995, 28.7% of German labor force (hours worked) was low-skilled and that share increased to 30.0% in 2003.

How much did knowledge contribute to the growth of labor productivity? ICT tangible capital, intangible capital and labor quality all reflects progress in knowledge. We sum up the contribution of ICT tangible capital, intangible capital and labor quality. Knowledge contributes more than half of the growth in labor productivity in all countries. Knowledge contributes the most in the UK (1.9 percentage points), followed by the US (1.8 percentage points), France (1.48 percentage points), Germany (1.0 percentage points), Spain (0.9 percentage points) and Italy (0.7 percentage points).

Spillover effects of intangible assets may account for a significant portion of MFP growth. MFP measures the productivity growth unexplained by the growth of capital and labor inputs. If no spillovers exist, after we include intangible assets in growth accounting, the growth of intangible assets should be uncorrelated with MFP growth. Instead of using the growth of intangible assets, we use intangible capital deepening because CHS (2006) and MHW (2007) do not provide the growth rates. Intangible capital deepening is the growth of intangible assets multiplied by its share of compensation in total value-added. Intangible capital deepening is strongly correlated with MFP, implying that intangible assets contribute to MFP through spillovers (Figure 5).

4. The difference before and after 2000.

If we treat years before and after 2000 as one period, we obscure that labor productivity grew at different trends before and after 2000. The growth rate of labor productivity increased before 2000 and plummeted after 2000. The periods we cover are 1995-2000 and 2000-2004.[6] We examine Germany, France, Italy and Spain, and exclude the US and the UK because CHS (2006) and MHW (2007) do not provide the estimates of the US and the UK of the same periods.

[6] We would like to analyze the periods before 1995, but we have no data on the stock of intangible capital.

Adding intangible investment to value added increases the *growth rate* of labor productivity when intangible investment is expanding rapidly, and decreases the *growth rate* of labor productivity when intangible investment is slowing down. When intangible investment grew fast before 2000, it would raise the growth rate of labor productivity (Table 5 and Table 6). When intangible investment slowed down after 2000, it would depress the growth rate of labor productivity in Italy and Spain.

As to the input contribution to labor productivity, including intangible assets decreases the contribution of ICT tangible capital, non-ICT tangible capital, labor quality and MFP.

Table 7 reports the results of growth accounting using intangible assets. Labor productivity plummets from the first to the second period in Germany, France and Italy, but increased slighted in Spain. In all countries before and after 2000, the contribution of intangible assets to labor productivity is substantial. Before 2000 it contributes to 0.6 percentage points of annual growth of labor productivity in Germany, 1.0 percentage points in France, 0.5 percentage points in Italy, and 0.2 percentage points in Spain. After 2000 the contribution of intangible assets still remains strong in Germany, France and Spain, but plummeted in Italy.

We estimate the contribution of three groups of intangible assets. Innovative property contributed the most to labor productivity in Germany (0.4 percentage points), Italy (0.2 percentage points) and Spain (0.2 percentage points) before 2000, and contributed the most in all four countries after 2000 (0.3 in Germany, 0.3 in France, 0.1 in Italy and 0.2 in Spain). Computerized information decreases it contribution in all four countries. Economic competency increases its contribution in Germany and Spain, and decreases its contribution in France and Italy.

The contribution of ICT assets follows a similar pattern as intangible assets. It is strong before 2000 and decreased after 2000 in all countries. The contribution of non-ICT tangible capital is slightly below the contribution of intangible assets before 2000, and remained

strong after 2000. The contribution of labor quality increased in Germany and Italy, but decreased in France and Spain.

How much did knowledge contribute to the growth of labor productivity? ICT tangible capital, intangible capital and labor quality all reflects progress in knowledge. We sum up the contribution of ICT tangible capital, intangible capital and labor quality. Knowledge contributes more than half of the growth in labor productivity in all countries both before and after 2000. Before 2000 knowledge contributes the most in France (1.7 percentage points), followed by Spain (1.1 percentage points), Germany (0.9 percentage points) and Italy (0.9 percentage points). After 2000 knowledge contributes the most in Germany (1.0 percentage points), followed by France (1.0 percentage points), Spain (0.8 percentage points) and Italy (0.3 percentage points).

MFP measures the productivity growth unexplained by the growth of capital and labor inputs. In the first period, France and Germany have the largest MFP (0.8 percentage points), followed by Italy (0.2) and Spain (-0.9). In the second period, MFP decreased and turned negative in all countries. Italy has the largest negative MFP (-1.2 percentage points), followed by Spain (-0.9), Germany (-0.05) and France (-0.03). The large negative MFPs in Italy and Spain imply that investing in tangible assets was unsuccessful to boost productivity.

IV. Conclusion

We estimate that Germany, France, Italy and Spain respectively invested 7.1%, 8.8%, 5.2% and 5.2% of GDP in intangible assets in the market sector in 2004, compared to 12.1% in the US in 2003 (CHS, 2005) and 10.1% in the UK in 2004 (MHW, 2007). Countries differ in how heavily they invest in intangible assets. The US, the UK and France invest more in intangible assets than tangible assets, Germany invest slightly less in intangible assets than tangible assets, and Italy and Spain invest much less in intangible assets than tangible assets.

Intangible assets contribute to the growth of labor productivity through increased capital input and through spillovers into MFP. As to increased capital input, we estimate that intangible assets contribute to 0.9 percentage points of the growth of labor productivity in France from 1995 to 2003, 0.6 percentage points in Germany, 0.4 percentage points in Italy and 0.2 percentage points in Spain. As to spillovers, we are unable to estimate the magnitude, but Figure 5 shows a strong relationship between MFP and intangible capital deepening.

A better understanding of MFP calls for research on the spillovers of intangible assets. Our findings imply that the spillover of intangible assets drives MFP. Research on intangible assets also calls for a standardized measure of intangible assets across countries. Because intangible assets are a new research field, national statistical offices have no data on most intangible assets, and researchers end up using data from different sources for different intangible assets and for different countries. Different data sources lead to different estimates of intangible investment.

This paper studies intangible assets at the national level, while within the same country some industries invest more in intangible assets than other industries. For example, pharmaceutical industries invest heavily in intangible assets. Bayer invested 2.6 trillion Euros in research and development in 2007 (Bayer Annual Report, 2007). In the future, we aim to measure intangible investment at the *industry* level and carry out growth accounting at the *industry* level. 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: Spending on Intangible Assets in the Market Sector (% GDP)

Type of Expenditure	Germany 2004	France 2004	Italy 2004	Spain 2004	UK 2004	US 1998-2000
1. Computerized information	**0.71**	**1.31**	**0.66**	**0.74**	**1.70**	**1.65**
a) Software	0.69	1.27	0.66	0.72		
b) Databases	0.02	0.04	0.01	0.03		
2. Innovative property	**3.47**	**3.12**	**2.26**	**2.51**	**3.23**	**4.57**
a) R&D, including social sciences and humanities	1.69	1.32	0.52	0.55	1.09	2.06
b) Mineral exploration and evaluation	0.00	0.02	0.04	0.04	0.04	0.19
c) Copyright and license costs	0.20	0.32	0.10	0.19	0.21	0.81
d) Development costs in financial industry	0.70	0.58	0.79	0.35	0.69	0.79
e) New architectural and engineering designs	0.87	0.88	0.80	1.38	1.2	0.73
3. Economic competencies	**3.27**	**5.22**	**2.67**	**2.19**	**5.95**	**6.91**
a) Brand equity	0.84	1.51	1.19	0.58	1.59	2.53
Advertising expenditure	0.69	1.24	0.91	0.33	1.2	2.33
Market research	0.15	0.27	0.28	0.25	0.39	0.2
b) Firm-specific human capital	1.34	1.51	1.00	0.83	2.45	1.25
Continuing vocational training	0.67	1.25	0.69	0.73		
Apprentice training	0.67	0.26	0.31	0.11		
c) Organizational structure	1.09	2.21	0.48	0.78	1.92	3.13
Purchased	0.50	0.31	0.11	0.25	0.6	0.87
Own account	0.59	1.90	0.37	0.53	1.31	2.26
Total Spending	**7.45**	**9.65**	**5.58**	**5.44**	**10.88**	**13.13**
Total Investment	**7.05**	**8.77**	**5.15**	**5.20**	**10.1**	**11.7**

Sources: The source of the US is CHS (2005). The source of the UK is MH(2006). For Germany, France, Italy and Spain, we use a wide range of data sources including national accounts, surveys of statistical offices, surveys of trade associations and corporate financial reports. For more details on data sources, please see Appendix 1.
Note: To convert spending into investment, 60% of expenditure on advertisement, 80% of expenditure on own-account organizational structure and 100% of all the other expenditure are investment (CHS, 2005).

