Can Investment in Intangibles Explain the Swedish Productivity Boom in the 1990s?*

By

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Abstract

After a severe crisis in the early 1990s, the Swedish economy experienced a boom in productivity growth. According to economists there have been primarily three explanations for the fast productivity growth in 1995–2004: Market reforms, recovery from the crisis and the impact of information and communication technology (ICT). This paper offers an alternative view by recognizing that firms make substantial investment in intangible assets such as R&D, design, advertising etc. These investments are not classified as investment in the National Accounts, where only tangible assets are defined as investment. This paper provides estimates of investment in intangible assets and uses the growth accounting framework to analyze the Swedish productivity boom. The results show that investment in intangibles was approximately 246 bn SEK in 2004 or 9 percent of GDP. Moreover, intangible capital accounted for almost 50 percent of labor productivity growth in the Swedish business sector 1995–2004. Thus, investment in intangibles was an important source to the Swedish productivity boom in 1995–2004.

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1. Introduction

After a severe crisis in the early 1990s, productivity growth started to increase in Sweden in the mid-1990s. Many economists thought that the high productivity growth was due to the recovery of the crisis and would evaporate after a few years. But productivity growth remained high throughout the period 1995–2005, even during the economic slowdown in 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*).

It has been argued by economists that there are primarily two reasons why Swedish business sector productivity growth has remained considerably higher than in many other industrialized countries: The effects from market reforms in the 1980s and the revolution in information and communication technology (ICT). Market reforms are believed to have effects on competition and thereby increasing the efficiency in the use of resources and thus productivity (Nickell 1996). In theory, efficient markets also lead to increased diffusion of new technology and increase the incentives to innovate. Despite the evidence of a positive impact of increased competition on productivity growth, it has been difficult to establish direct links between Swedish market reforms in the 1980s and productivity growth in the 1990s due to long time lags.

According to Schumpeter (1939) innovations are 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 the 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 och Henrekson 2006; Edquist 2008). Similar evidence was found for the US

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[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).

economy (Oliner and Sichel 2000; Jorgenson 2001; Jorgenson *et al*. 2008; Stiroh 2002).

Although ICT investment remained important for productivity growth after the turn of the millennium, its relative impact started to decrease (Jorgenson *et al*. 2008; Edquist 2008). Instead, total factor productivity growth increased in both Sweden and the US. Thus, the increase in productivity failed to remove all suspicion surrounding the ability of official data to accurately capture the factors that affect economic growth (Corrado, Hulten and Sichel (CHS) 2006). Several studies have argued that an important additional explanation for economic growth is investment in intangible assets (CHS 2005; 2006; Marrano and Haskel 2006; Marrano, Haskel and Wallace (MHW) 2007; Hao and Manole 2008).

In the Swedish national accounts, intangibles have been treated as an intermediate expense and not as an investment.[2] Intangibles are considered difficult to measure compared to tangible assets such as buildings and machinery. Nevertheless, many advanced economies are moving towards "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 education and research and development has increased. One way of defining intangible investment is as expenditures by businesses intended to boost output in the future that do not take the form of traditional physical capital (CHS 2005; 2006). Unlike physical capital, its value does not appear on a firm's balance sheet.[3]

To my knowledge, the impact of intangibles on the Swedish economy has never been systematically explored at the macro-level.[4] Thus, this paper will use the methods developed by CHS (2006) and Marrano and Haskel (2006) to estimate expenditures and investment in intangibles in the Swedish business sector in 1995–2004. The results will be compared with similar results for the UK and the US. Based on these

[2] Computer software which is defined as an intangible capital in this paper is included in the Swedish GDP figures.
[3] As opposed to tangible assets the value of intangibles is highly uncertain; a competitive market for intangible assets often does not exist.
[4] Eliasson (2000) investigates the impact of some intangibles on the 9 and 17 largest manufacturing firms in Sweden.

estimates the growth accounting framework will be used to investigate how important investment in intangibles was for economic growth and productivity growth in Sweden in 1995–2004.

The following questions will be investigated:

- How large were intangible spending and investment in the Swedish business sector in 2004?
- How does intangible investment in Sweden compare to other countries like the UK and the US?
- How important were investment in intangibles for economic growth and productivity growth in the Swedish business sector 1995–2004?

2. Data and sources

CHS (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.[5]

This paper follows the methodological framework set up by CHS (2006). According to CHS, intangible assets can be organized 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, design)
3. Economic competencies (brand equity, vocational training and organizational capital)

[5] Sweden has a large public sector compared to both the US and the UK. This implies that comparisons of investment in intangible assets in the private sector expressed as a percentage of total GDP could be affected.

Various methods and surveys are used to estimate the spending on such assets for the years 1995–2004. The specific methods and sources for Sweden are described below. It should be noted that the spending only measures the total expenditure on a specific asset and therefore in some cases includes both current consumption and deferred consumption. Only deferred consumption can be considered as investment and therefore different methods are used to separate the spending on current production from actual spending that is made to expand future productive capacity (see section 4).

2.1 Computerized information

2.1.1 Computer software

The estimates for computer software stem from the EU KLEMS (2008), a database financed by the European Commission to analyze productivity in the European Union at the industry level. The database includes measurements of output growth, employment, skill creation, capital formation and total factor productivity at the industry level. Investment is measured by nominal gross fixed capital formation (GFCF) in software for Sweden 1995–2004. Investment for the public sector is excluded.

2.1.2 Computerized databases

Spending on computerized databases is already included in the estimates of software spending provided by the EU KLEMS (2008) database for Sweden.

2.2 Innovative property

2.2.1 Research and development (R&D)

R&D expenditure data for Sweden is derived from the ANBERD database (OECD 2006). The ANBERD database has been constructed with the objective of creating a consistent data set that covers business enterprise expenditures on R&D (BERD) in

OECD countries. The guidelines for the collection of internationally comparable BERD data are set out by the Frascati Manual (2002). According to the Frescati Manual, R&D is defined 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".

The basic criterion for distinguishing R&D from other activities is that R&D should include an appreciable element of novelty and the resolution of scientific and technological uncertainty. Thus, it is likely that most R&D that is reported is of scientific nature and items such as design and market research will not be included in R&D figures. Moreover, in order to avoid double counting with the software figures, the total R&D spending was deducted with the R&D spending on computer and related activities.[6] Moreover, R&D figures for social science and humanities in the business sector were added based on data from Statistics Sweden.[7]

2.2.2 Mineral exploration

Mineral exploration is based on data from the Geological Survey of Sweden. It primarily covers the prospecting of 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

CHS (2006) estimate copyright and license costs with the development of motion pictures and that of radio, television, sound recording and book publishing. Unfortunately, there is no data over development costs available for the Swedish radio, television, sound recording and book publishing. However, there is data from Sweden available for the development costs of motion pictures based on Screen

[6] For the year 2005 data is based on figures provided by Statistics Sweden. Moreover, for the years 2004 and 2005 it is assumed that R&D spending on computer and related activities were the same as in 2003 since data is missing.

[7] R&D in social science and humanities is measured as the output of the industry producing social science research (SNI 732). To capture own account spending the expenditure is multiplied with a factor of 2. Moreover, in 2005 R&D in social science and humanities only accounted for 0.3 percent of total R&D spending.

