the review of income and wealth

Review of Income and Wealth
Series 57, Number 4, December 2011
DOI: 10.1111/j.1475-4991.2010.00436.x

CAN INVESTMENT IN INTANGIBLES EXPLAIN THE SWEDISH PRODUCTIVITY BOOM IN THE 1990s?

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In the early 1990s the Swedish economy experienced a severe economic and financial crisis which resulted in a substantial GDP decrease. Even though the crisis was not a complete surprise for many economists, almost no one expected that the Swedish economy would be prospering with booming productivity growth only a few years later. Economists have presented three explanations for the fast recovery and productivity growth in 1995–2006: market reforms, crisis recovery, and the impact of ICT. This paper offers an alternative view, emphasizing instead firms' substantial investment in intangible assets such as R&D, design, and advertising. Based on the growth accounting framework, intangible capital accounted for more than 30 percent of the labor productivity growth in the Swedish business sector from 1995 to 2006. Thus, Swedish TFP growth, one of the highest among OECD countries, is reduced substantially when investment in intangibles is included in the growth accounting analysis.

1. Introduction

In autumn 2008 the investment bank Lehman Brothers went bankrupt, triggering crises in most countries worldwide. Sweden was no exception, with a GDP drop of almost 5 percent in 2008–09. In the early 1990s Sweden had experienced another economic and financial crisis that also resulted in a substantial decline in GDP growth. Over the period 1990–93 GDP decreased by 4.3 percent. The crisis was characterized by a sharp increase in real interest rate, a bank crisis, and a currency crisis (Hagberg and Jonung, 2005). The crisis was not a total surprise for many economists who had been criticizing the design of the Swedish welfare state, but almost none of them thought the Swedish economy would prosper just a few years after the crisis.

In 1994 the Swedish economy started to recover from the crisis with substantial economic and productivity growth. Many economists thought the high productivity growth could be ascribed to the recovery in wake of the crisis—and that it would evaporate after a few years. But productivity growth remained high throughout 1995–2006, even during the economic slowdown at the beginning of the millennium. In fact, productivity growth in the Swedish business sector was one of the highest throughout the western world (see Figure 1).

Economists have emphasized two reasons behind the comparably high productivity growth in the Swedish business sector: market reforms in the 1980s, and the revolution in information and communication technology (ICT). Market

Note: I am grateful for useful comments and suggestions by Lena Hagman, Jonathan Haskel, Henrik Jordahl, Annarosa Pesole, Erik Ruist, and participants at COINVEST seminars in Lisbon, Mannheim, Paris, and Stockholm. Financial support from the European Commission is also gratefully acknowledged.

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Published by Blackwell Publishing, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main St, Malden, MA, 02148, USA.

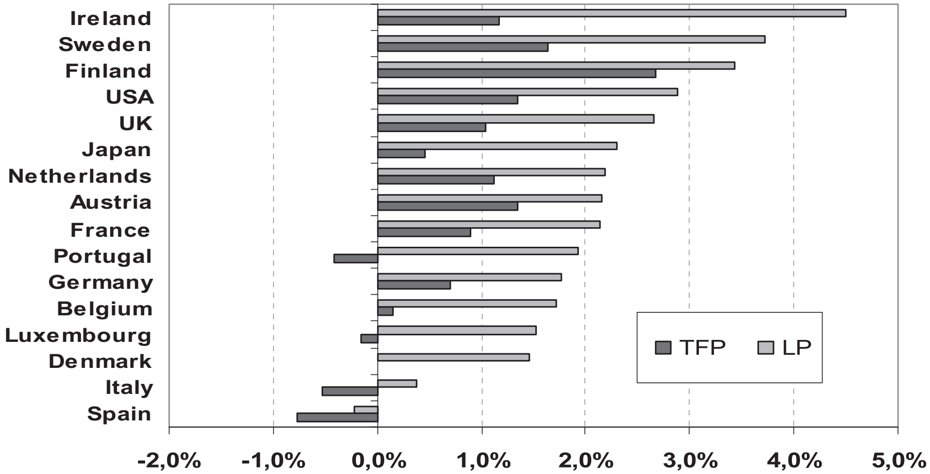

Figure 1. Labor and Total Factor Productivity Growth in the Business Sector in EU-15, Japan, and the U.S., 1995–2006 (percent)

Note: TFP estimates for Luxembourg and Portugal are based on the period 1995–2005. Data for Greece are missing.

Source: EU KLEMS (2008, 2009) and own calculations.

reforms are believed to affect competition, thereby increasing resource efficiency and thus productivity (Nickell, 1996). In theory, efficient markets also lead to increased diffusion of new technology and increase the incentives to innovate.

According to Schumpeter (1939), innovation is crucial for economic growth. During the last decades, breakthroughs in ICT have spurred a technological revolution. The invention of the transistor launched the revolution that generated innovations such as the semiconductor and the integrated circuit, the internet, and cell phones. Although these new products were available on the market, their effect on macroeconomic productivity growth materialized slowly.[1] Several studies have shown that ICT has had a significant impact on productivity growth in Sweden since the mid-1990s (Edquist and Henrekson, 2006; Edquist, 2008). Similar evidence was found for the U.S. economy (Gordon, 2000; Oliner and Sichel, 2000; Jorgenson, 2001; Stiroh, 2002; Jorgenson *et al.*, 2008; van Ark *et al.*, 2008).

Although ICT investments have been interpreted as an important factor to the recovery from the crisis, TFP has remained high throughout the period 1995–2006 (Edquist, 2008; Jorgenson *et al.*, 2008). Thus, the traditional inputs, i.e. capital and labor, are far from accounting for most of the strong economic growth in Sweden and some other countries. In response, several studies have pointed to investment in intangible assets as an additional explanation for economic growth (Corrado *et al.*, 2005, 2006, 2009; Marrano and Haskel, 2006; van Rooijen-Horsten *et al.*, 2008; Fukao *et al.*, 2009; Hao *et al.*, 2009; Marrano *et al.*, 2009).

[1]This was named the Solow paradox after Nobel Laureate Robert Solow's famous remark that "you can see the computer age everywhere but in the productivity statistics" (Solow, 1987).

In the National Accounts, intangibles have been identified as an intermediate expense and not as an investment.[2] Indeed, intangibles are considered difficult to measure compared to tangible assets such as buildings and machinery. Nevertheless, many advanced economies are moving toward "knowledge economy" activities, in which intangible assets play a large role (Marrano and Haskel, 2006). As some economies have become more dependent on high-tech products and knowledge intensive services, investment in intangible assets such as vocational training and research and development has increased. The purpose of this paper is to explore the role of intangible investment for the recovery of the Swedish economy after the financial crisis of the 1990s.

Intangible investment can be defined as expenditures by businesses intended to boost output in the future that do not take the form of traditional physical capital (Corrado *et al*., 2005, 2006). To the best of my knowledge, the impact of intangibles on the Swedish economy has never been systematically explored at the macro-level.[3] This paper will adapt the methods developed by Corrado *et al*. (2006) and Marrano and Haskel (2006) to estimate expenditures and investment in intangibles in the Swedish business sector from 1995 to 2006.

The following questions will be investigated:

- How large were intangible spending and investment in the Swedish business sector in 2006?
- How does intangible investment in Sweden compare to other countries like Japan, the U.K., and the U.S.?
- How important was investment in intangibles for economic growth and productivity growth in the Swedish business sector 1995–2006, i.e. after a severe economic and financial crisis?

2. Data and Sources

Corrado *et al*. (2006) and Marrano and Haskel (2006) focus on intangible investment in the business sector. To facilitate the comparison of their results with the Swedish data, this paper will only address investment in intangibles in the business sector. Intangible investment in the public sector is also important, and will be explored in future papers.

