Background Facts on Economic Statistics

2004:07

Labor Quality and Productivity: Does Talent Make Capital Dance?

Department of Economic Statistics

Avdelningen för Ekonomisk statistik

The series Background facts presents background material for statistics produced by the Department of Economic Statistics at Statistics Sweden. Product descriptions, methodology reports and various statistic compilations are exampels of background material that give an overview and facilitate the use of statistics.

Publications in the series
Background facts on Economic Statistics

2001:1 Offentlig och privat verksamhet – statistik om anordnare av välfärdstjänster 1995, 1997 och 1999

2002:1 Forskar kvinnor mer än män? Resultat från en arbetstidsundersökning riktad till forskande och undervisande personal vid universitet och högskolor år 2000

2002:2 Forskning och utveckling (FoU) i företag med färre än 50 anställda år 2000

2002:3 Företagsenheten i den ekonomiska statistiken

2002:4 Statistik om privatiseringen av välfärdstjänster 1995–2001. En sammanställning från SCB:s statistikkällor

2003:1 Effekter av minskad detaljeringsgrad i varunomenklaturen i Intrastat – från KN8 till KN6

2003:2 Consequences of reduced grade in detail in the nomenclature in Intrastat – from CN8 to CN6

2003:3 SAMU. The system for co-ordination of frame populations and samples from the Business Register at Statistics Sweden

2003:4 Projekt med anknytning till projektet "Statistik om den nya ekonomin". En kartläggning av utvecklingsprojekt och uppdrag

2003:5 Development of Alternative Methods to Produce Early Estimates of the Swedish Foreign Trade Statistics

2003:6 Övergång från SNI 92 till SNI 2002: Underlag för att bedöma effekter av tidsseriebrott

2003:7 Sveriges industriproduktionsindex 1913–2002 – Tidsserieanalys
The Swedish Industrial Production Index 1913–2002 – Time Series Analysis

2003:8 Cross-country comparison of prices for durable consumer goods: Pilot study – washing machines

2003:9 Monthly leading indicators using the leading information in the monthly Business Tendency Survey

2003:10 Privat drift av offentligt finansierade välfärdstjänster. En sammanställning av statistik

2003:11 Säsongrensning av Nationalräkenskaperna – Översikt

2003:12 En tillämpning av TRAMO/SEATS: Den svenska utrikeshandeln 1914–2003

2003:13 A note on improving imputations using time series forecasts

2003:14 Definitions of goods and services in external trade statistics

Continued on inside of the back cover!

These publications and others can be ordered from:
Statistics Sweden, Publication Services, SE 701 89 ÖREBRO, Sweden
phone +46 19 17 68 00 or fax +46 19 17 64 44.

You can also purchase our publications at our **Statistics Shop**:
Karlavägen 100, Stockholm, Sweden

2004:07

Labor Quality and Productivity: Does Talent Make Capital Dance?

Statistics Sweden
2004

Producer	Statistics Sweden Department for Economic Statistics
Inquiries	Lena Hagman, +46 8 506 942 23 e-mail: lena.hagman@scb.se

ISSN 1650-9447
Printed in Sweden
SCB-tryck, Örebro 2004

Index

Labor Quality and Productivity: Does Talent Make Capital Dance?[1]

Gunnar Forsling[2] and Tomas Lindström[3]
March, 2004

Abstract

This paper studies to what extent the resurgence in Swedish productivity growth in the second half of the 1990s is attributed to a better-quality labor force. The analysis is based on a state-of-the-art and, in this context, exceptionally detailed employee-level data on the workers' educational attainment. Growth accounting illustrates that a switch toward workers with a relatively high marginal product has raised average labor (ALP) productivity growth in the business sector by about 0.2 percentage points per year (6,9 percent of ALP growth). This effect, which was particularly large in the ICT sector (0,4 percentage points per year or, equivalently, 2,7 percent of ALP growth), originated from a growing share of employees with an economics or engineering bachelor's degree.

Keywords: *economic growth, growth accounting, ICT, labor quality, productivity*

JEL classification: *O3, O4, O5*

This study relies on labor market data from Statistics Sweden as well as unpublished National Accounts data gathered up to mid-June 2003.

---

[1] Several colleagues made valuable contributions to this research; we particularly acknowledge comments by Lena Hagman, Ann-Sofie Kolm, Jukka Jalava, Larry Rosenblum, and Paul Schreyer. The usual disclaimer applies.