Digest (2005). Moreover, there is also data on the turnover of motion pictures and video production and sound recording. Thus, the ratio of investment in motion picture over the total turnover of the industry can be estimated.[8] It then is assumed that the video production and sound recording industry has the same investment/turnover ratio as the motion picture industry.

2.2.4 Development costs in financial services

Product development in the financial services industry is measured by CHS to be 20 percent of total intermediate spending by financial services. I therefore use the measure of intermediate service input which excludes intermediate spending in the manufacturing sector. According to Marrano and Haskel (2006) one problem is that intermediate spending includes the purchase of advertising, software, consulting services and architectural and engineering activities which is calculated elsewhere in the spending calculations. Unfortunately it is not possible to subtract spending on these activities from the Input-Output tables, because there is only data available at the 2-digit industry level. The source of the intermediate service spending is EU KLEMS (2008).

2.2.5 Design

It is important to be aware of what is meant by design before trying to quantify the extent of design as an economic activity. Distinguishing design from other activities matters because several design-related activities are already counted in the formation of capital in the National Accounts. According to Marrano and Haskel (2006) a good starting point to define the design activity is the relationship between design activities and the official measurement of R&D under the Frescati Manual framework. According to the latter if design is made for the setting up and operating of pilot plants and prototypes, these costs should be included in R&D. However, if they are carried out for the preparation, execution and maintenance of production

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[8] Data on the development cost in motion pictures is only available for the period 2000–2004. For the years 1993–1999 and 2005 it is assumed that the investment/turnover ratio is the same as the average for the years 2000–2004.

standardization or to promote the sale of products, they should be excluded from the definition of R&D.

The System of National Accounts (1993) sets out the convention regarding the treatment of design services. Accordingly, these are fully used up or fully transformed by the production process. This implies that design services are treated in most cases as intermediate consumption, not as capital investment. It also implies that the costs of in-house design activities are deemed not to generate an independent output and so not counted as a separate product.

In CHS 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, in this paper both purchased and own account design activities are estimated by more sophisticated methods. Thus, the AED services bought in the marketplace and the AED services which companies produce in-house for internal use will be measured.

Galindo-Rueda, Haskel and Pesole (GHP) (2008) estimate the spending on design in the UK by using wages earned by designers and supply-use tables for the product group Architectural activities and technical consultancy. Unfortunately, it has not been possible to obtain supply-use tables for Sweden at the disaggregated level that is needed to measure the supply of architectural activities and technical consultancy services. Thus, the methods used in this paper will differ from the methods developed by GHP (2008).

The AED services brought in the market place 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 that 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. Based on GHP (2008) the following occupations have been defined as design occupations: Architects and town planners (SSYK 2141), Civil engineers (SSYK 2142), Electrical engineers (SSYK 2143), Electronics and telecommunications engineers (SSYK 2144), Mechanical engineers (SSYK 2145), Chemical engineers (SSYK 2146), Designers (SSYK 2456) and Decorators and commercial designers (SSYK 3471).[9] Thus the spending on purchased design activities can be written[10]:

$$Y_p = Y^{742} \cdot \frac{N^{742AED}}{N^{742}} \qquad (1)$$

Where, Y_p is the measured purchased AED output, Y^{742} is the output of SIC 742 and N^{742AED} is the number of employees with design occupations in SIC 742 and N^{742} is the number of 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 both working within SIC 742 and outside. This implies that by multiplying this ratio Y_p/ wN^{742AED} with the wage bill of persons with design occupations not working in SIC 742 (wN^{BAED}) we obtain the own account output. This can be expressed in the following formula:

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

where Y_{own} is the own account output, Y_p the purchased output.[11]

[9] SSYK is the Swedish Standard Classification of Occupations.
[10] For some engineering occupations it is likely that the employees to some extent is also involved in R&D activities which then implies double counting. This problem is further discussed in Appendix A.
[11] Data for all variables in equation 1 and 2 is available for the period 1997–2005. For the period 1995–96 the wage bill has been estimated based on the average ratio of wage bill/turnover for the years 1997–2005. Moreover, data on the number of persons employed in SIC 742 1995–96 are based on the average ratio of employment in SIC 742 and total employment in 1997–2005.

2.3 Economic competences

2.3.1 Brand equity

2.3.1.1 Advertising

Data on spending on advertising is based on 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.[12]

The available data includes the public sector. According to a survey by SIFO Research International approximately 1.1 percent of all spending on advertisement was made by the government sector in 2007. Hence, it is assumed that this share is the same for the period 1993–2004 and the total investment is deducted by 1.1 percent for each year. However, this does not include the investments made by “Svenska Spel”, the state-owned gambling company.

2.3.1.2 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

Spending on vocational training by firms is measured using data on how much firms in the business sector spent on continuing vocational training (CVT). The source is a survey of employer provided training conducted by Statistics Sweden in 1999 (CVTS 1999). A similar survey was carried out in 2005, but it was never published by Statistics Sweden due to a low response ratio.

[12] It is assumed that classified ads also accounted for 8 percent of the total spending on advertisement for the period 1995–2005.

CVTS (1999) measures the direct and indirect costs of continuing vocational training in firms with at least 10 employees as a percentage of total labor costs in 1999. Thus, to measure the spending on vocational training for all firms it is assumed that firms with less than 10 employees spend the same proportion of their total labor costs on vocational training. Moreover, it is assumed that the proportion of labor costs spend by firms in 1995–2004 is the same as in 1999. This assumption must be made due to the fact that reliable data on continuing vocational training is only available for the year 1999.

2.3.3 Organizational structure

2.3.3.1 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 products that only include services that affect organizational structure are included.[13] Moreover, the share of the turnover that is purchased by the public sector is excluded based on data from the Swedish business magazine Affärsvärlden (2001–2004).[14]

2.3.3.1 Own account organizational structure

Investment in own-account organizational structure is measured as 20 percent of managers' compensation. The occupation used for managers is "Legislators, senior officials and managers". However, since the public sector is excluded legislators and senior government officials are excluded, but senior officials working for special-interest organizations are still included.

The data is based on Statistics Sweden. Wage data for each group of managers is available for the period 1997–2005. There are no wage data available for the period

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[13] The following services are assumed to affect organizational structure: Advise 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 and the same share is therefore used to estimate purchased organizational structure for other years.

[14] 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 2001–2004.

1995–1996 for each group of managers. Therefore it has been assumed that 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

3.1 Results for Sweden

Table 1 shows that the total spending on intangibles in Sweden in 2004 was 300 billion SEK. Thus, the spending was approximately 11 percent of total GDP and 17 percent of total value added in the business sector. *Table 1* also shows the spending for the different categories of intangibles. The largest expenditure was on R&D with 68 billion or 23 percent of total spending on intangibles. This corresponds well with the general view that Sweden is considered to be an R&D-intensive country. Spending was also considerable for design, software, advertising, vocational training and purchased organizational structure. In fact, together with R&D these categories of assets accounted for almost 90 percent of the total spending on intangibles.

Spending on own account organizational structure was 15 billion SEK and thereby accounted for 5 percent of total spending. For all other categories of intangibles the spending was 2 percent or less of the total expenditure on intangibles. For mineral exploration the spending was as low as 0.1 percent of the total spending.