This paper follows the methodological framework of Corrado *et al*. (2006) which points to the feasibility of organizing intangible assets in three main groups:

1. Computerized information (software, computerized databases).
2. Innovative property (research and development (R&D), mineral explorations, copyright and license cost, product development in financial industries, and design).
3. Economic competencies (brand equity, vocational training, and organizational capital).

Various methods and surveys are used to estimate the spending on such assets for the years 1993–2006, the specifics of which are described in Section 2.1–2.3.

[2]Computer software, copyright and license costs that are defined as intangible capital in this paper are included in the Swedish GDP figures.

[3]Eliasson (2000) investigates the impact of some intangibles on the 17 largest manufacturing firms in Sweden.

2.1. *Computerized Information*

2.1.1. Computer Software

The estimates for computer software stem from the EU KLEMS (2009), a database financed by the European Commission to analyze productivity in the European Union at the industry level. Investment is measured by nominal gross fixed capital formation (GFCF) in software for Sweden during the years from 1993 to 2006.

2.1.2. Computerized Databases

Spending on computerized databases is already included in the estimates of software spending provided by the EU KLEMS (2009) database for Sweden.

2.2. *Innovative Property*

2.2.1. Research and Development

R&D expenditure data for Sweden is derived from the ANBERD database (OECD, 2009a). The ANBERD database exists to create a consistent dataset that covers business enterprise expenditures on R&D (BERD) in OECD countries, as delineated by the *Frescati Manual* (OECD, 2002). The *Frescati Manual* defines R&D as "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."

R&D should include an appreciable element of novelty and involve the resolution of scientific and technological uncertainty. Thus, it is likely that most reported R&D is of a scientific nature—and work such as design and market research will not be included in R&D figures. Moreover, in order to avoid double counting with software figures, total R&D spending was deducted with the R&D spending on computer and related activities.[4]

2.2.2. Mineral Exploration

Mineral exploration is based on data from the Geological Survey of Sweden. It primarily covers the prospecting for new ore deposits with the expectation of future returns (as opposed to expenditure on ore mining to extract existing ore deposits).

2.2.3. Copyright and License Cost

Copyright and license cost are measured as investment in entertainment, literacy, and artistic originals in the GFCF accounts. These figures cover literacy, musical works, and the production of film and certain TV and radio programs. However, to be included they must be covered by copyright, have primary artistic

[4]R&D in social science and humanities has been added. It is measured as the output of the industry producing social science research (SNI 732). In 2005, R&D in social science and humanities only accounted for 0.3 percent of total R&D spending.

intent, meet the capitalization criterion of use for more than one year, and not be accounted for anywhere else in the National Accounts.

2.2.4. Development Costs in Financial Services

Corrado *et al*. (2006) measured product development in the financial services industry, finding it to be 20 percent of total intermediate spending. This paper follows their method and uses a measure of intermediate input for financial intermediation (ISIC 65) and activities related to financial intermediation (ISIC 67).[5] The source of the intermediate spending is EU KLEMS (2008, 2009).

2.2.5. Design

Distinguishing design from other activities matters because several design-related activities are already counted in the formation of capital in the National Accounts. Marrano and Haskel (2006) define design activity as the relationship between design activities and the official measurement of R&D under the *Frescati Manual* framework. The manual states that if design is made for the setting up and operating of pilot plants and prototypes, these costs should be included in R&D. In contrast, if design is carried out for the preparation, execution, and maintenance of production standardization or to promote the sale of products, they should be excluded from the definition of R&D.

In Corrado *et al*. (2006), half of the turnover of the architectural and design industry was used as a proxy for purchased and own account expenditure on architectural and engineering design (AED). However, purchased and own account design activities are estimated by more sophisticated methods in this paper: both AED services bought in the marketplace and AED services produced in-house for internal use will be measured.

The AED services bought in the marketplace are estimated as the turnover of the architectural activities and technical consultancy industry (SIC 742). Due to the lack of supply-use tables, it has not been possible to estimate how much of the market design services are actually produced by SIC 742. Nonetheless, the total output is weighted by the share of the total proportion of employment in SIC 742 that is related to design occupations.[6] Thus the spending on purchased design activities can be written:[7]

$$Y_p = Y^{742} \cdot \frac{N^{742AED}}{N^{742}}, \tag{1}$$

[5]The purchase of other intangibles that are counted elsewhere (i.e. software, consultancy services, architectural and engineering services, and advertising) is subtracted from intermediate inputs.

[6]Based on Galindo-Rueda *et al*. (2008) the following occupations are defined as design occupations: architects and town planners, civil engineers, electrical engineers, electronics and telecommunications engineers, mechanical engineers, chemical engineers, designers, decorators, and commercial designers.

[7]For some engineering occupations, it is likely that the employees to some extent are also involved in R&D activities which implies double counting. This problem is further discussed in the Appendix.

where Y_p is the measured purchased AED output, Y^{742} is the output of SIC 742, N^{742AED} is the number of employees with design occupations in SIC 742, and N^{742} is the number of total employees in SIC 742.

To estimate the AED produced by industries outside SIC 742 (own account), we divide purchased AED (Y_p) with the wage bill of designers in SIC 742 (wN^{742AED}). Thus, a ratio indicating the output per invested wage unit in SIC 742 is obtained. It is then assumed that each invested wage unit is the same for persons with design occupations working either within SIC 742 or outside. This implies that multiplying this ratio Y_p/wN^{742AED} by the wage bill of persons with design occupations not working in SIC 742 (wN^{BAED}) allows us to obtain the own account output. This can be expressed in the following formula:

$$(2) \qquad Y_{own} = \frac{Y_p}{wN^{742AED}} \cdot wN^{BAED},$$

where Y_{own} is the own account output, and Y_p the purchased output.[8]

2.3. *Economic Competences*

2.3.1. Brand Equity

Advertising

Data on spending on advertising comes from the Swedish Institute for Advertisement (IRM). Data on classified ads were deducted based on figures for 2007. Classified ads then accounted for approximately 8 percent of total advertisement and 35 percent of the advertisement in newspapers.[9]

The available data includes the public sector. According to a survey by SIFO Research International, the government sector accounted for approximately 1.1 percent of total spending on advertisement. Hence, it is assumed that this share is the same for the period 1993–2006; total investment is deducted by 1.1 percent for each year.

Market Research

Expenditure on market research is measured as twice the turnover of the market and consumer research industry (ISIC 7413). The estimation is based on the assumption that own account market research equals purchased market research.

2.3.2. Vocational Training

Corrado *et al*. (2005) argue that spending on firm-specific human capital can be measured by the spending of employer-provided workforce training. This can

[8]Data for all variables in equations (1) and (2) are available for the period 1997–2006. For the period 1993–96 the wage bill has been estimated based on the average ratio of wage bill/turnover for the years 1997–2006. Moreover, data on the number of persons employed in SIC 742 in 1993–96 are based on the average ratio of employment in SIC 742 and total employment in 1997–2006.

[9]It is assumed that classified ads also accounted for 8 percent of the total spending on advertisement for the period 1993–2006.

be measured by spending on vocational training that includes both the direct firm expenses and the wage/salary cost of employees undertaking vocational training. The measure of vocational training includes both general and firm-specific training.[10] Becker (1962) argued that firms would only pay for training which would not be of use to workers if they moved to another company. In reality, training paid by firms is usually both general and firm-specific (Acemoglu and Pischke, 1998, 1999; Barnes and McClure, 2009). Moreover, even though the skills are general, it is still likely that for any firm in the economy they have an effect on productivity growth and therefore should be included as an input in the growth accounting analysis. It could be viewed as an extra skill that is paid for by firms and is thus a complement to the general skills picked up in the measure of labor quality.