[2] Corresponding author: gunnar.forsling@rgk.se.

[3] The National Institute of Economic Research (NIER), Box 3116, SE-103 62, Stockholm, SWEDEN.

1 Introduction

Forget the old world order. Forget what you knew yesterday. The revolutionary reality is that 1.3 kilograms of brain holds the key to all our futures. Competitive advantage comes from being different. Increasingly, difference comes from the way people think rather than what organizations make. Today, the only thing that makes capital dance is talent. [Riddarstråle and Nordström (2000)][4]

The last couple of years have witnessed a surge of interest in the role of human capital formation for the development of economies. For example, Jones (2002) developed a model where long-run growth arises from the worldwide discovery of ideas, which, in turn, depends on population growth. According to his model, long-run growth can proceed at a faster rate than predicted by population growth if educational skills and research intensity rise steadily over time. Jones also pointed out that the time spent accumulating skills through formal education has increased over the years in the United States as well as in the OECD, and that the search for new ideas has intensified over time as a growing fraction of the employees engage in research and development (R&D) activities.[5] The Swedish labor force has undergone similar changes.[6]

The rising educational attainment should, according to most models of economic growth, lead to higher levels of long-run income. The growth effect, however, is only temporary in neoclassical models, while it is permanent in most endogenous growth models. Hence, according to these models, it seems to be a good idea to invest in knowledge, both for individuals who may then earn higher wages and for governments who may then experience more rapid economic growth.[7]

The recent interest in human capital formation, and its implications for the economy as a whole, has been parallel to the resurgence of productivity growth, in particular in the United States (but also in many other developed countries) in the second half of the 1990s. In the United States this period has now been identified as the longest-ever-recorded period of sustained growth accompanied by a low and stable inflation rate. The Swedish economy has experienced a similar productivity lift.[8] For example, after growing only about 1.2 percent per year 1981–1990, average labor productivity (ALP) growth for the Swedish economy as a whole jumped to close to 2 percent per year over the period 1991–2000. For the business sector, ALP growth averaged a bit more than 2.5 percent over the period 1991–2000 – about a 50 percent higher productivity growth rate than its average annual growth rate over the period 1981–1989.

While trying to explain the recent productivity revival, a number of economists call attention to fast capital accumulation – in particular the latest investment boom in ICT equipment – and extraordinary technological progress in ICT producing industries. This is the so-called new doctrine (new economy or new era) literature which, as usually stated, rejects the deep-rooted idea that the risk for inflation limits the possibilities for fast and long-lasting econo-

---

[4] Quoted from the book *Funky Business – Talent Makes Capital Dance*.

[5] According to Jones, in 1940 less than 25 percent of the adults in the United States had completed high school, and only 5 percent had completed four or more years of college. In 1993, in contrast, more than 80 percent had completed high school, and more than 20 percent had completed at least four years of college.

[6] Hansson (1997), for example, reported that the share of Swedish employees with higher education (meaning at least 15 years of schooling) has increased from about 8 percent in 1970 to 25 percent in 1994. There are two key explanations to this upgrading of labor; first, the rising international competition due to the ongoing globalization, and, second, the technological progress that reduces the need for unskilled labor (so-called skill-biased technological change (SBTC)).

[7] Note, however, that although e.g. Mankiw et al. (1992) found a large and positive growth effect from human capital, this traditional insight is sometimes challenged by empirical studies. One reason for the differences in results is that empirical studies always have to rely on approximating measures for the level of human capital (which is largely unobserved in real life), who may, or may not, fully capture the true level of productive knowledge. Another reason has to do with the use of new data and estimation techniques (see, for example, Islam (1992) and Judson (2002)).

[8] See, for example, Lindström (2002).

mic growth. There are also economists who emphasize the usual procyclical response of productivity when output grows faster than trend. Yet others lay emphasis on enhanced methods for measuring price deflators.

Recent attempts to analyze the productivity gains from ICT include, for example, Jorgenson and Stiroh (2000). While using standard growth accounting, they found that a combination of large technological improvements in ICT sectors and the follow-on investment boom in ICT equipment are the principal driving forces behind the recent U.S. productivity shift. Oliner and Sichel (2000) confirmed this result. Moreover, Jorgenson (2001) argued that the productivity growth revival is above all due to the sharp decline in ICT prices – deep-rooted in the progress of semiconductor technology. Gordon (2000), in turn, argued that productivity gains are probably due to a more efficient production of computers and cyclical factors. Colecchia and Schreyer (2001) reported that the growth contribution of ICT capital has increased in the second half of the 1990s in several OECD countries (and Schreyer (2000) reported the same result for the G7 countries).