3.2 Comparisons with other countries

Figure 2 shows the private spending on intangibles as a percentage of GDP in Sweden, the UK and the US for the three major intangible asset categories: computerized information, innovative property and economic competencies. All countries spent close to similar percentages on software. However, Sweden spent more than the other countries in relative terms on innovative property, but the spending on economic competencies was lower in Sweden compared to the other countries.

Table 2 presents the results of spending on intangibles as a percentage of GDP for all sub-categories. According to *Table 2* the spending on R&D was higher in Sweden than in the US and considerably higher than in the UK. Swedish private spending on scientific R&D accounted for 2.6 percent of GDP. Hence, Sweden spent more than twice as much as the UK on R&D. The US spent considerably more on copyright and licence costs than Sweden and the UK. Development costs in the financial industry were also higher in the US and the UK, while the share of design spending was considerably larger in Sweden.

Sweden spent approximately the same amount as the UK on advertisement, but a considerably larger amount was spent in the US. Moreover, Swedish and US firms spent a little bit more than 1 percent of GDP on vocational training, while the UK spending was 2.5 percent. Spending on organizational structure was lower in Sweden compared to the other countries. As a percentage of GDP spending on own account organizational structure was more than 3 times higher in the US. However, the way own account organizational structure is measured poses some doubts about what is actually measured. For example US managers are in general better paid than their Swedish colleagues, but it does not necessarily mean that they are more productive.

In total, the US had the highest private spending on intangibles in relative terms with 13 percent of GDP. For Sweden and the UK the corresponding figures were approximately 11 percent. Hence, the relative spending on intangibles in the business sector was higher in the US, but was also a large share of GDP in the UK and Sweden. However, since Sweden has a larger public sector than the US and the UK, it is possible that its relative spending on intangibles would be higher if only value added for the business sector was considered.

Figure 3 shows the spending on intangibles as a share of GDP and value added in the business sector for the three countries. The Swedish spending on intangibles was 17 percent, while the corresponding figures for the UK and the US were 16 and 18 percent, respectively. Thus, in relative terms the Swedish spending was larger than the British and the gap to the US decreased when the business sector was considered instead of total GDP. This is explained by the fact that the public sector in Sweden is larger than in the two other countries.

4. How much of the spending is investment?

According to CHS (2005, 2006) and MHW (2007) 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. The service life of a specific asset can sometimes be ambiguous. For example the definition used by the Bureau of Economic Analysis (BEA) might differ depending on the sector that is considered. The BEA approximate that business fixed assets have a useful service life of at least three years, but there are also studies defining business sector equipment as having a service life of more than one year.

Based on this logic CHS (2005) use four different steps to estimate the proportion of spending that can be considered as investment.

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 a 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 a strong suspicion that a portion of the spending may be of routine tasks or represent current consumption, the point estimate is discounted 20 percent.

It is recognized that these steps do not provide a precise measure of the spending that can be considered to be capital investment. Especially the last two steps are vague and the discounted percentage is arbitrary. Nevertheless, in total the results by CHS (2005) show that business spending on intangibles was a substantial and growing component of the economy in the 1990s. Though, it is essential that future research try to improve these methods.

Table 1 shows the proportion of spending considered as investment based on CHS (2005). Little is known about the service life of software. However, the BEA assumes three years service life for all prepackaged software and a five year service life for custom and owned software. Therefore CHS (2006) assume that 100 percent of the 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 costs and development costs in financial services.

Based on estimates provided by GHP (2008) only 50 percent of design spending should be counted as investment. Economic research on marketing finds that the effects of advertising are generally short lived. However, according to Landes and Rosenfield (1994) more than half has a service life of at least one year and one-third makes a cutoff of three years. Thus, CHS (2005) estimate that approximately 60 percent of total advertising expenditures have long lasting effects. Continuing vocational training has long lived effects and is therefore counted as investment. Spending on organizational change is also likely to have long-lived effects. However, a portion of purchased management expertise is rather routine tasks and therefore only 80 percent of the purchased spending on organizational structure is considered as investment.

It is evident that the process of estimating the proportion of the spending that is actually investment in many cases is not very precise but rather based on ad hoc assumptions. Nevertheless, it is of importance to use the best available information to try to measure investment in intangibles. Moreover, for some of the more important types of intangibles like scientific R&D and vocational training the service life is without doubt at least 3 years and 100 percent of the spending should therefore be counted as investment.

Figure 4 shows that the measured spending on intangible assets was approximately 11 percent of GDP in 2004. Based on the method described above, it is estimated that the total investment in intangibles was 246 billion SEK or 9 percent of GDP. The Swedish investment in fixed capital for the business sector in 2004 was 361 billion SEK or 14 percent of GDP. Hence, the estimated investment in intangibles was almost two-thirds of the investment in physical capital. This clearly shows that investment in intangibles was considerable in comparisons with investment in physical capital.

It is also interesting to note that in 1960 the investment in physical capital in the Swedish business sector was 22 percent of GDP. The 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 the total investment becomes 23 percent of GDP. There are no estimates available for intangible capital in 1960, but it is likely that investment in intangibles were much lower in 1960 compared to 2004. Thus, it is not necessarily true that investment in the Swedish economy has decreased quite rapidly as argued my many economists. It is more likely that the structure of the Swedish economy has become more based on services.

5. Growth accounting methodology

The growth accounting methodology is used to analyze the impact of intangibles on productivity growth and labor productivity growth. The model used is based on CHS (2006) and MHW (2007). It assumes that there are three goods produced, a consumption good, with real output volume C_t and price P_t^C, 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 the Swedish national accounts most intangibles are treated as intermediates, while it could be argued that they should be treated as capital.

5.1 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:

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

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:

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

(b) Tangible sector:

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

(c) Consumption sector:

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

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 (3 and 4) 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:

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

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.

5.2 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, $P_t^R R_t$, 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:

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

where the total output of the intangible good $N=N_N+N_I+N_C$ and the intangible stock is $R=R_N+R_I+R_C$.

The following conclusions can be drawn. With intangibles being treated as capital output is increased from $P_t^{Q'} Q_t'$ to $P_t^Q Q_t$. The investment rate increases from $P_t^I I_t / P_t^{Q'} Q_t'$ to $(P_t^I I_t + P_t^N N_t) / P_t^Q Q_t$ and the labor share falls from $P_t^L L_t / P_t^{Q'} Q_t'$ to $P_t^L L_t / P_t^Q Q_t$ where labor share is the proportion of total income paid to labor.