Table 2: Composition of Intangible Investment (% of total intangible investment)

	Germany			France			Italy			Spain		
	Comp Info	Innov Prop	Econ Comp	Comp Info	Innov Prop	Econ Comp	Comp Info	Innov Prop	Econ Comp	Comp Info	Innov Prop	Econ Comp
1991	8.45	44.12	47.42	8.55	35.45	56.00	12.64	42.38	44.98	11.32	39.03	49.65
1992	8.36	43.43	48.20	8.88	35.81	55.30	11.37	47.19	41.44	10.54	38.53	50.92
1993	8.17	43.74	48.09	7.79	36.35	55.87	11.26	46.49	42.24	10.19	38.44	51.36
1994	8.19	43.99	47.81	8.49	37.18	54.33	11.81	45.62	42.57	11.14	37.09	51.77
1995	8.27	44.36	47.37	8.78	36.84	54.39	12.04	45.42	42.54	11.96	36.65	51.39
1996	8.71	44.11	47.18	9.46	36.07	54.47	13.01	42.47	44.52	12.58	36.57	50.85
1997	9.21	44.90	45.89	11.52	35.24	53.24	12.55	44.70	42.75	12.43	36.50	51.06
1998	9.67	45.74	44.58	13.25	35.41	51.35	12.83	41.02	46.14	12.82	36.42	50.76
1999	9.88	46.33	43.79	15.84	34.14	50.02	13.51	41.19	45.30	14.43	46.07	39.50
2000	10.33	49.00	40.67	15.26	32.81	51.94	13.24	40.03	46.73	14.03	43.97	41.99
2001	10.52	48.15	41.34	16.39	33.59	50.02	14.06	40.98	44.96	15.28	44.38	40.34
2002	10.08	48.13	41.79	15.86	34.87	49.27	13.27	41.29	45.45	14.85	46.46	38.69
2003	9.94	48.78	41.28	15.00	35.90	49.10	12.78	43.03	44.20	14.72	46.91	38.37
2004	10.07	49.14	40.79	14.92	35.52	49.55	12.86	43.83	43.31	14.30	48.15	37.55

Sources: We use a wide range of data sources including national accounts, surveys of statistical offices, surveys of trade associations and corporate financial reports. For more details of data sources, please see Appendix 1.

Table 3: Depreciation Rates

Assets	Depreciation Rates
Intangible Assets	
Software	0.315
Databases	0.315
R&D	0.2
Mineral exploration and evaluation	0.2
Copyright and license costs	0.2
Development costs in financial industry	0.2
New architectural and engineering designs	0.2
Advertising expenditure	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	0.189
Other machinery and equipment	0.126
Non-resident structures	0.031
Other assets.	0.126

Sources: EU KLEMS provides the depreciation rates of tangible assets, software and databases. CHS (2005) provides the depreciation rates of intangible assets except software and databases.

Table 4: 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	1.72	2.10	0.43	0.20
Contribution of Inputs						
ICT tangible capital deepening (ex. software)	0.70	1.13	0.34	0.21	0.19	0.27
Non-ICT tangible capital deepening	0.28	0.51	0.64	0.56	0.35	0.40
Labor Quality	0.38	0.36	0.08	0.40	0.17	0.53
MFP	1.42	0.58	0.65	0.93	-0.28	-1.00
	Including Intangible Capital (%)					
Labor productivity growth	3.09	2.93	1.90	2.39	0.59	0.28
Contribution of Inputs						
ICT tangible capital deepening (ex. software)	0.60	1.02	0.30	0.18	0.18	0.24
Non-ICT tangible capital deepening	0.24	0.52	0.55	0.45	0.32	0.34
Intangible Capital deepening	0.84	0.59	0.59	0.88	0.35	0.18
Labor Quality	0.33	0.31	0.08	0.35	0.15	0.50
MFP	1.08	0.48	0.39	0.54	-0.40	-0.98
Software	0.27	0.18	0.10	0.23	0.04	0.07
Innovative Property	0.22	0.14	0.38	0.34	0.16	0.23
Economic Competency	0.35	0.26	0.11	0.30	0.14	-0.11

Sources: The source of the US is CHS (2005). The source of the UK is MHW (2007). For Germany, France, Italy and Spain, the sources are EU KLEMS, CHS (2005), and our estimates of intangible investment. EU KLEMS provides the investment, stock, deflators and depreciation rates of tangible assets and the depreciation rates of software and databases. CHS (2005) provides the deflators of all intangible assets and the depreciation rates of intangible assets excluding software and databases. We estimate intangible investment using national accounts, surveys of statistical offices, surveys of trade associations and corporate financial reports.

Table 5: Growth Accounting without Intangible Assets, 1995-2000 and 2000-2004

	1995-2000				2000-2004			
	Germany	France	Italy	Spain	Germany	France	Italy	Spain
Annual growth rate of labor productivity of the business sector	1.95	2.46	1.13	0.07	1.40	1.35	-0.45	0.57
Contribution of Inputs								
ICT tangible capital deepening (ex. Software).	0.41	0.25	0.28	0.38	0.26	0.17	0.10	0.14
Non-ICT tangible capital deepening	0.60	0.44	0.32	0.14	0.58	0.53	0.43	0.77
Labor Quality	-0.04	0.59	0.14	0.62	0.29	0.28	0.18	0.46
MFP	0.98	1.17	0.39	-1.06	0.27	0.37	-1.16	-0.79

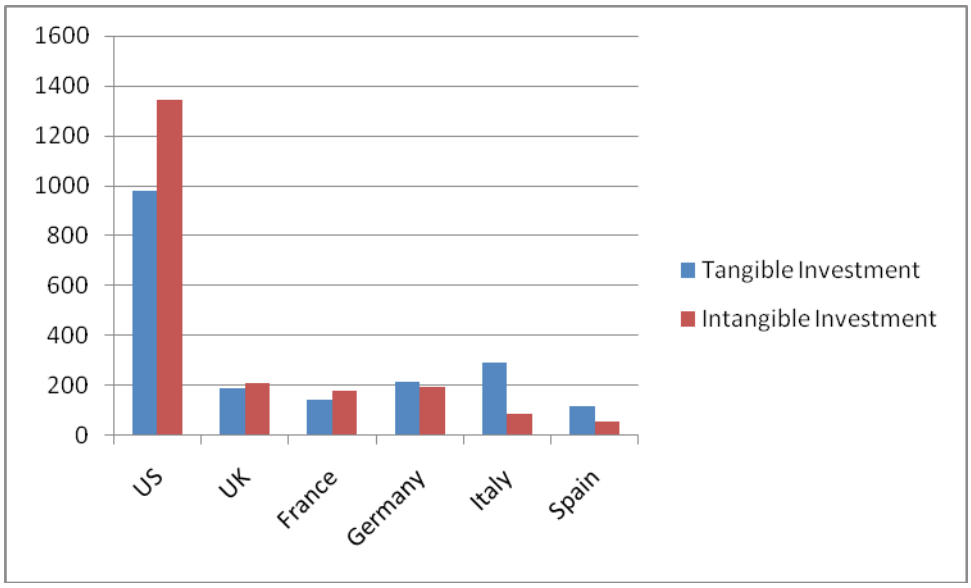
Sources: EU KLEMS provides the investment, stock, deflators and depreciation rates of tangible assets and the depreciation rates of software and databases. CHS (2005) provides the deflators of all intangible assets and the depreciation rates of intangible assets excluding software and databases. We estimate intangible investment using national accounts, surveys of statistical offices, surveys of trade associations and corporate financial reports.
Note: All values are for the market sector.