Now, some researchers, in fact, claim that too much attention has been paid to ICT when it comes to explaining the recent productivity revival, and that too little attention has therefore been paid to, in particular, human (non-tangible) capital formation. While allowing for both human and ICT capital, Bresnahan et al. (1999), for example, argued that the balance between tangible (physical) and non-tangible assets is crucial. Their results suggest that producers typified by skilled labor and large ICT capital outlays are often the most productive.[9]

Although the Swedish productivity revival of the 1990s is probably too large to be explained by either better labor quality or ICT (ICT is here broadly defined to include the production as well as the use of ICT), this dual research focus surely deserves attention since educational attainment and ICT seem to go hand-in-hand over time.[10] One important (albeit casual) observation, for example, is that highly skilled workers are more likely to use computers on the job – and this suggests that human capital is, to a large extent, complementary with ICT. Another indication of this strong relationship between knowledge and ICT is that the share of workers with a bachelor's degree has increased sharply in the ICT sector throughout the 1990s – in the Swedish ICT sector, for example, this share has increased from about 40 percent in 1993 to 50 percent in 2002.[11]

In Sweden, we have for a long time lacked useful data on ICT capital. One exception is the information on computer investments that until 1994 were officially published in the so-called Investment Surveys provided by Statistics Sweden. These data have been used earlier by Gunnarsson and Mellander (1999), and Gunnarsson et al. (2001), who constructed real computer capital by combining these data with the National Accounts**.**

In this study, we use new and preliminary data on real ICT equipment from 1993 through 2000.[12] These data are provided by Statistics Sweden and are yet to be publicly available. They originate from earlier work by the Commission on the Review of Economic Statistics, which in 2002 brought together data on ICT equipment for a number of sectors. Lindström (2002) took a closer look at these data while using standard growth-accounting techniques. He found, for example, that total factor productivity (TFP) growth has been particularly

---

[9] They also found that producers characterized by unskilled labor and low ICT capital outlays are often more productive than producers that are characterized by either unskilled labor and large ICT capital outlays or skilled labor and small ICT capital outlays.

[10] The link between technological change and the labor market has been a main concern of economists for as long as economics has been considered an individual research field. The recent increase in wage inequality is, for example, frequently attributed to skill-biased technological (SBTC) change related to computer hardware and software technologies. However, when analysing this topic further, Card and DiNardo (2002) found that this hypothesis is in conflict with parts of the development of the wage structure in the United States in the 1980s and 1990s; in particular, they argued that the stabilization of wage inequality during the 1990s is difficult to reconcile with the parallel success of the U.S. economy that largely owes to new technologies.

[11] These figures are derived from the employee-level data that are used in the present study (for details, see chapter 3).

[12] These data have been revised since the study by Lindström (2002).

strong in ICT producing industries throughout the 1990s and that other industries have at the same time invested heavily in ICT equipment. His analysis, however, was purposely partial in the sense that changes in the composition of the labor force was not taken into account. As a consequence, he did not account for the effect of a growing share of employees with higher marginal products, and the residually-calculated TFP growth rate was therefore, at least to some extent, overrated. Although it is, of course, difficult to know ex ante by how much the computed TFP growth rate was biased in this way, some guidance can perhaps be obtained from other work. According to some studies, for example, labor quality may contribute by as much as 0.1–0.4 percentage points to annual labor productivity growth (the effect, of course, depends on the choice of country, sector, industries, and time period for the analysis).[13] Hence, given that the Swedish labor force has undergone changes that are similar to those of other developed countries, a qualified guess would probably lie in this interval.

This study expands the work by Lindström (2002) while bringing into play a very detailed employee-level data set on the labor force's scholarly proficiency, both in terms of the length of the education (i.e., the years of schooling) and the type of the education (i.e., the main field of study). These data on labor characteristics are compiled from Statistics Sweden's annual surveys covering the complete population of employees.[14] The principal aim of this article is threefold.

The first objective is to take a closer look at the Swedish productivity revival in the second half of the 1990s while bringing up to date and expanding on the work by the Commission on the Review of Economic Statistics in 2002. In particular, this paper explores the productivity growth effects from a better-quality labor force during the period 1994–2000. Obviously, this focus is closely related to the ongoing shifting out of goods production into services in the economy as a whole.