5.3 Growth accounting

Based on the growth accounting framework described in sections 5.1 and 5.2 the growth accounting relations can be written in the following way:

$$\Delta \ln Q_t^{'} = s_t^{'L} \Delta \ln L_t - s_t^{'K} \Delta \ln K_t + \Delta \ln TFP_t^{'} \quad (13)$$

$$\Delta \ln Q_t = s_t^{L} \Delta \ln L_t - s_t^{K} \Delta \ln K_t + s_t^{R} \Delta \ln R_t + \Delta \ln TFP_t \quad (14)$$

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:

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

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

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.[15] In equation (16) the level of output has risen, however, 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 for tangibles there are plant, buildings, vehicles and computer hardware; for intangibles there are R&D, software, design etc. Thus, the ΔlnK and ΔlnR 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

[15] 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.

output. These services for each type of capital can be measured by the rental payments that a profit-maximizing firm would pay were it is renting its capital. Since firms rarely do this but 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:

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

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 ΔlnK and ΔlnR 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. This can be written:

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

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 ΔlnK and ΔlnR

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

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

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 therefore they 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 equation (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 in the following steps.

a) Collect a time series of nominal investment in intangible and tangible assets, deflate to get real investment series and build a real capital stock using perpetual inventory method. See equations (3) and (8).
b) Re-calculate market sector value added to include intangibles, see equation (7).
c) Adjust the operating surplus φ for market sector value added, see equation (18).
d) Calculate volume index of capital services of all capital inputs, ensuring the asset rental payments are consistent with the adjusting operating surplus, see equations (17)–(20).
e) Build a quality adjusted labor index to measure L^{QA} in equations (13)–(16)
f) Undertake growth accounting in equations (13)–(16)

6. Growth accounting results

Growth accounting for the Swedish business sector has been carried out for both GDP growth (see equations 13 and 14) and labor productivity growth (see equations 15 and 16). The growth of GDP and labor productivity is analyzed both including and excluding intangible capital. The analysis is based on the time period 1995–2004 and for the subperiods 1995–2000 and 2000–2004. The choice of subperiods has been made to analyze the boom years of the Swedish ICT miracle and the years after the burst of the Swedish ICT bubble.

6.1 Contribution to business sector growth

Table 3 shows the result of the growth accounting for the whole period 1995–2004. When intangibles are excluded the annual the business sector growth was 3.9 percent. ICT tangible capital accounted for 0.4 percentage points of the value added increase while other tangible capital accounted for 1.3 percentage points. Labor and labor quality accounted for 0.1 and 0.3 percentage points, respectively. The residual, TFP, accounted for 1.8 percentage points. Thus, a considerable share of the Swedish business sector growth could not be explained by the traditional types of inputs i.e. labor and tangible capital.

Table 3 also presents figures of growth accounting including intangible assets. The value added growth then increases to 4.1 percent, indicating that intangibles also 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 1.2 percentage points, respectively. The same holds for labor and labor quality with 0.1 and 0.3 percentage points of business sector growth rate. The largest difference is found for intangible capital that accounted for as much as 1.8 percentage of business sector growth. Hence, intangible capital accounted for 44 percent of the total business sector growth in 1995–2004. TFP only accounted for 0.4 percentage points, and thus TFP decreased substantially when intangible capital was included in the growth accounting analysis.

For the subperiod 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 compared to the period 1995–2004. This implies that TFP accounted for 1.1 percentage points compared to 1.8 percentage points in 1995–2004. When intangible capital was included in the analysis it accounted for nearly 2.5 percentage points of value added also resulting in negative TFP growth by –0.5 percentage points. Thus, investment in intangible capital was considerable during the Swedish productivity boom of the 1990s.

For the period 2000–2004 annual business sector growth decreased to 3.2 percent with intangibles excluded. Both the contribution from ICT-tangible capital and non-ICT tangible capital was lower than for the earlier period with 0.2 and 1.0 percentage points, respectively. Labor had a negative impact on growth with approximately –0.8 percentage points. TFP accounted for 2.6 percentage points of value added. When intangible capital was included the growth rate decreased to 3.0 percent. Intangible capital accounted for 0.9 percentage points of business sector growth, while the impact of other inputs decreased slightly and TFP still accounted for 1.5 percentage points.

In total, the results show that intangible capital accounted for a large share of total business sector growth in 1995–2004. When intangible capital was included in the growth accounting analysis, TFP decreased considerably. The results for the subperiods 1995–2000 and 2000–2004 show that intangibles had a much larger impact on business sector growth in the earlier period, where inputs accounted for all growth and TFP was negative. For the period 2000–2004 TFP accounted for a larger share of business sector growth.

6.2 Contribution to labor productivity growth

While GDP is a measure of the growth rate of all final goods and services produced, labor productivity measures the growth rate of GDP per amount of labor resources used to produce the output in the economy. *Table 4* shows the labor productivity growth in the Swedish business sector 1995–2004 and for the subperiods 1995–2000 and 2000–2004.

For the period 1995–2004 the annual labor productivity growth was 3.7 percent when intangible capital was excluded. ICT tangible capital and non-ICT tangible capital accounted for 0.3 and 1.3 percentage points, respectively. Labor quality accounted for 0.3 percentage points while TFP accounted for 1.8 percentage points. When intangible capital was included, labor productivity growth increased slightly to 3.9 percent. The other inputs all accounted for slightly smaller shares, while intangible capital accounted for 1.8 percentage points of the growth rate and thus 46 percent of the total labor productivity growth. TFP accounted only for 0.4 percentage points of the productivity growth when intangibles were included.

For the subperiod 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 2.3 percentage points and thus more than 60 percent of the labor productivity growth. In total inputs accounted for all the labor productivity growth implying that TFP was negative.

For the period 2000–2004 the labor productivity growth was 4.4 percent and thus more than 1 percentage points higher than in 1995–2000. TFP was as high as 2.6 percentage points. When intangible capital was included the labor productivity growth rate became 4.2 percent. Intangible capital then accounted for 1.1 percentage points and TFP decreased to 1.5 percentage points.

Table 5 shows the decomposition of intangible capital into the different categories of intangible capital. For the period 1995–2004 computerized information, innovative property and economic competencies accounted for 0.2, 1.0 and 0.6 percentage points of labor productivity growth. R&D accounted for the largest share with approximately 0.7 percentage points, indicating that investment in R&D was of very high importance to labor productivity growth. Design, vocational training and purchased organizational structure were also important for labor productivity growth with a contribution of 0.3, 0.2 and 0.2 percentage points, respectively. Computerized information and advertisement also accounted for significant shares of labor productivity growth.

In total, intangibles accounted for as much as 46 percent of labor productivity growth in the business sector in 1995–2004. For the subperiod 1995–2000 the share was even higher than 60 percent making TFP turn negative. For the period 2000–2004 the impact of intangible capital decreased while, TFP became larger. Thus, the results for labor productivity growth follow the same pattern as for GDP growth in the business sector.

6.3 Comparisons with other countries

There has been a number of studies of the impact of intangibles on growth and productivity growth for other countries (see CHS 2006; MHW 2007; Hao and Manole 2008). The results show that investment in intangibles accounted for a substantial part of GDP and labor productivity growth in the US, the UK, Germany, France, Italy and

Spain in 1995–2003. Among these countries the US had the highest productivity growth with 3.1 percent per year. Intangible capital accounted for 0.8 percentage points or 27 percent of the total labor productivity growth. However, the total factor productivity remained as high as 1.1 percentage points even when intangible assets were included in the growth accounting model.

In the UK and France annual labor productivity growth was 2.9 percent and 2.2 percent, respectively. Intangible capital accounted for 0.6 and 0.7 percentage points, which then implies that the relative impact from intangible capital was 20 and 34 percent, respectively. For Germany annual labor productivity growth was lower with 1.6 percent, but the relative impact from intangibles was as high as 41 percent.