Table 6: Growth Accounting with Intangible Assets, 1995-2000 and 2000-2004

	1995-2000				2000-2004			
	Germany	France	Italy	Spain	Germany	France	Italy	Spain
Annual growth rate of labor productivity of the business sector	2.18	2.91	1.39	0.30	1.44	1.39	-0.49	0.50
Contribution of Inputs								
ICT tangible capital deepening (ex. Software)	0.37	0.21	0.26	0.34	0.23	0.14	0.09	0.13
Non-ICT tangible capital deepening	0.52	0.36	0.29	0.13	0.49	0.41	0.39	0.67
Intangible Capital deepening	0.56	0.98	0.46	0.19	0.52	0.62	0.08	0.20
Labor Quality	-0.04	0.52	0.13	0.57	0.26	0.24	0.16	0.42
MFP	0.78	0.84	0.24	-0.93	-0.05	-0.03	-1.22	-0.91
Software	0.10	0.25	0.05	0.07	0.08	0.17	0.02	0.06
Innovative Property	0.38	0.35	0.18	0.21	0.32	0.30	0.10	0.22
Economic Competency	0.08	0.38	0.23	-0.09	0.11	0.16	-0.04	-0.08

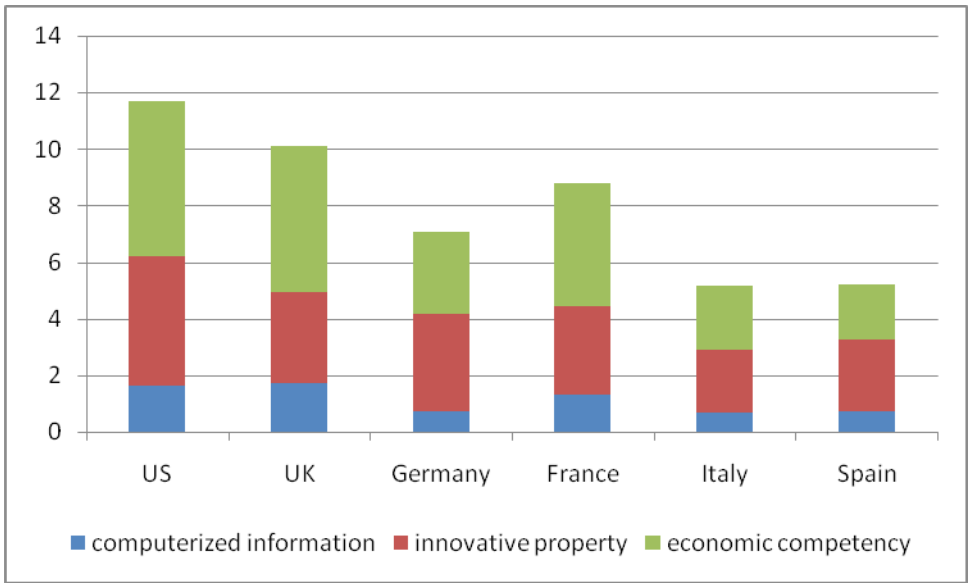
Sources: EU KLEMS provides the investment, stock, deflators and depreciation rates of tangible assets and the depreciation rates of software and databases. CHS (2005) provides the deflators of all intangible assets and the depreciation rates of intangible assets excluding software and databases. We estimate intangible investment using national accounts, surveys of statistical offices, surveys of trade associations and corporate financial reports.
Note: All values are for the market sector.

Figure 1: Intangible and Tangible Investment in 2004 ($billion, current prices)



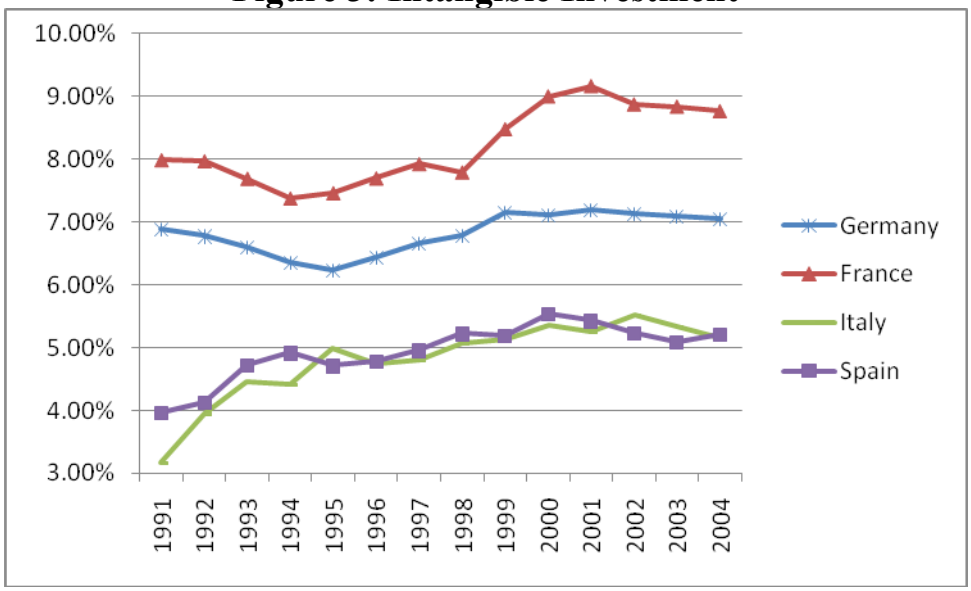
Note: The values of the US are the averages of 2000-2003.
Sources: The source of the US is CHS (2005). The source of the UK is MH (2006). For Germany, France, Italy and Spain, we use a wide range of data sources including national accounts, surveys of statistical offices, surveys of trade associations and corporate financial reports. For more details of data sources, please see Appendix 1.

Figure 2: Intangible Investment in the Market Sector (% GDP, 2004)



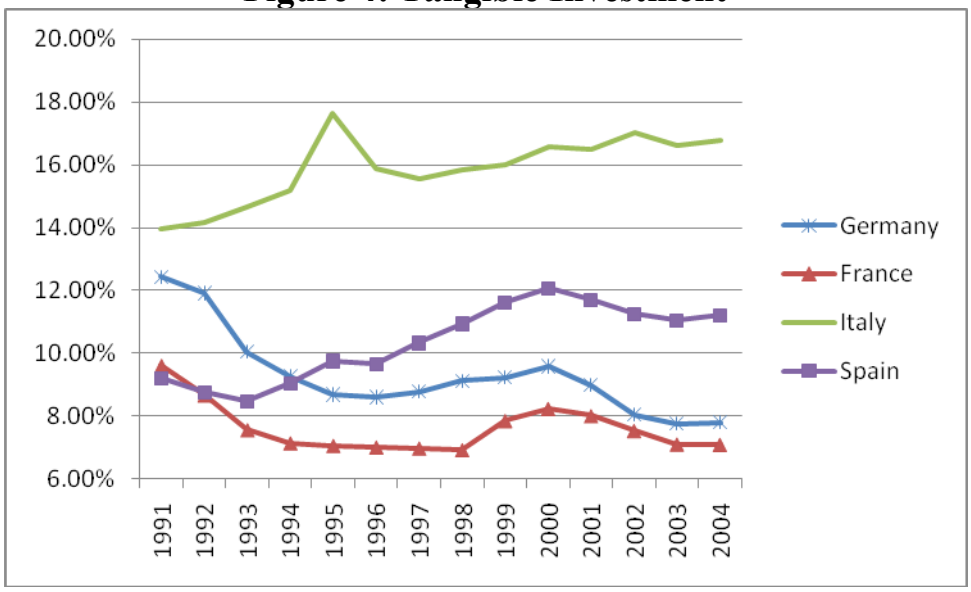
Note: The values of the US are the averages of 2000-2003.
Sources: The source of the US is CHS (2005). The source of the UK is MHW (2007). For Germany, France, Italy and Spain, we use a wide range of data sources including national accounts, surveys of statistical offices, surveys of trade associations and corporate financial reports. For more details of data sources, please see Appendix 1.

Figure 3: Intangible Investment



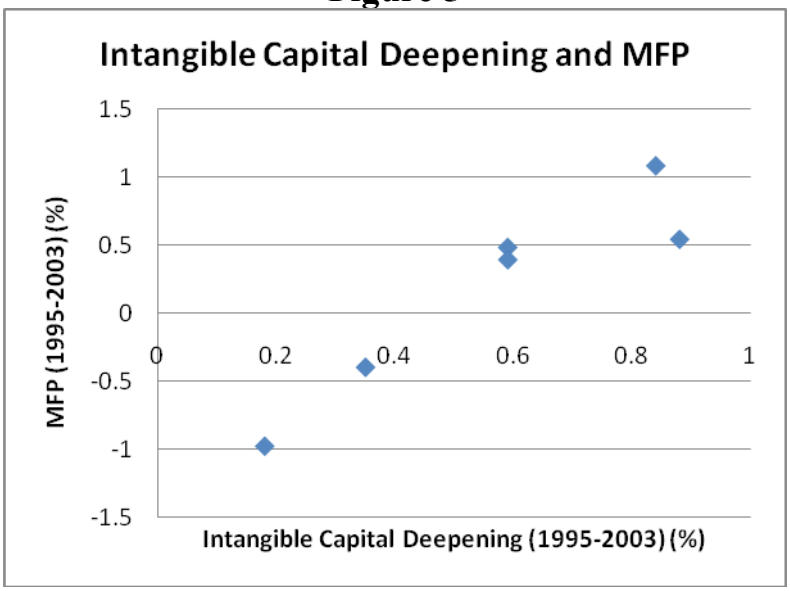
Sources: We use a wide range of data sources including national accounts, surveys of statistical offices, surveys of trade associations and corporate financial reports. For more details of data sources, please see Appendix 1.
Note: The values are for the market sector.