Spending on vocational training is measured using data reporting how much firms in the business sector spend on continuing vocational training (CVT). The source is a survey of employer provided training conducted by Statistics Sweden in 1999 (CVTS, 1999). CVTS (1999) measures the direct and indirect costs of continuing vocational training (in firms with at least ten employees) as a percentage of total labor costs in 1999.[11]

2.3.3. Organizational Structure

Purchased Organizational Structure

Investment in organizational structure (OS) includes investment in purchased OS and own account OS. Purchased OS is measured with the turnover of business and management consultancy activities (SIC 7414). The turnover has been adjusted so that only products which include services that affect organizational structure are included.[12] Moreover, the share of the turnover purchased by the public sector is excluded, based on data from the Swedish business magazine *Affärsvärlden* (2001–04).[13]

Own Account Organizational Structure

Investment in own-account organizational structure is measured as 20 percent of managers' compensation. The occupations identified as managers are "legislators, senior officials, and managers." However, legislators and senior government officials are excluded because the public sector is excluded. The wage data that are used to estimate own account organizational structure are provided by Statistics Sweden. Wage data for each group of managers are available for the period

[10]General training is defined as any training which increases the marginal productivity of employees by exactly the same amount in firms providing the training as in other firms. Firm-specific training has no effect on the productivity of trainees that would be useful in other firms.

[11]It is assumed that firms with less than 10 employees spend the same proportion of their total labor costs on vocational training and that the proportion of labor costs spent by firms in 1993–2006 is the same as in 1999.

[12]The following services are assumed to affect organizational structure: advice regarding distribution, employees, mergers and acquisition, organizations, taxes, marketing, production, project leadership, and administration. It has only been possible to estimate the share of these services for the year 2006; the same share is therefore used to estimate purchased organizational structure for other years.

[13]It is assumed that the share of turnover purchased by the public sector is the same for the period 1995–2000 as the average share for the period 2001–06.

1997–2006. For these groups this information is unavailable for the period 1993–96. Therefore, it has been assumed the wages follow the average development for wages in the private sector and that the number of managers remained the same as in 1997.

3. Results of Intangible Spending and Investment

3.1. *Intangible Spending in Sweden*

Table 1 shows that the total spending on intangibles in Sweden in 2006 was 352 billion SEK. Thus, the spending was approximately 12 percent of total GDP and 18 percent of gross value added (GVA) in the business sector. Table 1 also shows the spending for the different categories of intangibles. The largest expenditure was on R&D, at 77 billion or 22 percent of total spending on intangibles. This corresponds well with the general view of Sweden as an R&D intensive country. Spending on design, software, advertising, vocational training, and purchased organizational structure was also considerable. In fact, together with R&D, these categories of assets accounted for more than 90 percent of total spending on intangibles.

Spending on own account organizational structure was 17 billion SEK, accounting for 5 percent of total spending. For all other categories of intangibles, spending amounted to 2 percent or less of the total expenditure on intangibles. Spending on mineral exploration was as low as 0.1 percent of total spending.

3.2. *How Much of the Spending is Investment?*

According to Corrado *et al.* (2005, 2009) and Marrano *et al.* (2009), not all spending on intangibles can be considered as investment. It is necessary to separate the expense of current production from outlays that expand future productive capacity. For physical capital, this distinction is often made on the basis of the durability or expected service life of a purchase. Yet the service life of a specific asset can at times be ambiguous. The BEA estimates that business fixed assets have a useful service life of at least three years, while other studies define business sector equipment as having a service life of more than one year.

Based on this logic, Corrado *et al.* (2005) assume that the proportion of spending that can be considered as investment should be based on four steps:

1. If economic research has clearly shown that a given type of spending is fixed investment, then 100 percent is classified as capital investment.
2. If economic research suggests that only a portion of the spending on an intangible pays off in future year (or years), these findings are applied.
3. When there is strong suspicion that the lifetime of a type of intangible may not be at least three years, the item is discounted by 20 percent and a range of estimates of capital investment is shown for the item.
4. When there is strong suspicion that a portion of the spending may be for routine tasks or represent current consumption, the point estimate is discounted 20 percent.

Table 1 shows the proportion of spending considered as investment according to Corrado *et al.* (2005). Little is known about the service life of software, yet the

TABLE 1

Business Sector Spending on Intangible Assets in Sweden in 2006 (billion SEK)

Type of Intangible Investment	Sources	Total Spending 2006 (bn SEK)	Percent of Intangibles	Proportion of Spending Considered as Investment
1. Computerized information		63.1	18	
a) Computer software	EU-KLEMS	63.1	18	1
b) Computerized databases	Included in computer software	n.a.	n.a	1
2. Innovative property		157.7	45	
a) R&D	OECD ANBERD	76.5*	22	1
b) Mineral exploration	SGU (Geological Survey of Sweden)	0.4	0.1	1
c) Copyright and license costs	Statistics Sweden	2.1	1	1
d) Development costs in financial industry	EU-KLEMS	4.4	1	1
e) Design	Statistics Sweden	74.3	21	0.5
3. Economic competencies		131.4	37	
a) Brand equity				
Adverting	Swedish Institute for Advertisement (IRM)	44.7	11	0.6
Market research	Statistics Sweden	5.2	1	0.6
b) Vocational training	Statistics Sweden	29.8	8	
c) Organizational structure				
Purchased	Statistics Sweden and Affärsvärlden	35.0	10	0.8
Own account	Statistics Sweden	16.7	5	1
Total spending		352.1	100	

Note: *To avoid double counting, the investment in R&D is deducted with the R&D investment for computer and related activities.
Source: Sources in the table and own calculations.

BEA assumes a three-year service life for all prepackaged software and a five-year service life for custom and owned software. Therefore Corrado *et al*. (2006) assume that 100 percent of total spending on computerized information should be classified as capital investment. The same rule applies for scientific R&D spending, mineral exploration, copyright and license cost, and development costs in financial services.

Based on estimates provided by Galindo-Rueda *et al*. (2008), only 50 percent of design spending should be counted as investment. Economic research on marketing has found that the effects of advertising are generally short lived. However, according to Landes and Rosenfield (1994), more than half of the expenditure on advertising has a service life of at least one year and one-third has an impact of more than three years. Thus, Corrado *et al*. (2005) estimate that approximately 60 percent of total advertising expenditures have long-lasting effects. In addition, continuing vocational training has long-lived effects and is therefore counted as investment. While spending on organizational change also has likely long-lived effects, only 80 percent is considered as investment because a portion of purchased management expertise comprises rather routine tasks.

It is evident that in many cases the process of estimating how much spending is actually investment is not very precise, often based on *ad hoc* assumptions. Nevertheless, an attempt to measure investment in intangibles must use the best available information. Moreover, for some of the more important types of intangibles like scientific R&D and vocational training, the service life is certainly at least three years, and 100 percent of the spending should therefore be counted as investment.

Figure 2 shows that the spending on intangible assets was approximately 12 percent of GDP in 2006. Based on the method described above, the total

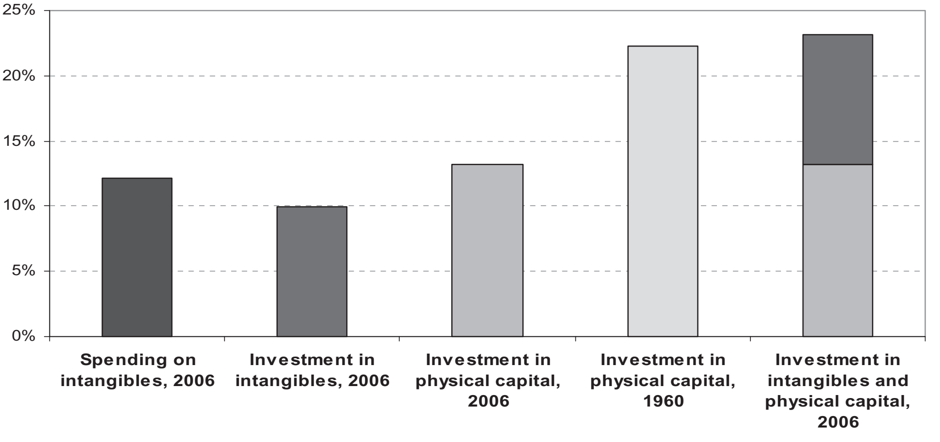

Figure 2. Business Sector Spending and Investment in Intangible Capital and Physical Capital in Sweden (percent of GDP)

Note: Copyright and license cost and software are excluded in physical capital. GDP is conventionally measured, i.e. including software and copyright but excluding other intangibles.