The second objective is to try to signal attention to measurement difficulties that always show up in this kind of analysis. For example, all the usual data limitations as regards the true quality and use of capital and labor inputs may certainly be amplified by technical hitches related to the operation time of computers and the true cost of computer power in a fast-growing services (and ICT) sector. Conceptually, measures of factor inputs should, of course, account for all differences in qualities and utilization rates – that is, to the extent that there are different types of capital and labor, and to the extent that these types are used in different rates over time, this should be taken into account by the perfect measures.

The third objective of this paper has to do with data production as such. Unlike the majority of previous studies, this study goes beyond simple data description, growth accounting line-ups, and discussions of data problems and results while considering some suggestions for future data production. It does so because data production can be improved in many respects, and the best way to accomplish this is probably to pool knowledge and resources from producers and users of data.

To summarize, the analysis provides support for the view that a better-quality labor force has raised Swedish labor productivity growth throughout the second part of the 1990s. The underlying logic is simple: it reflects a substitution toward workers with higher marginal products. Hence, labor input of some educational levels or types grow (fall) which has higher (lower) productivity than the average. In the business sector, for example, this change in the composition of the labor force has raised labor productivity growth by about 0.2 percentage points per year during the period 1994–2000. The results also indicate that the productivity growth effect from an improved labor force has been higher in the service sector (0.24 percentage points per year on average) than in the goods sector (0.17 percentage points). This labor quality effect was even larger in the ICT sector (0.37 percentage points per year). Overall, the substitution toward workers with higher marginal products seems to reflect a growing share of workers with an economics or engineering bachelor's degree. The flip side

---

[13] See, for example, Oliner and Sichel (2000).

[14] More specifically, the data include all individuals that are in work (full time or part time) at some point in a specific week every year.

of this development is a falling share of employees with the compulsory nine years of basic education.

The organization of this paper is as follows: Chapter 2 outlines the theoretical framework. Chapter 3 then describes the data, and chapter 4 presents the main findings. Concluding remarks close the analysis in chapter 5.[15]

2 A Brief Model Outline[16]

There is by now a large and growing literature on the productivity effects of a better-quality labor force. One approach in this literature is to use simple growth accounting. This framework – which is simple enough to be useful, and yet not disastrously at odds with reality – is practical when it comes to finding out if the recent productivity upturn is wide-ranging and if sources of productivity growth differ over time.

Expressing all variables in terms of rates of growth (log differences), one can write a production function that includes technological change in the following simple form:

$$d\ln y_{it} = d\ln Y_{it} - d\ln L_{it} = d\ln x_{it} + d\ln V_{it}, \tag{2.1}$$

where $d\ln Y$, $d\ln L$, and $d\ln V$ are the growth rates of value-added output Y, labor L, and the level of technology (i.e., TFP) V. The variables are indexed with subscripts to emphasize that they can vary across firms (subscript i) and over time (subscript t). The term $d\ln x_{it}$ denote the growth of "weighted" inputs per hours worked:

$$d\ln x_{it} = (1-\alpha_{cit})d\ln k_{it}, \tag{2.2}$$

where

$$d\ln k_{it} = d\ln K_{it} - d\ln L_{it}. \tag{2.3}$$

The term α_c in equation (2.2) is labor's share in total costs, and $d\ln K$ is the growth rate of overall capital K. Hence, equation (2.1) splits labor productivity growth into capital deepening (in the sense of capital per hours worked) and TFP growth. Equations (2.1) and (2.2) capture the essence of the growth-accounting approach that is used in the present study.[17] It is implicitly assumed that production is subject to constant returns to scale (RTS).

3 The Data

3.1 Labor

In this study, labor is classified along two dimensions: the level of formal education, and the type of this education.[18] The level, which is measured in terms of the number of years of schooling, is split into four groups. The first is the required nine years of schooling; the second is the 12-year high-school equivalent; the third is a bachelor's degree (16 years); and the fourth level is a graduate or PhD level (that is, 21 years or more).

---

[15] In each of chapter 3 to 5, an attempt is made to limit the amount of technical information provided. In addition, while each chapter follows the preceding chapter, deliberate efforts are made to make each of the chapters "self-contained". A reader may thus read the chapters in order of preference.