Figure 4: Tangible Investment



Source: EU KLEMS.
Note: the values are for the market sector.

Figure 5



Source: CHS (2006), MHW (2007) and our estimates.
Note: The six countries are the US, the UK, Germany, France, Italy and Spain. We use intangible assets in growth accounting to estimate MFP. Intangible capital deepening is the annual growth rate of intangible assets multiplied by its share of compensation.

Appendix 1: Measuring Investment in Intangible Assets

I. Spending on Intangible Assets in 2004.

This section estimates how much Germany, France, Italy and Spain spent on intangible assets in the *market sectors* in 2004.

1. Computerized information

The major component of computerized information is software. Germany, France, Italy and Spain respectively spent 0.69%, 1.27%, 0.66% and 0.72% of GDP on software in the market sector in 2004 (Table 1). The other component of computerized information is databases. Germany, France, Italy and Spain respectively spent 0.02%, 0.04%, 0.01% and 0.03% of GDP on databases in the market sector in 2004.

(1) Computer Software

The data source is EU KLEMS. EU KLEMS provides the estimates of the investment and stocks for eight 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. To estimate how much the market sector invested in software, we exclude how much the public sector invested in software by industry[7]. Since EU KLEMS provides how much each industry invested in software, we aggregate industries of the market sector to estimate how much the market sector invested in software.

We estimate that Germany, France, Italy and Spain respectively spent 0.69%, 1.27%, 0.66% and 0.72% of GDP on software in the market sector in 2004 (Table 1). In million Euros (current prices), Germany, France, Italy and Spain respectively spent 15,331 million Euros, 21,025 million Euros, 9,127 million Euros and 6,042 million Euros in software in the market sector (Table 2).

Robustness Check

German national accounts provide that the public and market sector of Germany invested 19,190 million Euros in software in 2004, slightly larger than what EU KLEMS estimates (18,720 million Euros). So we might have slightly under-estimated how much Germany invested in software.

(2) Computerized 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 Classification

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

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 investment in the market sector, we exclude 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, the public sector accounts for 2.00% of the total use of the products of Computer and Related Services (NACE 72) in 2001.

We estimate that Germany, France, Italy and Spain respectively invested 0.02%, 0.04%, 0.01% and 0.03% of GDP in databases in the market sector in 2004 (Table 1). In million Euros (current prices), Germany, France, Italy and Spain respectively invested 373 million Euros, 709 million Euros, 77 million Euros and 214 million Euros in databases (Table 2).

Robustness Check

Our estimation is smaller than that of 2004 OECD Software Survey. The 2004 OECD Software Survey covers 13 countries, including Germany and Italy but excluding France and Spain. It collects data on intermediate consumption of computerized information (software and databases), and investment in own-account and purchased computerized information. It estimates that the private and public sectors of Germany invested 0.9% of GDP in software and databases in 2003, while we estimate the private and public sectors of Germany invested 0.85% of GDP in software and databases in 2004. OECD surveys estimates that the private and public sector of Italy invested 1.5% of GDP in software and databases in 2003, while we estimate they invested 0.76% of GDP in 2003.

2. Innovative property

Innovative property is the expenditure that leads to a patent, copyright or license, or the acquisition of new resources (CHS, 2005). 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. 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. We estimate that Germany, France, Italy and Spain respectively spent 3.47%, 3.12%, 2.26% and 2.51% of GDP on innovative property in 2004 (Table 1).

(1) R&D

Our data source for R&D is EUROSTAT. EUROSTAT provides R&D expenses from 1981 to 2004, including both natural science and social science. EUROSTAT breaks the sectors of R&D performance into four categories—business enterprise sector, government sector, higher education sector, and private non-profit sector. To measure how much market sectors spent R&D, we exclude expenditure by government and higher education sector.

We exclude R&D in software industry to avoid double-counting[8]. 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. After excluding software, we estimate that the market sector of France spent 1.32% of GDP or 21,859 million Euros (current prices) on R&D in 2004.

Similarly, we exclude R&D in software industry for Germany, Italy and Spain, and estimate that the market sector of Germany spent 1.69% of GDP or 37,445 million euros (current prices), Italy spent 0.52% of GDP or 7,288 million euros, and Spain spent 0.55% of GDP or 4,615 million Euros on software investment in 2004.

[8] After excluding software investment, BERD still does not equal R&D investment, because we ignore the imports of, exports of and fixed investment in R&D. R&D investment=BERD+Acquisition of R&D-Fixed investment included in R&D + COFC on fixed investment + Return on fixed investment + Other taxes less other subsidies on production – software + Imports – Exports (Jalava, Ahmavaara and Alanen, 2007). We have no data to adjust R&D investment in the above way.

We should be cautious when we compare R&D expenses across countries. Statistical bureaus of different countries interpret the definitions of each item of R&D differently, and use different survey methodologies (EUROSTAT, 2008). Moreover, because some R&D is carried out by multi-national companies, we may include, for example, some R&D located in Germany by France companies as R&D located in France.

(2) Mineral explorations

We use national account to measure oil and gas exploration costs for Germany, and use company financial reports for France, Italy and Spain. For Germany, the national accounts provide that Germany spent 110 million Euros on drilling exploration in 2004. For France, the largest oil and gas company, Total S.A. spent 374 million Euros on exploration in 2004. For Italy, ENI is the largest oil and gas company of Italy. It spent 499 million Euros on exploring oil and gas fields. For Spain, Repsol is the largest oil and gas company of Spain. It spent 309 million Euros on exploring oil and gas fields. We might have under-estimated the exploration costs for France, Italy and Spain, because we might have exclude how much small companies spent on exploring oil and gas fields. We estimate that Germany spent 0.005% of GDP on exploring costs, France spent 0.02% of GDP, and Italy and Spain respectively spent 0.04% of GDP.

(3) Copyright and license costs

For Germany, the national accounts provide that Germany spent 4,940 million Euros on copyright. For France, Italy and Spain, we have no data to directly measure copyright and license costs. We modify the method of CHS (2005) to estimate them. CHS (2005) estimate that the total copyright and license costs are three times the development costs of motion pictures. We modify the threes times to five times, because we find that copy right and license costs are five and a half times the development costs of motion pictures in Germany,

and are four and a half times in the UK. We get copyright and license costs of the UK and Germany from national accounts. We take average of the ratios of Germany and the UK, and assume that in France, Italy and Spain, copyright and license costs are five times the development costs of motion pictures.

Our data source of France, Italy and Spain is Screen Digest (2005). Screen Digest is a London-based research institute on audiovisual media. Screen Digest provides the production costs for 59 countries from 2000 to 2005. The US invested $14,716 million in 2004 and accounted for 64.8% of the total production costs in the world. The UK is the biggest movie investor in Europe, investing $1,479 million (£807 million), followed by France ($1,304 million, or €1,048 million) and German ($993 million, or €798 million). The Netherlands invested $85.1 million (€68.4 million).

We estimate that Germany spent 0.20% of GDP on copyright and licenses in the market sector in 2004, France 0.32%, Italy 0.10% and Spain 0.19%. If we measure investment by million Euros (current prices), Germany spent 4,380 million Euros on copyright and licenses, France 5,240 million Euros, Italy 1,422 million Euros and Spain 1,576 million Euros.

(4) 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)[9].

We assume that 20% of the adjusted intermediate costs equal the costs to develop new products. We estimate that Germany spent 0.70% of GDP on developing new products in the financial sector 2004, France 0.58%, Italy 0.79% and Spain 0.35%. If we measure investment by million Euros (current prices), Germany spent 15,544 million Euros on developing new products in the financial sector in 2004, France 9,666 million Euros, Italy 11,001 million Euros and Spain 2,929 million Euros.

Robustness check

Then we use a different data source to check how accurate our estimates are. The USE tables of EUROSTAT provide the intermediate inputs of the financial sector. After excluding the intermediate inputs from NACE 72 and NACE 74 and multiplying the adjusted costs with 20%, we estimate that Germany spent 17,230 million Euros on developing new products in the financial sector in 2004, France 9,811 million Euros, Italy 7,457 million Euros and Spain 3,338 million Euros. Comparing estimates of EUROSTAT and those of STAN, we might have over-estimated the spending for Italy and under-estimated the spending for Germany, France and Spain.