Source: Own calculations based on the framework in Corrado *et al*. (2006), Marrano and Haskel (2006), and Edvinsson (2005).

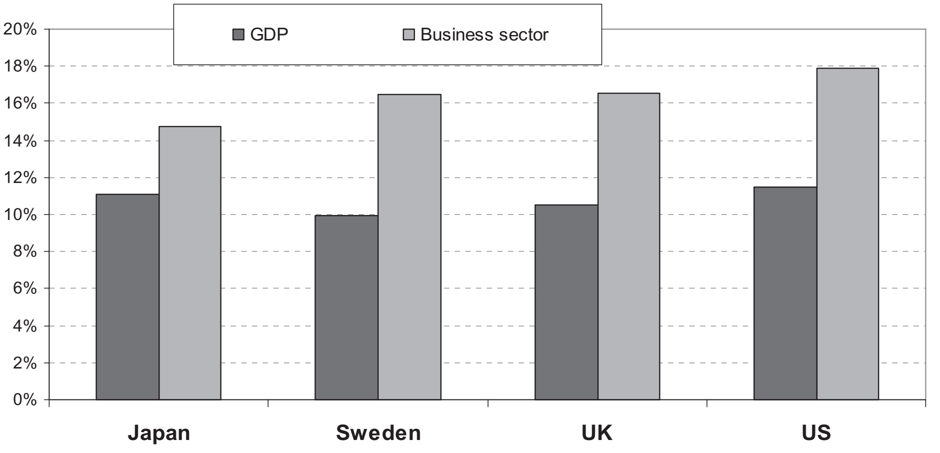

Figure 3. Investment in Intangibles as a Share of Total GDP and Business Sector GVA in Sweden, Japan, the U.K., and the U.S. in 2006

Note: Data for Japan are for the period 2000–05. GDP and GVA are conventionally measured, i.e. including software and copyright but excluding other intangibles.

Source: van Ark *et al*. (2009), Fukao *et al*. (2009), EU KLEMS (2009), OECD (2009b), and own calculations.

investment in intangibles is estimated to be 288 billion SEK or 10 percent of GDP. The Swedish investment in fixed capital for the business sector in 2006 was 382 billion SEK or 13 percent of GDP.[14] Hence, the estimated investment in intangibles was approximately 75 percent of the investment in physical capital. This clearly shows that investment in intangibles was considerable in comparison with investment in physical capital.

It is also interesting to note that in 1960, investment in physical capital in the Swedish business sector came to 22 percent of GDP. Investment in physical capital has thus decreased considerably in the Swedish business sector since 1960. However, if investment in intangible capital is added to physical capital, total investment reaches the figure of 23 percent of GDP. There are no estimates available for intangible capital in 1960, but it is likely that investment in intangibles was much lower in 1960 compared to 2006. Thus, it is not necessarily true that investment in the Swedish economy has decreased quite rapidly, as many economists have argued. It is more likely that the structure of the Swedish economy has become more service-based.

3.3. *Comparisons with Other Countries*

3.3.1. Total Investment

Figure 3 shows investment in intangibles as a share of total GDP and business sector GVA in Sweden, Japan, the U.K., and the U.S. In terms of GDP, the U.S. had the highest investment in intangibles with 12 percent of GDP, while Japan had

[14]Investments in software and copyright and license costs were subtracted from fixed capital since they are defined as intangible investments.

the second highest with 11 percent of GDP. Sweden and the U.K. had approximately the same investment ratio, namely 10 percent of GDP.

In terms of business sector value added, the investment ratio was still highest in the U.S. with 18 percent. Sweden and the U.K. had investment ratios of 16 percent, while the corresponding figure for Japan was 15 percent. It is interesting to note that the investment ratio in Sweden increases more than in other countries in terms of business sector value added instead of GDP; this can be traced to the fact that Sweden has a larger public sector than these other countries. Since only business sector investment in intangibles is measured, business sector GVA would constitute the more valid measure to use for comparisons between countries, rather than GDP.

3.3.2. Development Cost in Financial Services

In the aftermath of the worldwide financial crisis in 2008, the impact of development costs in the financial industry on economic growth has been questioned. Financial services have typically been described as highly innovative, and after the financial crisis seen as excessively innovative. Nevertheless, most experts would agree that financial innovations such as internet banking, automatic teller machines, and derivatives have had substantial positive effects on productivity in the world economy over many decades. Since financial innovations are poorly picked up in the R&D measures, it is of particular interest to try to measure and compare the development cost in financial services.

Figure 4 shows development costs in financial services in 2006 in four different countries based on the method advocated by Corrado *et al.* (2006), i.e. 20 percent of total intermediate spending by financial services. According to Figure 4,

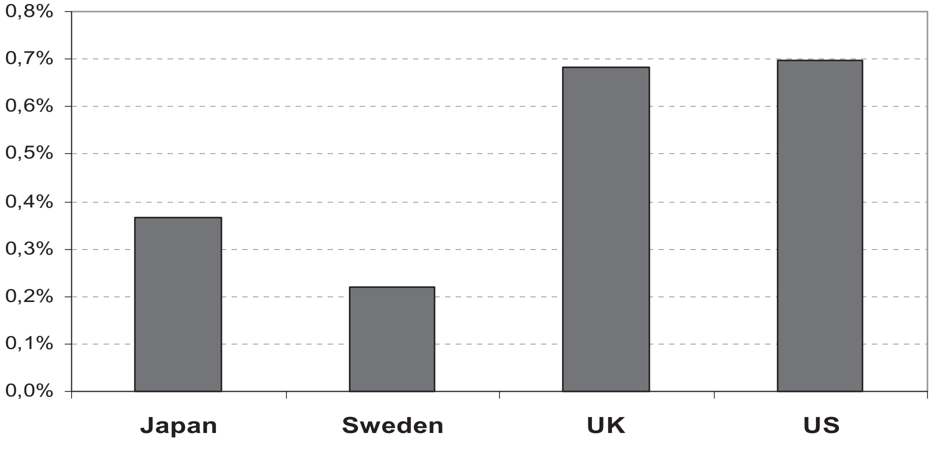

Figure 4. Development Costs in the Financial Industry in Japan, Sweden, the U.K., and the U.S. in 2006 (percent of GDP)

Note: The development costs are measured as 20% of intermediate input for financial intermediation (ISIC 65) and activities related to financial intermediation (ISIC 67). Software investment has been subtracted from intermediate inputs. GDP is conventionally measured.
Source: EU KLEMS (2008, 2009).

development costs in the financial industry were considerably higher in the U.K. and the U.S. than in Sweden and Japan. In Sweden the development cost only accounted for 0.2 percent of GDP, compared to as much as 0.7 percent in the U.K. and the U.S. An interesting point is that both Sweden and Japan experienced severe financial crises in the 1990s while the U.K. and U.S. did not.