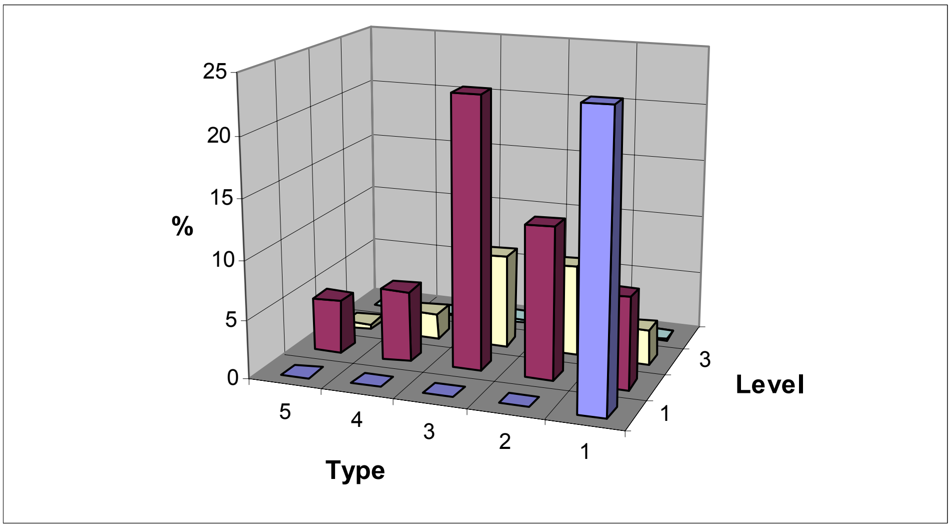
[16] For more details about the model than are included in this chapter, see appendix A.

[17] Appendix A provides a more thorough description of the underlying theoretical framework and shows how it can be generalized to include different kinds of capital and labor.

[18] Hence, these data do not account for other aspects of labor quality, such as skills obtained through on-the-job training or work experience.

The type of labor, in turn, which reflects the main field of the study, is split into five groups. The first is referred to as the "general profile" (G), which apart from the most general topics includes aesthetics, language, pedagogy, and religion; the second is the "economics profile" (E), which includes economics, "office", behavioral and social science, and trade; the third is the "industry profile" (I), which includes biology, chemistry, engineering, handcraft, mathematics, and physics; the fourth is the "caring profile" (C), which includes the care of children and elderly, communication and transportation, farming, fishing, forestry, gardening, and nursing; and the fifth type, is the "service profile" (S), which includes general services, private guards and military service. For ease of presentation, this classification of the labor force is pictured in Diagram 1.

Diagram 1
Composition of the labor force in the Business sector in 1998



Note: The three-dimensional diagram shows how labor was split into 20 categories in 1998. The bars sum to 100 percent. Level 1 refers to the compulsory years of education (i.e., 9 years), Level 2 to three additional years after the compulsory years (i.e., 12 years), Level 3 to a bachelor's degree (i.e., 16 years of education or more), and Level 4 to a graduate/PhD degree (i.e., 21 years of education or more). Type 1 refers to the "general profile", Type 2 to the "economics profile", Type 3 to the "industry profile", Type 4 to the "caring profile", and Type 5 to the "service profile".

The diagram shows, for example, that about 25 percent of the labor force in the business sector had only the mandatory nine years of education in 1998 – and, not surprisingly, all of these employees had the "general profile". Moreover, the diagram shows that about 25 percent of the employees had 12 years of schooling and an "industry profile". Note also that the diagram suggests an almost negligible share of PhDs in the business sector (the bars for the PhDs (i.e., Level 4) are not that easy to see in the diagram, however, since they are hidden behind the other bars).

To facilitate presentation, we also show this labor composition (expressed as annual averages during the period 1993–1998) in Table 1.[19]

[19] See also appendix B.

Table 1
The composition of labor 1993–1998
The business sector (ISIC 01-95)

Level	Type	L-share	W-share	Wage	#
9	G	26.82	23.10	161,841	612,602
9	E	0	0		0
9	I	0	0		0
9	C	0	0		0
9	S	0	0		0
12	G	7.02	6.11	163,798	161,262
12	E	13.07	11.97	172,368	299,508
12	I	23.03	24.24	197,873	528,096
12	C	5.92	4.64	147,421	136,116
12	S	4.18	3.06	137,947	96,113
16	G	2.58	2.41	175,676	59,384
16	E	7.00	10.19	273,938	160,838
16	I	7.38	10.38	264,691	169,565
16	C	2.12	2.51	222,440	48,686
16	S	0.50	0.63	235,064	11,546
21	G	0.02	0.03	225,164	489
21	E	0.04	0.10	425,503	1,003
21	I	0.24	0.48	374,144	5,554
21	C	0.07	0.14	412,040	1,513
21	S	0.01	0.01	272,067	184