When the results presented for Sweden are compared with the other countries it is evident that the labor productivity growth in the Swedish business sector was the highest among the countries with 3.9 percent per year. Moreover, no other country had as high TFP growth as Sweden when intangibles were excluded (se *figure 1*). Thus, for no other country the actual TFP growth decreased so much as for Sweden when intangible assets were included in the growth accounting analysis in 1995–2004.

6.4 ICT and intangible investment

One important explanation for the high productivity growth is that Swedish firms to a large extent invested in ICT. Several studies have found that ICT had an important impact on productivity growth in Sweden as well as the US (see Oliner and Sichel 2000; Gordon 2000; Stiroh 2001; Edquist and Henrekson 2006; 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 4* shows that investment in ICT capital only accounted for 16 percent when intangible assets are excluded.

There are primarily two reasons why the results in this paper differ from Edquist (2008). The first is that software that is usually defined as ICT-capital in this paper is defined as an intangible investment. *Table 5* shows that software accounted for 0.2

percentage points of the labor productivity growth in 1995–2000. The second reason is that Edquist (2008) attributes a large share of the TFP growth to ICT. The reason is that TFP growth has been very high in the ICT-producing industry. This is primarily due to rapid technological change in the ICT-producing industry, but also to the fact that ICT-producing firms have made substantial investments in intangible assets that show up as TFP growth in the ICT-producing industry instead as intangible investment. For example the Swedish telecommunication equipment firm Ericsson invested approximately as much as 31 billon SEK in R&D worldwide in 2008.

7. Conclusions

Few industrialized countries have had as high growth rates of productivity as Sweden since the mid 1990s. Among economists large Swedish investment in ICT and the market reforms undertaken in the 1980s to improve competition have been two important explanations for the productivity boom. In this paper it is argued that extensive investment in intangible assets also had an important impact on the productivity growth in 1995–2004.

To investigate the impact of investment in intangible assets, data of intangibles has been collected based on the framework by CHS (2005; 2006). Although the methodological framework must undergo improvements the results show that intangibles are quantitatively important. In 2004 the total private spending on intangibles was 300 billion SEK which is equivalent to 11 percent of GDP or 17 percent of value added in the business sector. Corresponding figures for the UK and the US were 11 and 13 percent of GDP, respectively.

Based on the method in CHS (2005), 246 of the 300 billion of spending on intangibles could be considered as investment. The corresponding figure for physical capital in the business sector was 361 billion, which implies that investment in intangibles accounted for approximately two-thirds of the investment in physical capital. Thus, investment in intangibles accounted for 9 percent of total GDP in 2004.

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, tangible assets, including ICT, accounted for 43 and 44 percent of economic and labor productivity growth, respectively. However, TFP still accounted for 45 percent of economic growth and 48 percent of labor productivity growth. Thus a large part of the productivity boom in 1995–2004 could not be explained by the respective inputs of tangible capital and labor.

When intangible assets were included in the growth accounting analysis the impact from other inputs decreased to 37 percent of both economic and labor productivity growth in 1995–2004. Intangible capital accounted for as much as 44 percent of economic growth and 46 percent of labor productivity growth. This also implied that the TFP component decreased radically to 9 percent of both economic and labor productivity growth. From these results it is possible to draw the conclusion that a large share of the unexplained labor productivity growth was explained by increased investment in intangible assets.

When the two subperiods are analyzed it is evident that intangible capital had a particular impact on labor productivity growth in 1995–2000. It then accounted for 63 percent of labor productivity growth. This also implied that TFP became negative, indicating that the inputs actually accounted for more than the actual output. It could be argued that this is a sign of overinvestment. In the second subperiod intangible capital only accounted for 27 percent of labor productivity growth, while TFP accounted for 37 percent of labor productivity growth.

It is important to be aware of the potential problems of the growth accounting framework when the results are interpreted. One of the problems with the growth accounting framework is that it assumes that investment has an immediate and constant effect on growth. It is however most likely that investment in both tangible and intangible capital has an effect on growth over many years, but in the growth accounting framework the effects are immediate and on a 1 to 1 basis. This makes it possible to argue that the large investment in intangibles in the mid 1990s could have had large effects on productivity growth also after the year 2000 when investment in intangible deceased this could be one of the reasons to the increased TFP growth in 2000–2004.

The strong productivity performance in the Swedish economy since the mid 1990s has among economists, primarily, been explained by a 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 shown that another very important explanation is the large investment in intangible assets made by Swedish firms. These investments accounted for 300 bn SEK in 2004 or as much as 9 percent of GDP. Based on the growth accounting framework, it is shown that investment in intangible assets accounted for as much as 46 percent of labor productivity growth in 1995–2004.

It is recognized that the estimation of investment in intangibles is no exact science and that the methodological framework must undergo improvements. Nevertheless, based on the results presented here it can be argued that the Swedish economy has become more dependent on intangible investment, including many knowledge intensive services. Moreover, since intangibles are important for understanding and analyzing economic and productivity growth, they should also be included in the National Accounts.

8. Tables and figures

8.1 Tables

Table 1 Spending on intangible assets in Sweden 2004

Type of intangible investment	*Sources*	*Total spending 2004 (bn SEK)*	*Percent of intangibles*	*Proportion of spending considered as investment*
1. Computerized information		**48.2**	**16**	
a) Computer software	EU-KLEMS	48.2	16	1
b) Computerized databases	Included in computer software	n.a.	n.a	1
2. Innovative property		**140.0**	**47**	
a) R&D	OECD ANBERD	68.3*	23	1
b) Mineral exploration	SGU (Geological Survey of Sweden)	0.25	0.1	1
c) Copyright and license costs	Screen Digest	1.5	0.5	1
d) Development costs in financial industry	EU-KLEMS	6.6	2	1
e) Design	Statistics Sweden	63.3	21	0.5
3. Economic competencies		**109.3**	**37**	
a) Brand equity				
Advertisement	Swedish Institute for Advertisement (IRM)	37.4	12	0.6
Market Research	Statistics Sweden	4.7	2	0.6
b) Vocational training	Statistics Sweden	27.6	9	
c) Organizational structure				
Purchased	Statistics Sweden and Affärsvärlden	27.3	9	0.8
Own-account	Statistics Sweden	15.1	5	1
Total Spending		**300.4**	**100**	

Note: *To avoid double counting the investment in R&D is deducted with the R&D investment for computer and related activities. The latter is based on the year 2003 while total R&D investment is based on the year 2004.

Sources: "*Sources*" in table and own calculations.

Table 2 **Percentage of GDP spending on intangible assets in Sweden and the UK in 2004 and the US in 1998–2000**

Type of intangible investment	*Sweden*	*US*	UK
1. Computerized information	**1.8**	**1.7**	**1.7**
a) Computer software	n.a.	n.a.	n.a.
b) Computerized databases	n.a.	n.a.	n.a.
2. Innovative property	**5.3**	**4.6**	**3.2**
a) R&D	2.6	2.1	1.1
b) Mineral exploration	0.01	0.2	0.04
c) Copyright and license costs	0.1	0.8	0.2
d) Development costs in financial industry	0.3	0.8	0.7
e) Design	2.4	0.7	1.2
3. Economic competencies	**4.3**	**6.9**	**6.0**
a) Brand equity	1.6	2.5	1.6
Advertisement	*1.4*	*2.3*	*1.2*
Market Research	*0.2*	*0.2*	*0.4*
b) Vocational training	1.1	1.3	2.4
c) Organizational structure	1.6	3.1	1.9
Purchased	*1.0*	*0.9*	*0.6*
Own-account	*0.6*	*2.3*	*1.3*
Percent of total GDP	**11.4**	**13.1**	**10.9**

Sources: CHS (2006), Marrano and Haskel (2007) and own calculations.