Haskel and Pesole (2010) argue that financial innovation requires investment in product development, software, marketing, training, and organizational change. They therefore use labor force data to try to estimate development costs based on spending on occupational groups in the financial industry. Their findings are that investment in development costs of U.K. financial services only accounts for 0.07 percent of GDP when the effects from other intangible investments are excluded. Their estimate is considerably lower than the result presented for the U.K. in Figure 4. Thus, it is probable that the impact of development costs in financial services is lower than suggested by earlier studies. However, for Sweden the impact of this would not be very large since the estimates based on the method used by Corrado *et al*. are already so low.[15]

4. Growth Accounting Methodology

Growth accounting methodology can be used to analyze the impact of intangibles on productivity growth and labor productivity growth. The model used is once again the same as Corrado *et al*. (2006) and Marrano *et al*. (2009). It assumes there are three goods produced: a consumption good, with real output volume C_t with price P_t^C; a tangible investment good, I_t with price P_t^I; and an intangible investment good, N_t with price P_t^N, where the subscript denotes time. In Swedish National Accounts, most intangibles are treated as intermediates, although it could be argued that they should be treated as capital.

4.1. *Intangibles Treated as Intermediates*

Assume that the intangible investment good is regarded as an intermediate. Then the tangible capital stock K_t is assumed to accumulate according to the perpetual inventory method:

$$K_t = I_t + (1 - \delta_K) K_{t-1} \tag{3}$$

with depreciation rate δ_K. Suppose that factors are paid their marginal product and the production function is homogenous of degree 1. Then it is possible to denote the production function and money flows for each sector as follows:

(a) Intangible sector:

$$N_t = F^N(L_{N,t}, K_{N,t}, t);\ P_t^N N_t = P_t^L L_{N,t} + P_t^K K_{N,t} \tag{4}$$

[15]The figure for development cost in financial services in Sweden remains at 0.2 percent of GDP when consultancy services, architectural and engineering services, and advertising are excluded from intermediate inputs.

(b) Tangible sector:

$$I_t = F^I(L_{I,t}, K_{I,t}, N_{I,t}, t); P_t^I I_t = P_t^L L_{I,t} + P_t^K K_{I,t} + P_t^N N_{I,t} \quad (5)$$

(c) Consumption sector:

$$C_t = F^C(L_{C,t}, K_{C,t}, N_{C,t}, t); P_t^C C_t = P_t^L L_{C,t} + P_t^K K_{C,t} + P_t^N N_{C,t}. \quad (6)$$

Equation (4) states that the output of intangibles is produced by labor and tangible capital in the intangible sector and that with factors paid their marginal products, the value of the intangibles produced equals the returns to labor and tangible capital used in that sector.

Since intangibles are supposed to be intermediates, the production functions for the tangible and consumption sectors show that the volume of intangible output is simply an input into the production of tangible and consumption goods. Thus, intangibles are intermediate inputs and do not appear in total output:

$$P_t^{Q'} Q_t' = P_t^C C_t + P_t^I I_t = P_t^L L_t + P_t^K K_t, \quad (7)$$

where the prime ′ indicates the case where intangibles are treated as intermediate expenditure and $L = L_N + L_I + L_C$ and $K = K_N + K_I + K_C$. Equation (7) shows the equality of GDP on the expenditure side and income side.

4.2. *Intangibles Treated as Capital*

Suppose that the intangible investment good is regarded as capital. The intangible capital stock, R_t also accumulates according to the perpetual inventory model:

$$R_t = N_t + (1 - \delta_R) R_{t-1} \quad (8)$$

where R depreciates at rate δ_R. The production function and money flows for each sector can be written:

(a) Intangible sector:

$$N_t = F^N(L_{N,t}, K_{N,t}, R_{N,t}, t); P_t^N N_t = P_t^L L_{N,t} + P_t^K K_{N,t} + P_t^R R_{N,t} \quad (9)$$

(b) Tangible sector:

$$I_t = F^I(L_{I,t}, K_{I,t}, R_{I,t}, t); P_t^I I_t = P_t^L L_{I,t} + P_t^K K_{I,t} + P_t^N R_{I,t} \quad (10)$$

(c) Consumption sector:

$$C_t = F^C(L_{C,t}, K_{C,t}, R_{C,t}, t); P_t^C C_t = P_t^L L_{C,t} + P_t^K K_{C,t} + P_t^N R_{C,t}. \quad (11)$$

In contrast to equation (4), the stock of intangible capital, R_t, rather than intangible output, appears as an input in the production functions and the payment to that stock; in addition, $P_t^R R_t$, appears in the payment equations rather than payment for the entire used up intermediate output. The corresponding output identity now includes the value of output of the intangible good on the production side, $P_t^N N_t$, and the payments to the stock of intangibles, $P_t^R R_t$, on the income side:

$$(12) \qquad P_t^Q Q_t = P_t^C C_t + P_t^I I_t + P_t^N N_t = P_t^L L_t + P_t^K K_t + P_t^R R_t,$$

where the total output of the intangible good $N = N_N + N_I + N_C$ and the intangible stock is $R = R_N + R_I + R_C$. With intangibles being treated as capital, output is increased from $P_t^{Q'} Q_t'$ to $P_t^Q Q_t$.

4.3. *Growth Accounting*

Based on the growth accounting framework described in Sections 4.1 and 4.2, the growth accounting relations can be written in the following way:

$$(13) \qquad \Delta \ln Q_t' = s_t'^L \Delta \ln L_t + s_t'^K \Delta \ln K_t + \Delta \ln TFP_t$$

$$(14) \qquad \Delta \ln Q_t = s_t^L \Delta \ln L_t + s_t^K \Delta \ln K_t + s_t^R \Delta \ln R_t + \Delta \ln TFP_t,$$

where equation (13) shows the expression in the case where intangibles are expensed and equation (14) shows the case where they are capitalized. The equations show that the effect of including intangibles on growth is ambiguous, depending on the growth rate of real intangible investment. Moreover, the shares differ between (13) and (14) since both output and payment to capital differ.

In terms of decomposing labor productivity we get the following equations:

$$(15) \qquad \Delta \ln (Q'/L)_t = s'^L \Delta \ln \left(L^{QA}/L\right)_t + s'^K \Delta \ln (K/L)_t + \Delta \ln TFP_t$$

$$(16) \quad \Delta \ln (Q/L)_t = s^L \Delta \ln \left(L^{QA}/L\right)_t + s^K \Delta \ln (K/L)_t + s^R \Delta \ln (R/L)_t + \Delta \ln TFP_t.$$

Since the quality of labor hours varies we distinguish between employee hours, L, and quality adjusted employee hours, L^{QA}. The factor shares are denoted with an s and are averages of shares over which the time difference is taken, so that is a Törnquist index number. The share of capital is defined as one minus the share of labor.[16] In equation (16) the level of output has risen, yet the growth rate may or may not rise depending on the growth rate of real intangible investment.