(5) New Architectural and Engineering Designs

[9] We are over-estimating the double-counted intangible investment. We intend to measure inputs from NACE 72.2, NACE 74.1, NACE 74.2 and NACE 74.4, but since the IO Tables are at the 2-digit level, we end up including other industries as well. Those other industries are NACE 72.2-72.6, NACE 74.3, NACE 74.5-74.8.

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 gross output of NACE 74.2. To avoid double-counting of intangible investment, as we did for the financial industry, we exclude the inputs from software, advertising and consulting (NACE K72 and NACE K74).

We estimate that Germany spent 0.87% of GDP on new architectural and engineering costs, France 0.88%, Italy 0.80% and Spain 1.38%. If we measure investment by million euros, Germany spent 19,140 million Euros on new architectural and engineering designs, France 14,593 million Euros, Italy 11,159 million Euros and Spain 11,645 million Euros.

3. Economic competencies

(1) Brand equity

i) Advertisement

Our data sources are EU KLEMS and World Magazine Trends. EU KLEMS provides the gross output of advertising industry (NACE K744) from 1970 to 2004. We exclude classified advertisement, because it does not increase brand equity. We have no data on classified advertisement and proxy it with half of the advertisement on newspapers. World Magazine Trends provides the share of advertisement in newspapers from 1994 to 2003. For example, France, Germany, and Italy respectively put 21%, 41%, 20% of advertisement on newspapers in 2003, and Spain put 30% of advertisement on newspapers in 2001. We average the percentages of available years and use the average percentage for 2004.

We estimate that Germany spent 0.69% of GDP on brand-forming advertisement, France 1.24%, Italy 0.91% and Spain 0.33%. If we measure spending with million Euros (current

prices), Germany spent 15,268 million Euros on advertisement that increases brand equity, France 20,552, million Euros, Italy 12.626 million Euros and Spain 2,793 million Euros.

Robustness Check

We use another data source to check how accurate our estimates are. The data is Business Services of EUROSTAT. Business Services are available for Germany and Spain in 2004, but unavailable for France and Italy in 2004. SBS provides the turnover of Advertising industry (NACE 744). Turnover is the total output invoiced, including all duties and taxes on and the transport costs of goods and services. We exclude spending on classified advertisement and estimate that Germany spent 12,774 million Euros (current prices) on advertisement in 2004, less than our estimate using EU KLEMS and World Magazine Trends. We estimate that Spain spent 10,502 million Euros on advertisement in 2004, much more than our estimate.

ii) 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. For own-account MR, we follow the assumption in CHS (2005) that own-account market research equals purchased MR. We estimate that Germany spent 3,249 million Euros on MR in 2004, France 4,444 million Euros, Italy 3,861 million Euros and Spain 2,105 million Euros. If we measure market research by percentages of GDP, Germany spent 0.15% of GDP on MR in 2004, France 0.27%, Italy 0.28% and Spain 0.25%.

Robustness Check

We use another data source for robustness check. That data is a survey in 2003 provided by the European Society for Opinion and Market Research (ESOMAR). ESOMAR estimates that France, Germany and Italy respectively spent 1,374 million euros[10] (current prices),

[10] The original data are in US dollars. We use the exchange rate between euros and US dollars in June 2003.

1,569 million euros and 678 million Euros on purchased market research. We double the estimate of ESOMAR to include own-account market research. We estimate that Germany, France and Italy respectively spent 0.14%, 0.18% and 0.05% of GDP on market research in 2003. All are smaller than our measures.

(2) Firm-specific human capital.

We measure how much firms spent on firm-specific human capital, using spending on vocational training. Vocational training includes initial vocational training and continuing vocational training. Initial vocational training is apprentice training (AT)[11]. Continuing vocational training (CVT) includes training courses, training at work places, training through job rotation, self-learning and learning at conferences, lectures and workshops. We measure apprentice training, because excluding it will under-estimate how much Germany spent on vocational training. Unlike the United States, Germany uses apprentice training extensively —5% of workers in Germany are apprentices, while only 0.3% of workers in the U.S. are apprentices.

Our major data sources of AT and CVT are (1) Labor Cost Survey (LCS) 2004, provided by EUROSTAT, (2) Continuing Vocational Training Survey (CVTS) 2005, provided by EUROSTAT, and (3) labor compensations, provided by EU KLEMS. LCS 2004 provides the wages, salaries of apprentices, and social benefits paid by employers for apprentices, as a percentage of total labor costs. It excludes firms with less than 10 employees and excludes industries such as agriculture, fishery and public sector. 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). CVTS 2005 include forgone hours as indirect costs. EU KLEMS

[11] Initial vocational training includes apprentice training and full-time schooling. Since firms do not pay for full-time schooling, we exclude it.

provides labor compensation, and LCS 2004 provides labor compensation as a percentage of labor costs. Using those two data sources, we calculate labor costs[12].

LCS 2004 provides that Germany spent 1.29% of labor costs on AT, followed by Italy (0.76%), France (0.47%) and Spain (0.12%). CVTS 2005 provides that France spent 2.3% of labor costs on CVT, followed by Italy (1.7%), Spain (1.5%) and Germany (1.3%). Adding up the costs of AT and CVT, we estimate that Germany spent 2.59% of labor costs on firm-specific human capital, France 2.77%, Italy 2.46% and Spain 1.62%.

In percentages of GDP, we estimate that Germany spent 1.34% of GDP on firm-specific human capital, France 1.51%, Italy 1.00% and Spain 0.83%. In million Euros, we estimate that Germany spent 29,673 million Euros on firm-specific human capital, France 24,986 million Euros, Italy 13,876 million Euros and Spain 7,005 million Euros.

(3) Organizational structure

i) Purchased organizational structure.

Investment in organizational structure (OS) includes investment in purchased and own-account OS. We measure purchased OS with the revenues of management consulting. 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 and fifteen sectors. The five classes of management consultancy are operations management, information technology, corporate strategy services, human resources management and outsourcing services. The fifteen sectors include eleven private sectors and four public sectors—non-profit and

[12] Total labor costs=labor compensation / labor compensation as a percentage of total labor costs.

government sector, the European Union, aerospace and defense sector, and healthcare and pharmaceutical sector.

To estimate how much the market sector spent on MC, we exclude public expenditure. FEACO provides the percentages of the public sector from 1999 to 2003 for France and from 1998 to 2004 for Germany, Italy and Spain. The public sector accounted for 16.4% of total MC in Germany, 18.1% in Italy and 24.9% for Spain in 2004. The public sector on average accounted for 13.1% of total MC spending in France from 1999-2003. So we exclude 16.4% of MC for Germany, 13.1% for France, 18.1% for Italy and 24.9% for Spain in 2004.

We estimate that Germany spent 0.50% of GDP on MC in 2004, France 0.31%, Italy 0.11% and Spain 0.25%. If we measure investment with million Euros, Germany spent 11,077 million Euros on MC in 2004, France 5,127 million Euros, Italy 1,597 million Euros and Spain 2,103 million Euros.

Robustness Check

We use another data source to check how accurate our estimates are. The Structural Business Statistics of EUROSTAT provides the turnover of Business and Management Consultancy Activities (NACE K74.1.4)[13] in Germany and Spain. The total turnover is 16,326 million euros in 2004 in Germany, much larger than the FEACO estimate of 13,250 million euros. The total turnover is 3,029 million Euros in Spain, larger than the FEACO estimate of 2,103 million Euros. So we might have under-estimated the spending on MC.

[13] NACE 74.1.4 includes (1) General management consulting services, (2) Financial management consultancy, (3) Marketing management consulting services, (4) Human resources management consulting services, (5) Production management consulting services, (6) Public relations services, (7) Other management consulting services, (8) Project management services other than for construction, (9) Arbitration and conciliation services, and (10) Other management related services. (source: Hertzman, Cecilia, Daniel Lennartsson and Pekka Alajaasko, 2004).

ii) 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 number of employees and the annual earnings by 9 occupational categories in 2002. The occupation we use for managers is "Legislators, Senior Officials and Managers".

We estimate the total earnings of Legislators, Senior Officials and Mangers. The number of legislators, senior officials and managers is 486,006 in Germany, 909,806 in France, 100,952 in Italy and 157,728 in Spain in 2002. The average annual earning of legislators, senior officials and managers is 66,638 Euros in Germany, 58,209 Euros in France, 85,785 Euros in Italy and 55,322 Euros in Spain in 2002. We assume that managers spend 20% of their time improving organizational structure, so we measure spending on own-account OS with 20% of managers' compensation.