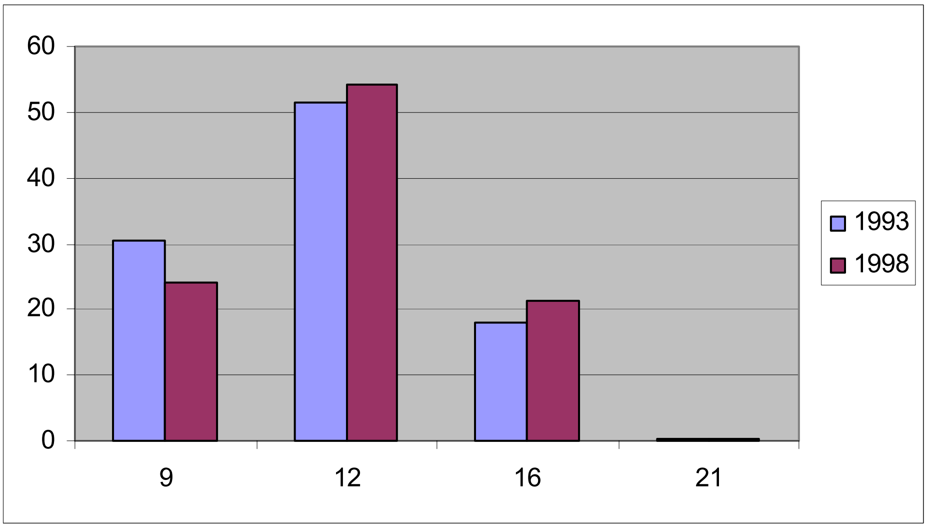
Note: The column labelled L-share shows the average share (%) of employees from each educational group. The column labelled W-share shows the average wage share (%) in total wage costs for each group. The column labelled Wage shows the average wage in nominal SEK for each group. The last column shows the number of employees in each group.

Source: Statistics Sweden and own calculations.

In the analysis below, labor is in each year classified according to diagrams such as Diagram 1. Note, however, that since this study primarily focuses on shifts in labor over time, it works with annual changes of the information inherent in these diagrams rather than with the actual levels. This implies, for example, that although the share of PhDs is always small, the annual percentage change can be much larger. The productivity impact of this change, however, can only be obtained through a scaling of this change with a factor reflecting both the graduates' share of total employment and the graduates' productivity.[20] Diagrams 2 and 3 show how the education-length shares have changed between 1993 and 1998.

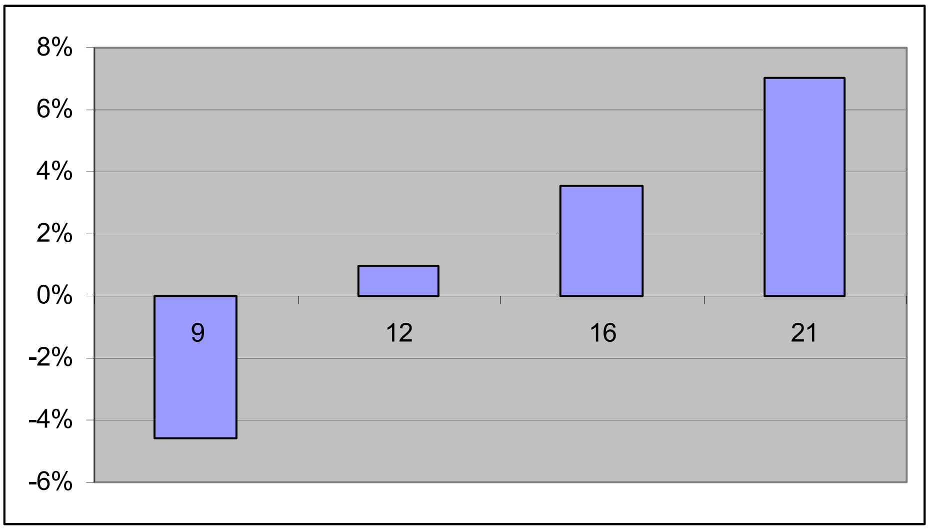
[20] Se appendix A.