There are many different capital assets. For example, tangibles involve plants, buildings, vehicles, and computer hardware; for intangibles there are R&D, software, design, and so forth. Thus, the $\Delta \ln K$ and $\Delta \ln R$ terms must be constructed to incorporate these many types. According to Jorgenson and Griliches (1967), the theoretically correct capital measure in a production function is the services that capital provides into output. These services for each type of capital can be measured by the rental payments that a profit-maximizing firm would pay when it is

[16]This is accurate if there are constant returns to scale at the overall economy level, but clearly an area where better measurement would be helpful.

renting its capital. Since firms rarely do this but rather buy the capital asset for a price p^A and then use it over its lifetime, the market-clearing rental payment for an asset B, p^B, can be derived as:

$$(17)\qquad P_{it}^{B} = T_{it}\left[r_{it} p_{i,t-1}^{A} + \delta_{it} p_{it}^{A} - \left(p_{it}^{A} - p_{i,t-1}^{A}\right)\right] \qquad B = K, R$$

where T is a tax adjustment and r is the rate of return on the asset. This equation holds for each type of capital i. The relation between this and the $\Delta \ln K$ and $\Delta \ln R$ terms in (14) can be derived as follows. The overall level of profit in the economy, φ, is by definition the overall payment to capital which is the sum of all rental payments to each capital type (Marrano *et al.*, 2009). This can be written:

$$(18)\qquad \varphi_t = \sum_{i=1}^{n} P_{it}^{K} K_{it} + \sum_{i=n+1}^{m} P_{it}^{R} R_{it},$$

where there are n tangible assets and $n+1$ to m intangible assets. Second, the overall volume index of capital services can be shown to be a share weighted average of all the asset-specific $\Delta \ln K$ and $\Delta \ln R$ terms (Marrano *et al.*, 2009):

$$(19)\qquad \Delta \ln K_t = \sum_{i=1}^{n} \left(p_{i,t}^{K} K_{it} / \varphi_t\right) \Delta \ln K_{it}$$

$$(20)\qquad \Delta \ln R_t = \sum_{i=n+1}^{m} \left(p_{i,t}^{R} R_{it} / \varphi_t\right) \Delta \ln R_{it}$$

where the shares are the flow of rental payment for each asset as a share of total rental payments (φ).

There are no time-varying depreciation rates available and they therefore are set constant over time. Moreover, there are no asset-specific rates of return, r_i, but in a competitive market r_i will equalize across assets. Under these assumptions it is possible to solve for r and p^K in equations (17) and (18). Since the overall payment to capital is known in the economy it is possible to solve for the unobserved asset-specific rental prices that would ensure that all payments to capital assets added up to φ.

To summarize, growth accounting is implemented by collecting a time series of nominal investment in intangible and tangible assets. The series is deflated to get real investment series. The deflators that are used are output deflators based on EU-KLEMS (2009).[17] Real capital stocks are constructed by using the perpetual inventory method; see equations (3) and (8). Market sector value added is recalculated by including intangibles (see equation (7)), and the operating surplus φ for market sector value added is adjusted (see equation (18)). A volume index of capital services of all capital inputs is calculated, ensuring that the asset rental payments are consistent with the adjusting operating surplus; see equations (17)–(20). A quality adjusted labor index to measure L^{QA} in equations (13)–(16) is

[17]Corrado *et al.* (2009) also use output deflators. More research is needed in order to improve deflators.

constructed. Finally, growth accounting in equations (13)–(16) can be carried out. It should also be noted that the growth accounting framework assumes a closed economy, which implies that there is no international trade in goods and services or financial assets.

All data except for intangibles are based on EU KLEMS (2008, 2009). Since data on labor quality for Sweden are not available in EU KLEMS (2009), the earlier version EU KLEMS (2008) was used.[18] Data on investment in intangibles has been collected from different sources for the period 1993–2006 (see Section 2). Business sector output deflators were used to create series of real intangible investment for all intangibles except software. The logic for choosing an output deflator instead of a wage deflator is explained by Corrado *et al.* (2009, pp. 668–69) and Marrano *et al.* (2009, pp. 703–04). Moreover, relatively little is known about depreciation rates of intangibles; for practical reasons best available estimates are the ones presented in Corrado *et al.* (2009).[19] Since there is no benchmark of initial capital stocks for intangibles it is assumed the initial capital stock was zero in 1992.[20]

5. Growth Accounting Results

Growth accounting for the Swedish business sector was performed for both business sector GVA growth (see equations (13) and (14)) and labor productivity growth (see equations (15) and (16)). The growth of GVA and labor productivity is analyzed both including and excluding intangible capital. The analysis is based on the time period 1995–2006 and the sub-periods 1995–2000 and 2000–06. The sub-periods were chosen for their value in analyzing the years directly following the economic and financial crisis in Sweden and the years after the burst of the Swedish ICT bubble.

5.1. *Contribution to Business Sector Growth*

Table 2 shows the result of growth accounting for the entire period of 1995–2006. When intangibles are excluded, average annual business sector growth was 4.1 percent. It should be noted that part of this growth has been driven by demand for Swedish products abroad. Net export has been substantial during the whole period analyzed. The impact from net trade is not possible to analyze in the growth accounting framework since it assumes a closed economy. ICT tangible capital accounted for 0.3 percentage points of the value added increase while other tangible capital accounted for 1.3 percentage points. Labor and labor quality accounted for 0.2 and 0.3 percentage points, respectively. The residual, TFP,

[18]It is assumed that labor quality is the same in 2006 as in 2005.

[19]The depreciation rates are: 0.33 for computerized information; 0.2 for R&D, mineral exploration, copyright and license cost, and design; 0.4 for vocational training, purchased and own account organizational structure; and 0.6 for adverting and market research.

[20]Setting initial capital stock to zero in 1992 might be subject to measurement errors since all of the true value of the benchmark will not have depreciated away in 1995 when measuring starts. In the Appendix, the period 1997–2006 is used to see how the impact from intangibles is affected when the period from the year when the capital stock is assumed to be zero to the actual measurement period is prolonged.

TABLE 2
Growth Accounting Results for the Business Sector in Sweden, 1995–2006

	1995–2006	1995–2000	2000–06
Excluding intangible capital (%)			
Annual value added growth	4.1	4.5	3.8
Contribution of inputs			
ICT tangible capital	0.3	0.6	0.3
Non-ICT tangible capital	1.3	1.6	1.0
Labor	0.2	0.9	–0.4
Labor quality	0.3	0.4	0.3
TFP	1.9	1.1	2.5
Including intangible capital (%)			
Annual value added growth	4.3	5.0	3.7
Contribution of inputs			
ICT tangible capital	0.3	0.5	0.2
Non-ICT tangible capital	1.1	1.4	0.8
Labor	0.2	0.8	–0.3
Labor quality	0.3	0.3	0.3
Intangible capital	1.3	1.7	0.9
TFP	1.2	0.4	1.8

Source: EU KLEMS (2008, 2009), sources listed in Table 1, and own calculations.

accounted for 1.9 percentage points. Thus, a considerable share of the Swedish business sector growth could not be explained by traditional types of inputs, namely labor and tangible capital.

Table 2 also presents growth accounting, estimates with intangible assets included. Value added growth increases to 4.3 percent, indicating that intangibles had a positive effect not only on the level of value added, but also on the business sector growth. ICT tangible capital and non-ICT tangible capital accounted for 0.3 and 1.1 percentage points, respectively. The same holds for labor and labor quality with 0.2 and 0.3 percentage points of business sector growth rate. The largest difference came in the guise of intangible capital, which accounted for as much as 1.3 percentage points of business sector growth. Consequently, intangible capital accounted for 30 percent of total business sector growth in 1995–2006. TFP accounted for 1.2 percentage points; hence, TFP decreased substantially when intangible capital was included in the growth accounting analysis.

For the sub-period 1995–2000, annual business sector growth was 4.5 percent when intangibles were excluded. Labor growth accounted for a considerably larger share of growth with 0.9 percentage points when compared to the period 1995–2006, implying that TFP accounted for 1.1 percentage. When intangible capital was included in the analysis, it accounted for nearly 1.7 percentage points of value added, resulting in TFP growth of 0.4 percentage points as well. Thus, there was considerable investment in intangible capital during the years following the economic and financial crisis in Sweden.

For the period 2000–06, annual business sector growth with intangibles excluded decreased to 3.8 percent. Both the contribution from ICT-tangible capital and non-ICT tangible capital was lower than for the earlier period with 0.3 and 1.0 percentage points, respectively. Labor had a negative impact on growth with approximately –0.4 percentage points. TFP accounted for 2.5 percentage points of value added. When intangible capital was included, the growth rate decreased to 3.7 percent. Intangible capital accounted for 0.9 percentage points of business sector growth, while the impact of other inputs decreased slightly and TFP accounted for 1.8 percentage points.