Table 3 Growth accounting with and without intangible assets for the business sector

	1995–2004	1995–2000	*2000–2004*
	Excluding Intangible Capital (%)		
Annual GDP growth rate	**3.9**	**4.5**	**3.2**
Contribution of inputs			
ICT tangible capital	0.4	0.5	0.2
Non-ICT tangible capital	1.3	1.6	1.0
Labor	0.1	0.9	–0.8
Labor quality	0.3	0.4	0.3
TFP	1.8	1.1	2.6
	Including Intangible Capital (%)		
Annual GDP growth rate	**4.1**	**5.0**	**3.0**
Contribution of inputs			
ICT tangible capital	0.3	0.5	0.2
Non-ICT tangible capital	1.2	1.4	0.8
Labor	0.1	0.8	–0.7
Labor quality	0.3	0.3	0.3
Intangible capital	1.8	2.5	0.9
TFP	0.4	–0.5	1.5

Sources: EU KLEMS (2008), sources listed in *table 1* and own calculations.

Table 4 Labor productivity growth accounting in the business sector

	1995–2004	1995–2000	2000–2004
	Excluding Intangible Capital (%)		
Labor productivity growth	**3.7**	**3.2**	**4.4**
Contribution of inputs			
ICT tangible capital	0.3	0.5	0.2
Non-ICT tangible capital	1.3	1.2	1.3
Labor quality	0.3	0.4	0.3
TFP	1.8	1.1	2.6
	Including Intangible Capital (%)		
Labor productivity growth	**3.9**	**3.7**	**4.2**
Contribution of inputs			
ICT tangible capital	0.3	0.4	0.2
Non-ICT tangible capital	1.1	1.1	1.0
Intangible capital	1.8	2.3	1.1
Labor quality	0.3	0.3	0.3
TFP	0.4	–0.5	1.5

Sources: EU KLEMS (2008), sources listed in *table 1* and own calculations.

Table 5 **Contribution of intangible capital deepening to the annual change in labor productivity in the business sector (percentage points)**

	1995–2004	*1995–2000*	*2000–2004*
1. Computerized information	***0.15***	***0.19***	***0.10***
2. Innovative property	***1.02***	***1.24***	***0.67***
a) R&D	0.66	0.79	0.45
b) Mineral exploration	0.002	0.003	0.001
c) Copyright and license costs	0.01	0.01	0.01
d) Development costs in financial industry	0.06	0.09	0.03
e) Design	0.28	0.35	0.19
3. Economic competencies	***0.63***	***0.88***	***0.36***
a) Brand equity	0.15	0.25	0.05
Advertisement	*0.13*	*0.22*	*0.05*
Market Research	*0.02*	*0.03*	*0.001*
b) Vocational training	0.20	0.28	0.11
c) Organizational structure	0.28	0.35	0.19
Purchased	*0.17*	*0.22*	*0.11*
Own-account	*0.11*	*0.13*	*0.08*
Total intangible capital deepening	**1.80**	**2.30**	**1.13**

Sources: EU KLEMS (2008), sources listed in *table 1*and own calculations.

Table 6 **Estimates of lower bound spending on intangible assets in Sweden 2004**

Type of intangible investment	*Total spending 2004 (bn SEK)*	*Lower bound estimates 2004*	*Investment*	*Lower bound investment*
1. Computerized information	**48.2**	**48.2**	**48.2**	**48.2**
a) Computer software	48.2	48.2	48.2	48.2
b) Computerized databases	n.a.	n.a.	n.a.	n.a.
2. Innovative property	**140.0**	**116.7**	**108.2**	**96.7**
a) R&D	68.3*	68.3	68.3	68.3
b) Mineral exploration	0.25	0.25	0.25	0.25
c) Copyright and license costs	1.5	1.5	1.5	1.5
d) Development costs in financial industry	6.6	6.6	6.6	6.6
e) Design	63.3	40.1	31.7	20.0
3. Economic competencies	**109.3**	**83.9**	**86.7**	**68.6**
a) Brand equity				
Advertisement	37.4	22.1	22.5	13.3
Market Research	4.7	4.7	2.8	2.8
b) Vocational training	27.6	22.1	27.6	22.1
c) Organizational structure				
Purchased	27.3	27.3	21.8	21.8
Own-account	15.1	7.6	12.1	7.6
Total Spending	**300.4**	**248.7**	**246.4**	**213.5**

Note: *To avoid double counting the investment in R&D is deducted with the R&D investment for computer and related activities. The latter is based on the year 2003 while total R&D investment is based on the year 2004.

Sources: "*Sources*" in table and own calculations.

Table 7 **Sensitivity analysis of labor productivity growth accounting**

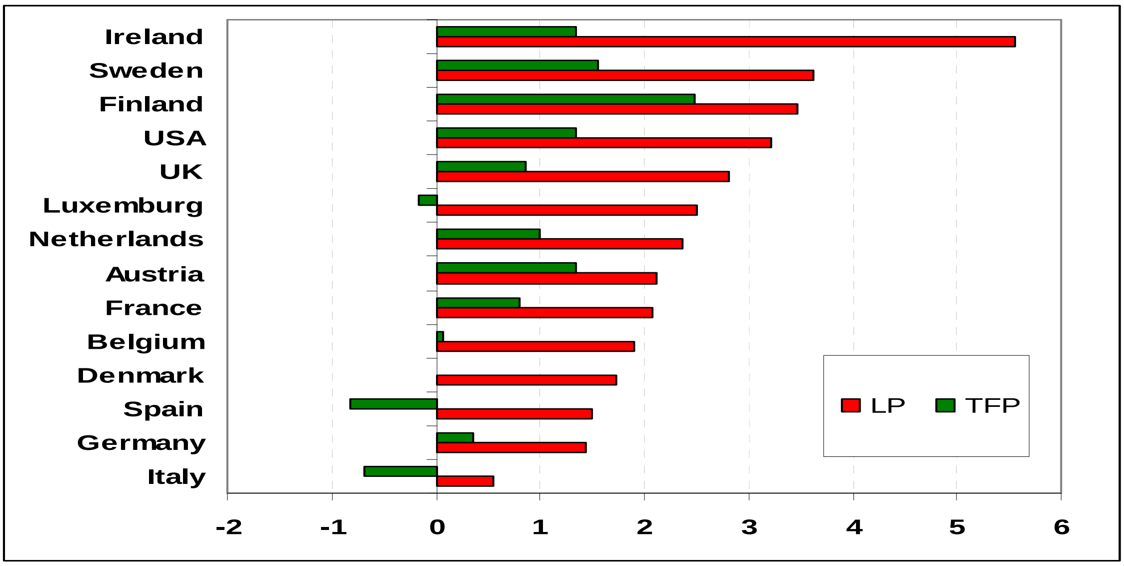
	Base case	***I***	***II***	***III***	**IV**
LP growth	3.9	3.8	4.0	3.9	4.2
Contribution of inputs					
Tangible capital	1.4	1.5	1.4	1.4	1.5
Intangible capital	1.8	1.0	2.3	1.4	1.9
Labor quality	0.3	0.3	0.3	0.3	0.3
TFP	0.4	1.0	0	0.8	0.5

Source: Own calculations.