Diagram 2
A shift toward higher-productive workers in the Business sector



Note: The diagram shows that the shares of workers with 12 and 16 years of education have increased from 1993 through 1998. Moreover, although not possible to see in the diagram, the share of PhDs has increased as well (see Diagram 3). The share of workers with 9 years of basic education has declined.

Diagram 3
Average annual change in the education-length shares in the Business sector



Note: The diagram shows that the shares of workers with 12, 16, and 21 years of education have increased from 1993 through 1998. The share of workers with 9 years of basic education has declined.

Labor has also, in addition to this two-dimensional classification, been classified into either of the level or the type dimension. This had only minor effects on the results – hence, the calculated productivity growth contributions (to be shown below) from a change in the composition of the labor force did not change much when labor was classified in four levels or five types rather than in 20 level-types.[21]

Note also that the flow of labor service should optimally be used as a measure of labor input. Hence, if there is just one kind of labor, and if labor effort is constant over time, the perfect measure of labor input would be the sum of hours worked over all individuals. In the present study, the number of hours worked is used when calculating ALP growth on the left-hand

[21] This holds, in particular, for the four-level classification as compared with the 20-level-type classification, a result that seems to suggest that it suffices to categorize labor in terms of just the level dimension (and that four distinct level groups are enough).

side of equation (2.1). Labor composition, however, is calculated in terms of the number of employees rather than in terms of the number of hours worked (see the term l_{ait} on the right-hand side of equation (A.12) in appendix A).

3.1.1 Is Years of Schooling a Good Measure?

The growth literature often emphasizes the role of human capital formation in the process of economic development. Lucas (1988), for example, derived a model of growth in which economic agents decide how much to invest in physical capital and how much to invest in intangible capital (i.e., their own bodies).[22] Moreover, while working with U.S. data over the period 1948–1995, Ho and Jorgenson (2001) found that rising labor quality has contributed to about 0.6 percentage points to annual labor input growth and that most of this effect originates from rising levels of educational attainment. However, as Mulligan and Sala-i-Martin (2000) pointed out, the level of education (e.g., the years of schooling or on-the-job-training) is not necessarily a good measure of human capital for a couple of reasons. First, this measure implicitly assumes that workers of each educational group are perfect substitutes in the production process for workers in all other groups. Second, it assumes that the productivity differentials among workers with different levels of education are proportional to the years of schooling. Third, an extra year of education is assumed to give the same increase in scholarly proficiency and skills irrespectively of the field of study or the quality of the teachers. Mulligan and Sala-i-Martin found that the stock of human capital (according to their preferred so-called labor-income-based (LIB) measure) has sometimes grown twice as fast as the average years of schooling, and that human capital dispersion across U.S. states went up in the 1980s while the dispersion of years of schooling decreased. This result underscores the difficulties associated with working with an unobserved variable such as human capital.

Judson (2002) used government expenditure on education as an approximating measure for human capital. This measure is a rougher approximation of true human capital than is the years of schooling because it is based on money outlays rather than the employee's characterristics: spending data is the price of producing knowledge at a given time, which is unlikely to be the same as human capital in particular since productive knowledge is in general long-lasting.

Earlier empirical work has typically used a few categories of educational attainment. Ho and Jorgenson (2001), for example, divided labor into six educational categories, and Fosgerau et al. (2002) tried to answer the question if there are any benefits of increasing the number of categories further. They found that the error that may result when using just six categories is likely to be rather small.

3.2 Capital

In this study, the measure of capital inputs are obtained from the buildup of gross physical investment figures along with an estimate of the depreciation rate of the quantity (i.e., the stock) of capital. This is the perpetual inventory method (PIM) – and here it is accordingly used to compute the stock of each of the three assets i) buildings (B), ii) machinery exclusive of ICT equipment (M), and iii) ICT capital (ICT):

$$K_{jt} = (1-\delta^{j})K_{jt-1} + I_{jt-1}, \;\; j = B, M, ICT, \tag{3.1}$$

[22] Another example of the growing interest in human capital formation is the recently published manual of productivity measurement by the OECD (2001), which both provides an important step toward improving the official statistics in the OECD and highlights the value of accounting properly for the change in the quality of the labor force (see Jalava (2002)).

where δ^j is the economic rate of annual depreciation and I_{jt-1} is the gross investment in asset j in period $t-1$.[23]

Note that capital input should ideally be measured by the flow of services rather than by the quantity (same argument as for labor input).[24] The ideal measure of capital input should take into account the machine hours used in the production process (i.e., the operation time or utilization rate). However, since this information is hardly ever available in practice, most studies instead rely on the quantity of physical capital.