In total, the results show that intangible capital accounted for a large share of total business sector growth in 1995–2006. When intangible capital was included in the growth accounting analysis, TFP decreased considerably. The results for the sub-periods 1995–2000 and 2000–06 show that intangibles had a much larger impact on business sector growth in the earlier period following the economic and financial crisis in Sweden. TFP only accounted for 0.4 percent of GVA growth in this period. For the period 2000–06, TFP accounted for a larger share of GVA.

5.2. *Contribution to Labor Productivity Growth*

While GVA is a measure of the growth rate of all final goods and services produced, labor productivity measures the growth rate of GVA per amount of labor resources used to produce the output in the economy. Table 3 shows the labor productivity growth in the Swedish business sector 1995–2006 and for the sub-periods 1995–2000 and 2000–06.

For the period 1995–2006, the annual labor productivity growth was 3.8 percent when intangible capital was excluded. ICT tangible capital and non-ICT tangible capital accounted for 0.3 and 1.2 percentage points, respectively. Labor quality accounted for 0.3 percentage points while TFP accounted for 1.9 percentage points. When intangible capital was included, labor productivity growth increased slightly to 4.0 percent. The other inputs all accounted for slightly smaller shares, while intangible capital accounted for 1.2 percentage points of the growth rate and thus 31 percent of the total labor productivity growth. TFP accounted for 1.2 percentage points of the productivity growth when intangibles were included.

TABLE 3

Labor Productivity Growth Accounting Results for the Business Sector in Sweden, 1995–2006

	1995–2006	1995–2000	2000–06
Excluding intangible capital (%)			
Labor productivity growth	3.8	3.2	4.3
Contribution of inputs			
ICT tangible capital	0.3	0.5	0.3
Non-ICT tangible capital	1.2	1.2	1.2
Labor quality	0.3	0.4	0.3
TFP	1.9	1.1	2.5
Including intangible capital (%)			
Labor productivity growth	4.0	3.7	4.2
Contribution of inputs			
ICT tangible capital	0.3	0.4	0.2
Non-ICT tangible capital	1.0	1.0	0.9
Intangible capital	1.2	1.5	1.0
Labor quality	0.3	0.3	0.3
TFP	1.2	0.4	1.8

Source: EU KLEMS (2008, 2009), sources listed in Table 1, and own calculations.

TABLE 4

Contribution of Intangible Capital Deepening to the Annual Change in Labor Productivity in the Business Sector (percentage points)

	1995–2006	1995–2000	2000–06
1. Computerized information	0.15	0.18	0.13
2. Innovative property	0.65	0.81	0.49
a) R&D	0.42	0.53	0.31
b) Mineral exploration	0.002	0.002	0.001
c) Copyright and license costs	0.01	0.02	0.01
d) Development costs in financial industry	0.02	0.03	0.01
e) Design	0.19	0.23	0.15
3. Economic competencies	0.42	0.50	0.34
a) Brand equity	0.11	0.18	0.07
Advertising	0.09	0.13	0.07
Market research	0.01	0.02	0.002
b) Vocational training	0.11	0.14	0.19
c) Organizational structure	0.21	0.22	0.19
Purchased	0.13	0.15	0.12
Own account	0.07	0.07	0.07
Total intangible capital deepening	1.22	1.50	0.96

Source: EU KLEMS (2008, 2009), sources listed in Table 1, and own calculations.

For the sub-period 1995–2000, the labor productivity growth was 3.2 percent when intangibles were excluded, while it increased to 3.7 when they were included in the growth accounting analysis. Intangible capital accounted for 1.5 percentage points and thus for more than 40 percent of the labor productivity growth. In total, inputs accounted for most of the labor productivity growth, implying in turn that TFP was only 0.4 percentage points. Thus, in the period following the economic and financial crisis, investment in intangibles accounted for a very large share of labor productivity growth, which almost reduced TFP to zero.

For the period 2000–06, the labor productivity growth was 4.3 percent and thus more than 1 percentage point higher than in 1995–2000. TFP was as high as 2.5 percentage points. When intangible capital was included the labor productivity growth rate became 4.2 percent. Intangible capital then accounted for 1.0 percentage points and TFP decreased to 1.8 percentage points.

Table 4 shows the decomposition of intangible capital into the different categories of intangible capital. For the period 1995–2006, computerized information, innovative property, and economic competencies accounted for 0.2, 0.7, and 0.4 percentage points, respectively, of labor productivity growth. R&D accounted for the largest share, with approximately 0.4 percentage points, indicating that investment in R&D was of major importance to labor productivity growth. Design, vocational training, and purchased organizational structure were also important for labor productivity growth, with a contribution of 0.2, 0.1, and 0.1 percentage points, respectively. Computerized information and advertising also accounted for significant shares of labor productivity growth.

In total, intangibles accounted for as much as 31 percent of labor productivity growth in the business sector in 1995–2006. For the early period 1995–2000, the share was even higher than 40 percent. For the later period 2000–06 the impact

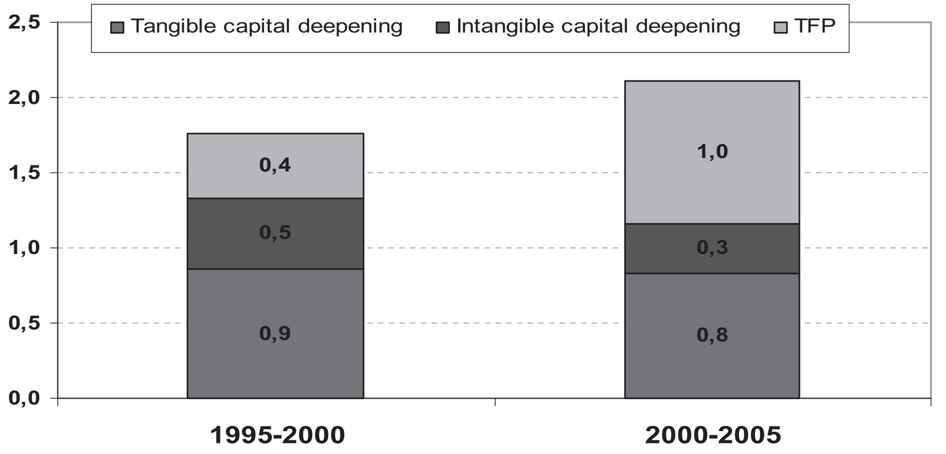

Figure 5. Labor Productivity Growth Accounting Including Intangible Investment in Japan, 1995–2005

Note: Growth accounting estimates are based on the total economy.
Source: Fukao *et al*. (2009).

of intangible capital decreased while TFP became considerably larger. Thus, the results for labor productivity growth follow the same pattern as for GVA growth in the business sector. Moreover, the results seem robust when time period, depreciation rates, deflators, and conversion factors are changed (see Appendix).

5.3. *Comparisons with Other Countries*

Since Japan also went through a considerable financial crisis in the 1990s, it is of particular relevance to compare the Swedish post-crisis development with the Japanese. As shown in Figure 3, intangible investment accounted for a substantial share of GDP in Japan. Figure 5 shows the contribution of intangible and tangible investment to the total economy in Japan for the periods 1995–2000 and 2000–05. As in the Swedish business sector, intangible capital deepening accounted for a larger share in 1995–2000 compared to the period 2000–05. Moreover, in both countries TFP also increased in the latter period.