Note: (I) All conversion factors are halved except for software. (II) Doubled expenditure on each intangible that is considered uncertain. (III) Doubled depreciation rates except brand equity, which is set to 0.9. (IV) Machinery and equipment deflators are used for intangibles instead of value added deflators.

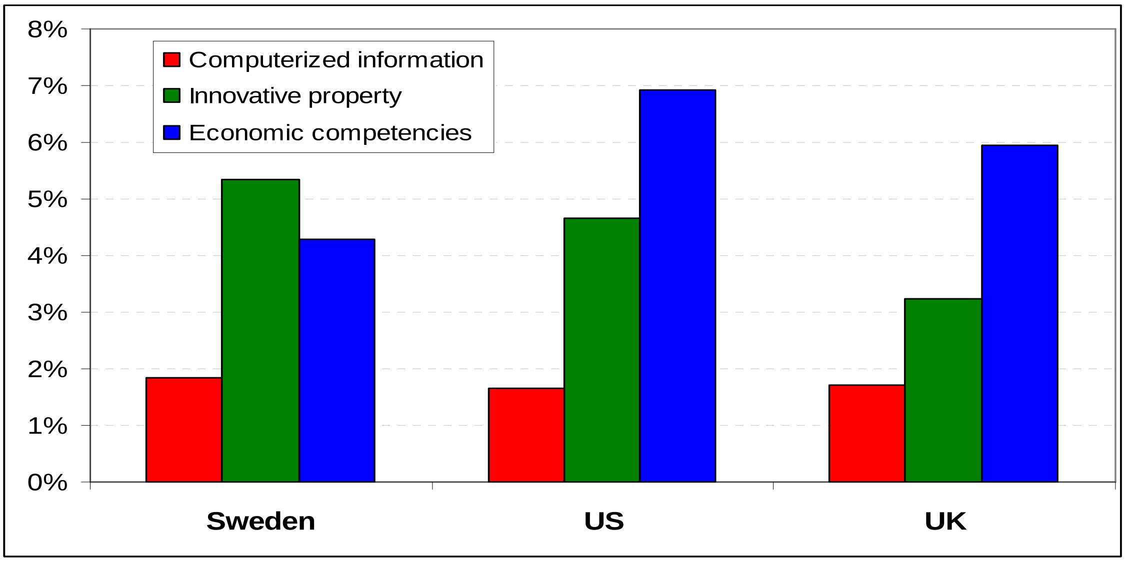
8.2 Figures

Figure 1 Labor- and total factor productivity growth in the business sector in 13 EU-countries and the US 1995–2005 (percent)



Sources: EU KLEMS (2008) and own calculations

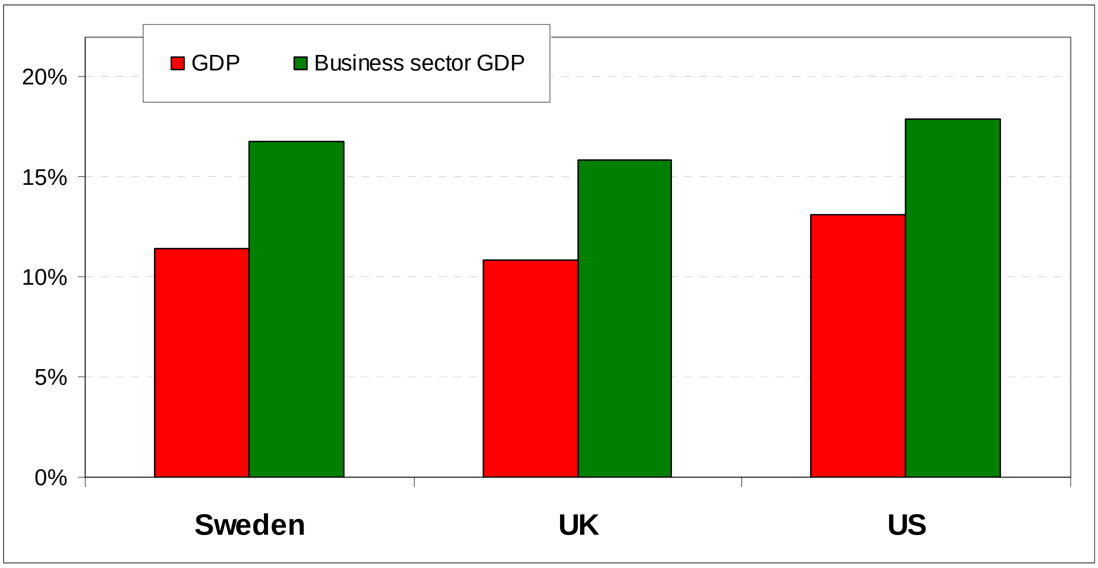
Figure 2 Business sector spending on intangibles in three countries (percent of GDP)



Note: Data for Sweden and the UK is for the year 2004, while data for the US is based on the years 1998–2000.

Sources: CHS (2006), Marrano and Haskel (2007) and own calculations.

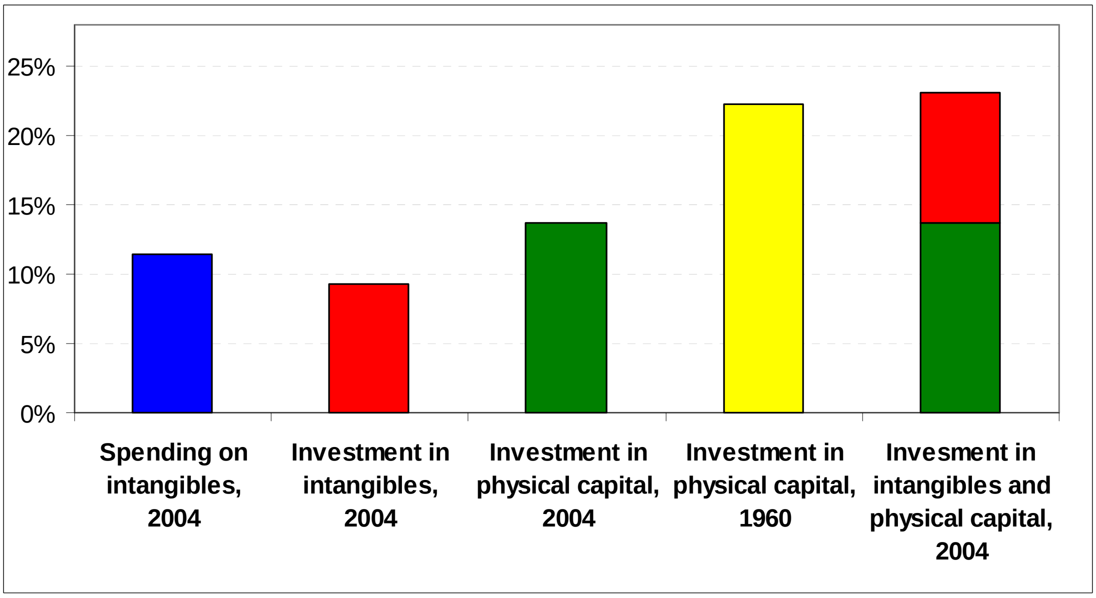
Figure 3 **Spending on intangibles as a share of total value added in the business sector and total GDP for Sweden, the UK and the US (percent)**



Note: Data for Sweden and the UK is for the year 2004, while data for the US is based on the years 1998–2000.