We estimate that Germany spent 0.59% of GDP on own-account organizational structure in 2004, France 1.90%, Italy 0.37% and Spain 0.53%. If we measure spending with million Euros, Germany spent 13,058 million Euros on own-account organizational structure in 2004, France 31,596 million Euros, Italy 5,108 million Euros and Spain 4,430 million Euros.

The estimation is rough. First, we do not know the exact percentage of time that managers spent on improving organizational structure. Second, we under-estimate how much Germany spent on own-account organizational structure, because Germany has a narrower definition of managers than France[14]. In France, "Legislators, Senior Officials and Managers" accounted

[14] Source: Emails with Ms. Corina Neuerer at the Federal Statistical Office of Germany. She said that Germany does not classify occupations strictly with International Standard Classification of Occupations, and thus Germany had a narrower definition of managers than France.

for 9 % of the labor force, while in Germany, they accounted for only 3% of labor force (SES, 2002). Third, earnings of managers miss other aspects of organizational structure. For example, Bloom and van Reenen (2007) survey 715 medium-size manufacturing firms in the U.S, the UK, France and Germany, and find that the US has the best management, followed by Germany, France and the UK. Their argue that partly because many French firms practice primogeniture (succession to the oldest son), French firms have worse management than German firms. Even though our estimation is rough, we still believe that it is better to roughly estimate own-account OS than to completely ignore it.

II. Investment in Intangible Assets in 2004.

If the spending benefits the spenders for more than one year, the spending is an investment (CHS, 2005). 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 are investment. Moreover, freely available goods should not be treated as investment. So RBT (2008) exclude public investment in R&D. We follow the methods of CHS (2005) and RBT (2008), and estimate that Germany invested 7.05% of GDP in intangible assets in the market sector in 2004, France 8.77%, Italy 5.15% and Spain 5.20%, roughly 0.2 to 0.9 percentage point lower than spending as a percentage of GDP.

We measure intangible investment roughly. First, we ignore imports and exports of R&D, architectural and engineering designs, market research and management consulting, because we have no data on the imports and exports of those intangible assets. Jalava, Ahmavaara and Alanen (2007) use imports, exports, fixed investment in R&D to adjust the R&D spending of BERD for Finland in 2005. They estimate that Finland invested 4275.4 million Euros in R&D in 2005, 398.5 million Euros larger than the unadjusted estimation. Second, we have no evidence that the financial industry spend 20% of their intermediate costs on developing new products or that managers spent 20% of their time improving on organizational structure. As rough as our estimates are, measuring intangible investment roughly is better than ignoring it completely.

III. Time Series.

We construct the time series of selected intangible assets from 1991 to 2004. Constructing time series is hard, mostly because some historical data are unavailable. For example, German statistical office did not collect information on the number and earnings of managers until after 1998. We present the time series of software, R&D, development costs in financial industry, advertisement, market research and management consulting.

Software investment

The data source is EU KLEMS. EU KLEMS provides software investment by industry from 1991 to 2005 for Germany and from 1970 to 2005 for France, Italy and Spain. We aggregate industries of the market sector to estimate how much the market sector invested in software.

Software investment increased by 0.39% of GDP in France, 0.27% in Italy, 0.26% in Spain and 0.13% in Germany from 1991 to 2001. After 2001, software investment declined in all four countries.

Databases

The data source is EU KLEMS. EU KLEMS provides the output of database activities (NACE 724) from 1970 to 2004.

R&D

The BERD of EUROSTAT provides how much business enterprise spends on R&D from 1981 to 2004 for Germany, France, Italy and Spain. We treat all business enterprise spending as investment in R&D. Germany and France invested more than 1.1% of GDP in R&D every year from 1991 to 2004, while Italy and Spain invested less than 0.7% of GDP every year from 1991 to 2001 (Figure 2). In particular, Germany is the largest R&D investor every year.

Mineral Exploration

The national accounts of Germany provide mineral exploration from 1991 to 2004. The financial reports of the largest oil and gas companies in France, Italy and Spain provide exploration costs for several years. I predict the missing years using a simple time trend.

Copyright and License Costs

Screen Digest provides movie investment from 2000 to 2004. EU KLEMS provides the output of motion picture and video activities (NACE 921) from 1970 to 2004. The ratio of movie investment to the output of NACE 921 is 0.34 on average from 2000 to 2004. We assume that the ratio is 0.34 before 2000 and estimate movie investment before 2000. Copyright and license costs are five times the movie investment.

Development Costs in Financial Industry

The data source is OECD STAN database and EU KLEMS. STAN provides the development costs in financial industry from 1991 to 2003 in Germany, from 1978 to 2003 in France, from 1970 to 2003 in Italy and from 1995 to 2000 in Spain. EU KLEMS provides the output of financial industry from 1970 to 2004 for all four countries. For Germany, France and Italy, we assume that the ratio of intermediate inputs to gross output stays the same from 2003 to 2004. As to Spain, we take the average ratio of intermediate costs to output from 1995 to 2000, and estimate the intermediate costs for the other years multiplying that average ratio with the output of those years. Then we exclude inputs from software and advertisement to avoid double-counting. We estimate that Italy expanded development costs by 0.48% of GDP from 1991 to 2004, followed by Germany (0.26%), France (0.07%) and Spain (0.04%).

New Architectural and Engineering Designs

The data source is EU KLEMS and EUROSTAT. EU KLEMS provides the output of Architectural, Engineering and Other Technical Activities (NACE 74.2). EUROSTAT

provides Input-Output tables of various years. Input-Output tables provide how much NACE 74.2 use inputs from other industries. We calculate the ratio of the input from the software industry and the business service industry to total input of NACE 74.2, take the average, and use that average ratio for all years. We exclude how much input NACE 74.2 used from the software industry and the business service industry to avoid double-counting software investment and advertisement investment.

All countries expanded investment in new architectural and engineering costs from 1991 to 2004. Investment was smooth in Germany and France and volatile in Italy and Spain. Germany invested 0.80% of GDP in 1991 and 0.87% in 2004. France invested 0.70% of GDP in 1991 and 0.88% in 2004. In contrast, Spain and Italy rapidly changed the investment over the years. Spain invested 0.86% of GDP in 1998, 1.39% in 1999 and 1.38% in 2004. Italy invested 0.32% of GDP in 1991, 1.12% in 1995 and 0.80% in 2004.

Advertisement

We measure investment in advertisement using 60% of the output of advertising industry from 1991 to 2004, excluding from output classified advertisement that is not brand-forming. We measure classified advertisement with half of the advertisement in newspapers. Data sources are EU KLEMS and World Magazine Trends. EU KLEMS provides the output of advertising industry (NACE K744) from 1970 to 2004. World Magazine Trends provides the percentages of advertisement in newspapers from 1993 to 2003 for Germany, from 1994 to 2003 for France and Italy, and from 1992 to 2001 for Spain. We average the percentages of available years and use the average percentage for the missing years.

Italy is the only country that increased investment in advertisement from 1991 to 2004. Italy invested 0.18% of GDP in advertisement in 1991 and invested 0.91% in 2004. Germany invested 0.48% of GDP in 1991 and 0.41% in 2004. France invested 0.76% of GDP in 1991 and 0.74% in 2004. Spain invested 0.59% of GDP in 1991 and 0.20% in 2004.

Market Research

Data sources are EU KLEMS and EUROSTAT. EU KLEMS provides from 1991 to 2004 the total output of industry K74.1--market research and public opinion polling, business and management consultancy, tax consultancy, and legal, accounting, book-keeping and auditing activities. EUROSTAT provides the turnover of industry K74.1.3 (market research) from 1996 to 2004 for Germany, from 1994 to 2004 for France, from 1995 to 2004 for Italy and from 1998 to 2004 for Spain. We estimate the output of K74.1.3 for the missing years using the ratio between the output of K74.1 and K74.1.3.

Germany decreased investment in market research from 1991 to 2004, while France, Italy and Spain increased investment from 1991 to 2004 (Figure 6). Germany invested 0.35% of GDP in market research in 1991 and invested 0.15% of GDP in 2004. France invested 0.26% of GDP in 1991 and invested 0.27% in 2004. Italy invested 0.12% of GDP in 1991 and 0.28% in 2004. Spain invested 0.21% of GDP in 1991 and 0.25% in 2004.

Firm-specific human capital

EU KLEMS provides total compensation from 1970 to 2004. CVTS 2005 provides continuing training costs as a percentage of total labor costs. LCS 2004 provides apprentice as a percentage of labor costs. We use that percentage for all years.