However, one important difference between the two countries is that labor productivity growth in the business sector was much higher in Sweden for the period 1995–2006. As shown in Figure 1, the labor productivity growth rate in Sweden was 3.7 percent, excluding intangibles, while the corresponding figure for the Japanese business sector was 2.3 percent.[21]

Another difference is that for the Swedish business sector TFP decreases considerably more when intangibles are included in the growth accounting analysis when compared to the Japanese economy. Figure 6 shows TFP growth for the business sector in Finland, France, Italy, Japan, Sweden, the U.K., and the U.S. The figure shows that TFP growth decreased for all countries when intangibles

[21]The Japanese business sector growth rate for 1995–2006 is based on EU KLEMS (2009).

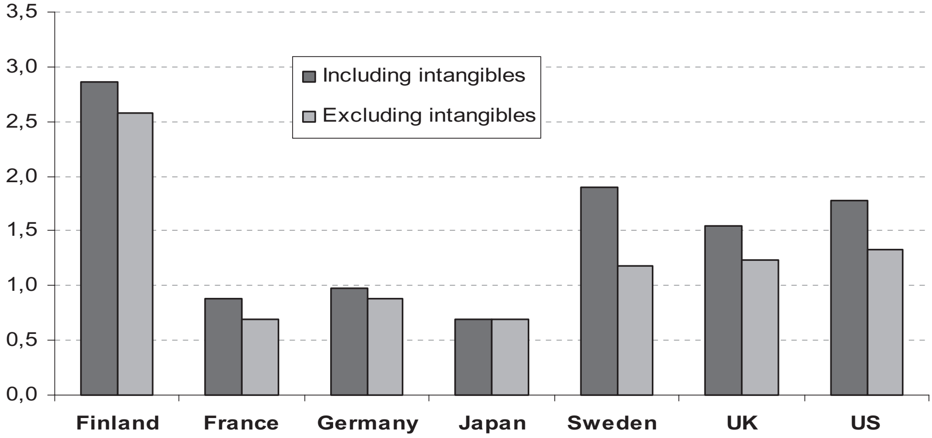

Figure 6. TFP Growth Including and Excluding Intangibles in a Number of Different Countries in 1995–2006

Note: TFP estimates for Finland and Japan are based on the period 1995–2005. Data for Japan are for the total economy, while it is for the market sector in the other countries.

Source: van Ark *et al*. (2009), Corrado *et al*. (2009), Fukao *et al*. (2009), Jalava *et al*. (2007), Marrano *et al*. (2009), and own calculations.

were included in the growth accounting model. For Japan and the U.K. the decrease was not very large. However, the figure clearly shows that for Sweden the TFP decrease was larger than in the other countries when intangible assets were included in the analysis. Thus, investment in intangibles seems to be able to explain a larger share of the labor productivity growth in the Swedish business sector than in other countries.

5.4. *ICT and Intangible Investment*

Sweden's high productivity growth can be largely traced to Swedish firms' large investment in ICT. Several studies have found that ICT had an important impact on productivity growth in Sweden as well as the U.S. (see Oliner and Sichel, 2000; Edquist, 2008; Jorgenson *et al*., 2008). Edquist (2008) argues that ICT accounted for nearly 50 percent of labor productivity growth in the Swedish business sector 1995–2000. However, the results presented in Table 3 show that investment in ICT capital only accounted for 16 percent when intangible assets are excluded.

There are two reasons why the results in this paper differ from Edquist (2008). The first is that software—usually defined as ICT capital—is defined instead as an intangible investment in this paper. Table 4 shows that software accounted for 0.2 percentage points of labor productivity growth in 1995–2000. This also means that if intangible and ICT are not capitalized the growth accounting results will be the same.[22] The second reason is that Edquist (2008) attributes a large share of the TFP growth to ICT, as TFP growth has been very high in the ICT-producing industry. This primarily stems from rapid

[22]If neither ICT nor intangibles are capitalized, non-ICT tangible capital accounts for 1.3 percentage points of the 3.2 percent annual growth in labor productivity.

technological change in the ICT-producing industry, but also the fact that ICT-producing firms have made substantial investments in intangible assets that show up as TFP growth in the ICT-producing industry. For example, the Swedish telecommunications firm Ericsson invested approximately 27 billion SEK in R&D worldwide in 2009.

6. Conclusions

In the early 1990s the Swedish economy experienced a severe economic and financial crisis which resulted in a drop in GDP of 4.3 percent in 1990–93. However, just a few years after the crisis, the Swedish economy was prospering with booming productivity growth. Moreover, the productivity growth remained one of the highest among industrialized countries for more than a decade. What can explain the strong recovery and development of the Swedish economy after the crisis? Economists have claimed that the large Swedish investments in ICT and the market reforms of the 1980s were the causes of the productivity boom. This paper proposes a broader answer, arguing that extensive investment in intangible assets also had an important impact on productivity growth in 1995–2006.

To investigate the impact of investment in intangible assets, data on intangibles was collected based on the framework developed by Corrado *et al*. (2005, 2006, 2009). Although the methodological framework must undergo improvements, the results show that intangibles are quantitatively important. In 2006, total investment in intangibles was 288 billion SEK or 10 percent of GDP. The corresponding figure for physical capital in the business sector was 382 billion, which implies that investment in intangibles accounted for approximately 75 percent of the investment in physical capital.

The estimates of investment in different intangibles were used in a growth accounting framework to decompose economic growth and labor productivity growth in the Swedish business sector. When intangibles were excluded from the analysis, TFP still accounted for 47 percent of economic growth and 50 percent of labor productivity growth. Thus a large part of the productivity boom following the economic and financial crisis in 1995–2006 cannot be explained by the inputs of tangible capital and labor.

When intangible assets were included as capital in the growth accounting analysis, they accounted for as much as 30 percent of economic growth and 31 percent of labor productivity growth. As a result the TFP component decreased radically in both economic and labor productivity growth. As shown in Figure 6, no other country investigated so far exhibits such a large effect on TFP when intangibles are included in the growth accounting framework as does Sweden. Consequently, increased investment in intangible assets explains a large share of the unexplained labor productivity growth.

When the two sub-periods are analyzed, it becomes evident that intangible capital had a particular impact on labor productivity growth. Soon after the economic and financial crisis, in 1995–2000 it accounted for 41 percent of labor productivity growth, while TFP growth only accounted for 11 percent of labor productivity growth. In the second sub-period intangible capital only accounted for 23 percent of labor productivity growth, while TFP accounted for 44 percent of labor productivity growth.

It is important to bear in mind the potential problems of the growth accounting framework when the results are interpreted. Most significantly, it assumes that investment has an immediate and constant effect on growth. It is however more likely investment in both tangible and intangible capital has an effect on growth over many years, rather than on an immediate and 1 to 1 basis. This means that the large investment in intangibles in the mid-1990s could have had large effects on productivity growth after the year 2000 as well, at which point the growth rate of investment in intangible decreased. This could in turn explain the increased TFP growth in 2000–06.

Economists have explained the strong recovery in productivity performance after the Swedish economic and financial crisis in the early 1990s by stressing the recovery effect, market reforms undertaken in the 1980s, and the impact from the technological revolution of ICT, including innovations such as the internet and mobile phones. This paper has revealed another very important explanation: the large investment in intangible assets made by Swedish firms. These investments accounted for as much as 10 percent of GDP in 2006. Based on the growth accounting framework, investment in intangible assets accounted for more than 30 percent of the labor productivity growth from 1995 to 2006.

The estimation of investment in intangibles is no exact science, however; the methodological framework must undergo improvements. Nevertheless, the results presented here are robust and imply that the investment in intangibles accounts for a large share of the recovery in productivity performance after the economic and financial crisis in Sweden in the early 1990s. The argument underscores how the Swedish economy has become more dependent on intangible investment, including many knowledge intensive services. Since intangibles are important for understanding and analyzing economic and productivity growth, they should also be included in the National Accounts.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix: Sensitivity Analysis.

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