Sources: EU KLEMS (2008), CHS (2006), Marrano and Haskel (2007) and own calculations.

Figure 4 **Business sector spending and investment in intangible capital and physical capital in Sweden**



Sources: Own calculations based on the framework in CHS (2006) and Marrano and Haskel (2007) and Edvinsson (2005).

9. Appendix

Appendix A: Sensitivity Analysis

This paper has presented estimates of spending and investment in intangible assets. Based on the description of the collected data in section 2, it is evident that there might be some uncertainty about the exactness of these estimates. It is therefore important to conduct some kind of sensitivity analysis which tries to decide a reasonable lower bound for these estimates. Therefore, I change the assumptions that the estimates are based on.

Based on the results presented in *table 1* it is evident that the spending on mineral exploration, copyright and licence cost and product development in financial services in total only accounted for 3 percent of the total spending on intangibles. Thus, it is likely that the impact from measurement errors for these categories would be small.

R&D spending was 68 billion SEK or 23 percent of the share of total spending. R&D figures for Sweden have been measured since 1965 and the methods are based on the Frascati Manual (2002), which has similar measurement guidelines for all OECD countries. It is therefore likely that there are quite small measurement errors for R&D and it is not unreasonable to assume that the estimates would be accurate.

Spending on design accounted for 63 billion SEK and had thereby the second largest share of total spending with 21 percent. The design spending estimates are based on a number of assumptions. One is that all persons with design occupation spend all of their time on design activities. It is likely that some employees with design occupations might be involved in R&D related projects rather than design related projects. Moreover, employees with design occupations outside the design sector are probably less likely to be involved in design projects. Thus, it is assumed that 100 percent of the employees with design occupations in the design sector all are involved in design related projects, but only 50 percent of the employees outside the design sector. The spending on design then becomes approximately 40 billion SEK instead of 63 billion SEK.

Computer software had the third highest share with 16 percent of the total spending or 48 billion SEK. Software spending is included in gross fixed capital formation and thus a part of GDP. This implies that the figures are estimated based on national accounts methods and therefore should not be subject to large measurement errors.

Brand equity, that includes both spending on advertisement and market research, accounted for 42 billion or 14 percent of total spending. Advertisement accounted for nearly 90 percent of the total spending on brand equity. The data is based on the Swedish institute for Advertisement which has collected this data on a yearly basis since 1975. It includes the actual spending on advertisement in media, but also spending on sponsoring events and gifts in purpose of promoting products. However, it excludes the actual production cost of the advertisement.

If the definition on spending on advertisement would be narrower and only include the actual spending on advertisement in media and not sponsoring and other events the total spending on advertisement would be 22 billion SEK instead of 37 billion. This must be seen as the lowest possible estimate. The spending on market research was only 5 billion or 2 percent of total spending and it is therefore reasonable to believe that measurement errors would have a quite low impact on the total spending on intangibles.

Continuous vocational training (CVT) is based on a survey conducted for Sweden in 1999. The major problem with the estimates is that there are almost no estimates for other years. It is therefore assumed that the same ratio of the total labor cost is spent on vocational training. One more CVT survey was conducted in 2005, but the answering ratio was too low so Statistics Sweden decided that the survey should not be published. Nonetheless, Statistics Sweden has reported some of the results of the survey to Eurostat. Unfortunately, the spending on CVT has not been reported, but there is data on the total hours in CVT courses per 1000 hours worked and in 2005 this ratio was 10, while it was 12 in 1999. This implies that the employees on average spent approximately 20 percent less of their time on vocational training in 2005 compared to 1999. If it is assumed that the employees spend the same amount of time on vocational training in 2004 as in 2005 and that the spending per time unit of vocational training is the same over time, then the total spending on vocational training in 2004 would be 22 billion SEK instead of 28 billion SEK.

Organizational structure (OS) accounted for 39 billion SEK or 13 percent of the total spending on intangibles. Purchased OS accounted for 27 billion, while own-account OS accounted for 12 billion. Purchased OS is measured as the turnover of Business and management consultancy activities (SIC 7414). The turnover has been adjusted so that products that only include services that affect organizational structure are included.[16] These services accounted for 88.3 percent of the total turnover of Business and management consultancy activities (SIC 7414). It is plausible that these estimates are accurate.

Own-account OS is measured as 20 percent of managers' compensation. As discussed in section 2.3.3.1 there are a number of problems with using managers' compensation as a measure of organizational structure. However, the estimates for Sweden are lower than in the UK and US. Thus, it is not likely that these estimates are overvalued compared to other countries. It is still uncertain exactly how much of their time managers spend on organizational structuring. Thus, if it is assumed that managers only spend 10 percent of their time on organizational structure the spending on own-account organizational structure would be 6 billion SEK instead of 12 billion.

Table 6 shows the lower bound estimates for spending and investment in intangible assets in Sweden in 2004. According to *table 6* the total spending based the lower bound estimates was 249 billion SEK instead of 300 billion SEK. Thus, the spending in terms of GDP was 9 percent instead of 11 percent. Based on the methods described in section 4 it is possible to estimate the share of spending that can be classified as investment. *Table 6* also shows that the investment in intangibles was 214 billion SEK instead of 246 billion SEK. This implies that in terms of GDP the investment was 8 percent instead of 9 percent. The results for the lower bound estimates show that even if we change some of the assumptions that the estimates are based on, it is evident that

[16] The following services are assumed to affect organizational structure: Advise 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 and the same shares are therefore used to estimate purchased organizational structure for other years.

intangibles still accounted for a large share of GDP and thus had an important impact on the Swedish economy.

It is not only the estimation of investment in intangible assets that implies some uncertainty, but also the assumptions that the growth accounting model is based on. Therefore, the robustness is tested by changing some of these assumptions. *Table 7* shows the results from this sensitivity analysis together with the base case (the chosen estimates as presented above). (I) shows the results when the conversion factors used to multiply expenditures into investment are halved for all categories of intangibles except software. (II) shows the results when we double the expenditure on each intangible asset that is considered uncertain.[17] (III) shows the results when all depreciation rates are doubled except for brand equity where the depreciation rate is set to 0.9. (IV) shows the results when Machinery and equipment deflators are used for intangibles instead of value added deflators.

Table 7 shows that intangible capital accounted for considerably less of the total labor productivity growth when the conversion factors are halved. Nevertheless, the contribution is still 1 percentage points or 27 percent of the total labor productivity growth. In all other cases (see *table 7*) the contribution from intangible capital was larger. Thus, the main findings of this paper that investment in intangibles was an important source to the Swedish productivity boom in 1995–2004 seem robust.

[17] According to MHW (2007) the following intangibles are considered uncertain: Development costs in the financial industry, design, market research, purchased and own-account organizational structure.

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