Management Consulting

FEACO provides the revenues of management consulting from 1998 to 2004. EU KLEMS provides the output of "Legal, accounting, book-keeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy" (NACE 741) from 1970 to 2004. We calculate the ratio of management consulting to NACE 741 on average from 1998 to 2004 and use that ratio for years before 1998. We multiply that ratio by the output of NACE 741 to estimate the revenues of management consulting before 1998.

Own-account Organizational Structure

EU KLEMS provides total compensation from 1970 to 2004. Structural Earnings Survey 2002 of Eurostat provides the percentage of managers' earnings in total earnings. We use that percentage for all years and multiply that percentage with the compensation from 1970 to 2004.

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Table A1: Spending on Intangible Assets in the Market Sector (2004 and % GDP)

Type of Expenditure	Germany 2004	France 2004	Italy 2004	Spain 2004
1. Computerized information	**15,704**	**21,734**	**9,204**	**6,257**
a) Software	15,331	21,025	9,127	6,042
b) Databases	373	709	77	214
2. Innovative property	**76,619**	**51,731**	**31,370**	**21,074**
a) R&D, including social sciences and humanities	37,445	21,859	7,288	4,615
b) Mineral exploration and evaluation	110	374	499	309
c) Copyright and license costs	4,380	5,240	1,422	1,576
d) Development costs in financial industry	15,544	9,666	11,001	2,929
e) New architectural and engineering designs	19,140	14,593	11,159	11,645
3. Economic competencies	**72,325**	**86,705**	**37,068**	**18,435**
a) Brand equity	18,517	24,996	16,487	4,898
Advertising expenditure	15,268	20,552	12,626	2,793
Market research	3,249	4,444	3,861	2,105
b) Firm-specific human capital	29,673	24,986	13,876	7,005
Continuing vocational training	14,894	20,747	9,589	6,109
Apprentice training	14,779	4,240	4,287	896
c) Organizational structure	24,135	36,723	6,705	6,533
Purchased	11,077	5,127	1,597	2,103
Own account	13,058	31,596	5,108	4,430
Total Spending	**164,647**	**160,171**	**77,642**	**45,765**
Total Investment	**155,929**	**145,631**	**71,570**	**43,762**

Sources: The source of the US is CHS (2005). The source of the UK is MH(2006). For Germany, France, Italy and Spain, we use a wide range of data sources including national accounts, surveys of statistical offices, surveys of trade associations and corporate financial reports. For more details on data sources, please see Appendix 1.

Note: To convert spending into investment, 60% of expenditure on advertisement, 80% of expenditure on own-account organizational structure and 100% of all the other expenditure are investment (CHS, 2005).

Appendix 2

Comparison of Estimates of Intangible Spending in the UK and the Netherlands.

Comparing intangible spending across countries is difficult, partly because different scholars use different data sources. For example, in the present study we use many data of trade associations for France and Germany, while MH (2007) and RBT (2008) mostly use national accounts for the UK and the Netherlands respectively. Further, even MH (2007) and RBT (2008) use data at different levels of aggregation from the national accounts. For example, MH (2007) directly measure the turnover of market research using national accounts, while RBT (2008) estimate it from the output of an aggregate industry that includes three other service industries.

In this Appendix, we replicate the results of MH (2007) and RBT (2008) using our data sources, finding out how different data sources may cause different estimates of intangible spending.

We find that different data sources may lead to very different estimates for a variety of reasons. First, indirect measures may differ much from direct measures. For example, for copyright and license costs, RBT (2008) directly measure revenues from royalties and licenses, using Dutch national account, while we indirectly measure copyright and license costs as three times the development costs of motion pictures. As a result, RBT (2008) estimate that the Netherlands spent 0.14% of GDP on copyright and license costs in 2004, while we estimate that the Netherlands spent 0.04% of GDP on copyright and license costs. Second, different surveys provide different estimates. For example, for firm-specific human capital, both RBT (2008) and we use CVTS and LCS of EUROSTAT, while MH (2007) uses the National Employer Skills Survey of the UK. MH (2007) estimates that the UK spent 2.45% of GDP on firm-specific human capital in 2004, while we estimate that the UK spent only 2.01% of GDP.

One may apply two standards to determine which data source should be preferred. The first standard is that a direct measure may generally be preferred over an indirect measure. For example, for copyright and license costs, we consider RBT (2008)'s measure preferable to than ours, because they directly measure revenues from royalties and licenses, while we measure the costs as three times the development costs in the movies industry. The second standard is to compare both measures with a third data source, and let that weigh in deciding which measure to use.

Below we compare the standardized estimate (using the two measurement standards described above) with the original estimates for the UK by MH (2007) and the Netherlands by RBT (2008) for 2004 and our estimates using the same source material as for our estimates for France, Germany, the UK and Italy.

Using the standardized method, we find that the *market* sector of UK spent 10.07% of GDP on intangible assets, 0.81%-point of GDP less than what MH (2007) estimate but 0.2%-point more than our own estimate (Table A1)[15]. In particular, we estimate that the *market* sector of UK spent 1.36% of GDP on computerized information, 2.85% of GDP on innovative property and 5.86% of GDP on economic competencies. In contrast, MH (2007) estimate that the *market* sector of UK spent 1.70% of GDP on computerized information, 3.23% of GDP on innovative property and 5.95% of GDP on economic competencies, whereas our original estimate shows 1.36% of GDP on computerized information, 2.80% of GDP on innovative property and 5.71% of GDP on economic competencies.

Similarly, we estimate that the Netherlands spent 10.50% of GDP on intangible assets in 2004 according to the standardized method, 1.16%-point of GDP more than what RBT (2008) estimate (Table A1). The standardized estimate suggest that the Netherlands spent 1.30% of GDP on computerized information, 3.56% of GDP on innovative property and 5.64% of GDP on economic competencies. In contrast, RBT (2008) estimate that the Netherlands spent 1.30% of GDP on computerized information, 3.01% of GDP on innovative property and 5.05% of GDP on economic competencies.

[15] In this Appendix, we focus on how much the market sector invests in intangible assets.

The rest of the Appendix compares our estimates, the estimates of MH (2007) and RBT (2008) and the standardized estimates. The results are in Table 2A. There are three columns for each country. Column (1) lists the estimates of the other authors (MH (2007) for the UK, and RBT (2008) for the Netherlands), and Column (2) shows the estimates using our data sources. Column (3) shows the standardized estimate.

1. Computerized Information (Software and Databases).

   Our data source is the capital account of EU KLEMS. EU KLEMS provides that the UK invested 28,512 million Euros or 1.63% of GDP in software and databases.

   The data source of the UK is national accounts. Since EU KLEMS is based on national accounts, we prefer to measure software investment directly from national accounts instead of from EU KLEMS. For the UK, our standardized estimate is that the UK invested 1.36% of GDP on software in 2004.

   We get the standardized estimate by adjusting downward the estimate of MH (2007). The data source of MH (2007) is the Office of National Statistics (ONS), which tends to over-estimate own-account software investment. ONS includes seven occupations in calculating hours spent on software (ONS, 2006)[16]—(1) IT Strategy and Planning Professionals, (2) Software Professionals, (3) Information and Communication Technology Managers, (4) IT Operations Technicians, (5) IT User Support Technicians, (6) Database Assistant/Clerks and (7) Computer Engineers, Installation and Maintenance. In contrast, other OECD countries include only the first two occupations. As a result, ONS estimates a large value of own-account software investment. ONS estimates that the UK invested 1.2% of GDP on own-account software investment, and invested 0.7% of GDP on purchased software in 2003, while OECD (2003) estimates that the US invested 0.7% of GDP on own-account software investment, and invested 1.0% of GDP on purchased software in 2003.

[16] Chesson, Adrian and Graeme Chamberlin, Survey-based measures of software investment in the UK, Economic Trends 627, Office for National Statistics, February 2006.

We adjust the ONS estimates, assuming that the UK has the same proportion of own-account investment to purchased investment as the US, and assuming that ONS estimates purchased software investment accurately (0.8% of GDP in 2004). We roughly estimate that the UK invested 1.36%[17] of GDP in software in 2003. We use that number for 2004.

For the Netherlands, RBT (2008) measure software investment using the Dutch National Accounts. We use their estimate as the standardized estimate.

Innovative Property.

(1) R&D, including natural sciences and social sciences.
Our estimates are close to those of MH (2007) and RBT (2008).

(2) Copyright and license costs.
We estimate smaller values than both MH (2007) and RBT (2008). We follow the indirect method of CHS (2005), and estimate copyright and license costs as three times the development costs of movies. Since MH (2007) and RBT (2008) directly measure this investment, we consider their measures to be preferred for the standardized estimates. MH (2007) use UK National Accounts to directly measure investment in TV and radio, publishing and music industries, and RBT (2008) use national accounts for the Netherlands to directly measure revenues from royalties and licenses.

(3) Development costs in financial industry.
We estimate a value similar to MH (2007) for the UK, but estimate a value much larger than RBT (2008) for the Netherlands. We follow the method of CHS (2005), and measure

[17] 1.36%=0.8%+0.8%*0.7.

development costs in financial industry as 20% of intermediate costs, while RBT (2008) argue that the development costs in the financial industry equals R&D in financial industry, which they argue to be already included in their measure of R&D and therefore is excluded here. However, development costs may include costs other than R&D costs. Moreover, if we use different measures of development costs and compare them across countries, we will reach wrong conclusions. For example, R&D expenditure in the financial sector of the Netherlands is only 45 million euros in 2003 (Eurostat, 2007), while 20% of the development costs in the financial sector of the Netherlands amount to 4,509 million euros (Eurostat, 2007).

(4) New architectural and engineering designs.

Our estimate of the UK is smaller than MH (2007), and our estimate of the Netherlands is larger than RBT (2008). We use 50% of the gross output of SIC 742 to measure investment in new architectural and engineering designs. Our data source is EU KLEMS. EU KLEMS estimates the gross output of 3-digit industries, using the output of 2-digit industries and Input-Output tables. Our estimate is preferred for the standardized method relative to than MH's, but for the Netherlands we used RBT's measure as standardized estimate.

As to the UK, our data source (EU KLEMS) provides that the gross output of SIC 742 is 42,447 million euros (28,807 million pounds, current prices) in 2004, while MH (2007) provides that the turnover (sales) of SIC 742 is 44,000 million euros[18]. We use a third data source to determine which measure is closest. The Structural Business Survey (SBS) of the EUROSTAT provides that the turnover is 33937 million euros, closer to our measure and smaller than MH's measure. As to the Netherlands, RBT (2008) directly measure investment in new architectural and engineering designs, using the National Accounts for the Netherlands, while we indirectly measure it as 50% of the gross output. So we consider their measure for the standardized estimate.

2. Economic Competencies.

[18] It is 30 billion pounds in MH (2007).

(1) Advertising expenditure.

We estimate smaller values than both the MH (2007) and RBT (2008). As to the UK, the MH's estimate is used as the standardized estimate. The data source of MH (2007) is the surveys of Advertising Association of the UK, providing that the UK spent 18 billion pounds (26,523 million euros, current prices) on advertisement in 2004. Our data source is EU KLEMS, estimating the gross output of advertising industry is 18,098 million euros. We also used a third data source to cross-check the two estimates. The Structural Business Survey (SBS) estimates that the turnover of advertisement is 26,344 million euros, closer to the MH number and much larger than our number.

As to the Netherlands, our data source (EU KLEMS) estimates that the gross output of advertising industry is 4,948 million euros (current prices). RBT's data source (Dutch National Accounts) estimates that the Netherlands spent 13,500 million euros on advertisement every year from 2001 to 2004, and the SBS of the EUROSTAT estimates that the turnover of advertisement is 6,629 million euros in 2004. RBT argue there are strong reasons to increase the turnover estimate because firms outside the advertising industry also account for a significant share of advertising. For international comparability, we chose the turnover estimates as the standard for comparison.

(2) Market research.

Our estimate of the UK is close to that of MH (2007), but our estimate of the Netherlands is twice as that of RBT (2008). As we directly measure the turnover of "market research and public polling" using the SBS of EUROSTAT, we use that measure for our standardized estimate. In contrast, RBT (2008) use no direct measure of market research. They use the Dutch national accounts, which provide the total spending on market research, organizational consultancy, public relation agencies and other economic research and consultancy. Then they estimate the spending on market research from that aggregate data. Since our measure is direct

we prefer it for our standardized measure.

(3) Training costs.

Our estimate is smaller than MH (2007), because our data source (CVTS) excludes initial startup training and on-the-job training (MH, 2007)[19]. MH (2007) compare CVTS with their data source, NESS05, and conclude that CVTS under-estimates training costs. NESS05 estimates that the training costs are 33.3 billion pounds in the UK in 2005, while CVTS estimates only 23.8 billion pounds in 2004 (Table 1A). Our standardized estimate is the estimate of MH (2007).

Our estimate is close to RBT (2008), because RBT (2008) also uses CVTS. We estimate that the Netherlands spent 1.45% of GDP on training in 2004. Because of the problem mentioned above, we adjust the estimate upward, using the percentage of training costs that CVTS covers in the UK. Our standardized estimate is that the Netherlands invested 2.61% of GDP[20] in training in 2004.

(4) Purchased organizational structure.

Our estimate of the UK is close to MH (2007), but our estimate of the Netherlands is much smaller than RBT (2008). We use our estimate for the Netherlands, because we directly measure management consulting using the Annual Survey on Management Consultancy, while RBT (2008) uses no direct measure. They estimate spending on organizational consultancy using the same method as they estimate market research.

(5) Own-account organizational structure.

Our estimate of the UK is larger than MH (2007). We use the Structure of Earnings Survey (SES), provided by EUROSTAT, while MH (2007) use the Annual Survey of Hours and Earnings, provided by the UK statistical office. We suspect that the SES inaccurately measures the number of managers[21], so MH (2007)'s estimate is

[19] We use both CVTS and apprentice costs for France and Germany. We exclude apprentice costs for the UK and the Netherlands, because EUROSTAT provides no apprentice costs for the Netherlands.
[20] 2.61%=1.45%*(33.3/18.5).
[21] For more information, please see the main text on own-account organizational structure.

preferred for the standardized measure. RBT (2008) do not estimate own-account organizational structure.

Our standardized estimate for the UK shows that MH (2007) over-estimate intangible spending by 0.81%-point of GDP, mostly because they over-estimate spending on software and architectural and engineering designs. Our standardized estimate of the Netherlands shows that RBT (2008) under-estimate intangible spending by 1.16%-point of GDP, mostly because they find lower development costs in financial industry, advertising expenditure, firm-specific human capital and own-account organizational structure.

Table A2: Intangible Spending in the UK and the Netherlands (2004, % of GDP)[1]

	UK[2]			Netherlands[3]		
Type of Expenditure	(1) MH (2007)	(2) Our estimation	(3) Our standardised estimation	(1) RBT (2008)[4]	(2) Our estimation	(3) Our standardised estimation
1. Computerized information	**1.7**	**1.36**	**1.36**	**1.30**	**1.30**	**1.30**
2. Innovative property	**3.23**	**2.8**	**2.85**	**3.01**	**4.35**	**3.56**
a) R&D, including social sciences and humanities	1.09	1.04	1.04	1.89	1.77	1.89
b) Mineral exploration and evaluation	0.04	--	0.04	0.04	--	0.04
c) Copyright and license costs	0.21	0.2	0.21	0.14	0.04	0.14
d) Development costs in financial industry	0.69	0.67	0.67	0.02	0.57	0.57
e) New architectural and engineering designs	1.2	0.89	0.89	0.92	1.97	0.92
3. Economic competencies	**5.95**	**5.71**	**5.86**	**5.05**	**4.48**	**5.64**
a) Brand equity	1.59	1.42	1.58	2.65	1.31	1.31
Advertising expenditure	1.2	1.04	1.2	2.38	0.81	0.81
Market research	0.39	0.38	0.38	0.24	0.50	0.50
b) Firm-specific human capital[5]	2.45	2.01	2.45	1.16	1.45[5]	2.61
Direct firm expenses	1.27	1.56	1.27	0.69	0.88	1.58
Wage and salary costs of employee time	1.17	0.45	1.17	0.47	0.57	1.03
c) Organizational structure	1.92	2.28	1.83	1.24	1.72	1.72
Purchased	0.6	0.52	0.52	1.24	0.41	0.41
Own account	1.31	1.77	1.31	-	1.31	1.31
Total Spending	**10.88**	**9.87**	**10.07**	**9.34**	**10.13**	**10.50**

Note: 1. Column (1) lists the estimates of the other authors (MH (2007) for the UK, and RBT (2008) for the Netherlands), and Column (2) shows the estimates using our data sources. Then we choose the better estimates between Column (1) and Column (2), and use it as our best estimate in Column (3).
2. Spending by the market sector.
3. Spending by the market sector and the public sector.
4. RBT (2008) measures investment in billion euros in Table 2. We use that table to calculate investment as a percentage of GDP. Numbers may not add up because of rounding.
5. We exclude apprentice training to make the UK and the Netherlands consistent, because we have data on apprentice training for the UK, but not for the Netherlands.