3.3 Unobserved Factor Utilization

Most measures of factor inputs suffer, at least to some extent, from the difficulty of how to measure capital and labor in general and their true utilization rate. For example, the so-called labor-hoarding hypothesis gives emphasis to major transaction costs when adjusting the labor force.[25] According to this hypothesis, firms may at times find it profitable to substitute labor use for actual labor when the labor force cannot be modified without costs (for example, the firms may try to raise labor effort instead of hiring new employees). As a consequence, labor effort may change pro-cyclically over time rather than the number of employees. The same argument applies to physical capital inputs. The omission of the effective (true) factor inputs in the baseline equation (2.1) plays down the productive contribution from these inputs.[26]

Note also that it is often important to tell apart the short and long run when analyzing production. In the short run, firms vary the intensity with which they use a given plant or piece of equipment. In the long run, they vary the size of the plant or machinery. However, there is in general no specific period that separates the short run from the long run. Rather, one must distinguish them on a case-by-case basis.

4 Empirical Analysis

4.1 Growth Accounting

The work reported in this chapter focuses on equations (A.6) and (A.12) in appendix A. These expressions split labor productivity growth into improved labor quality, capital deepening, and TFP growth. In this way, growth accounting provides a mechanical decomposition of productivity growth.[27] Diagram 4 shows a very detailed picture of the average (yearly) productivity growth contribution (as calculated by equation (A.12) in appendix A) from each of the 20 level-type labor-force categories from 1993 through 2000. The diagram shows, for example, that the quality effect originates from a growing share of employees with an economics or engineering bachelor’s degree (see the highest bars). The flip side is a falling share of less skilled workers.[28]

---

[23] Note that in order to be able to develop accurate capital stocks according to the PIM, long time series of real investments are needed. If long time series are not available, the assumption about the initial value of the capital stock is very likely to affect the growth rates. It is, to us at least, unclear to what extent the current data make use of long enough time series. In the U.S. most non-ICT capital stocks are based on real investment data beginning in 1901 (we thank Larry Rosenblum at the Bureau of Labor Statistics (BLS) in the United States for this information).

[24] See, for example, Barro and Sala-i-Martin (1995) and OECD (2001a,b).

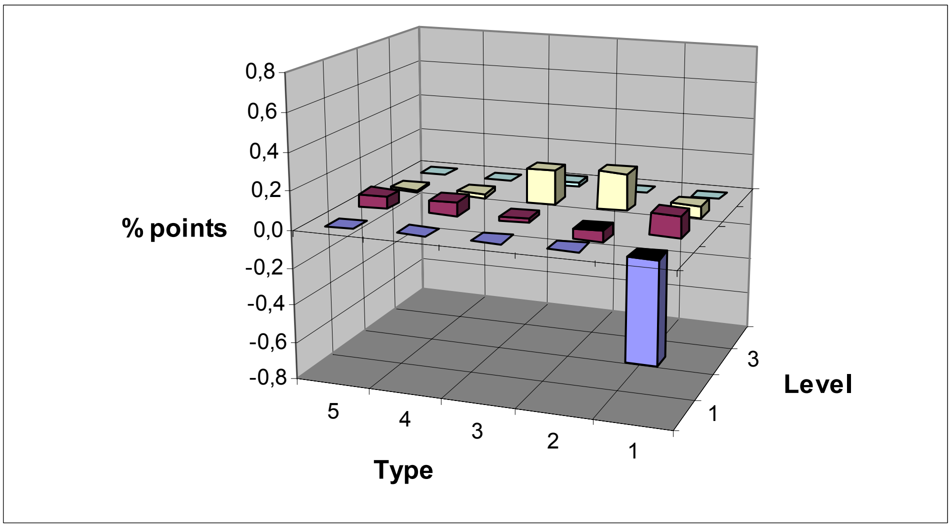
[25] See, for example, Sbordone (1996).

[26] One way of dealing with this is to exclude periods of intense downturns and upturns in the business cycle. The reason is that the difference between measured inputs and the true (effective) inputs is higher during these periods.

[27] Successful accounting is often useful and may stimulate the development of economic theories of growth (Barro and Sala-i-Martin (1995)). It does not, however, provide a theory of growth because it does not attempt to explain how (and why) factor inputs and TFP change over time.

[28] See also appendix D, which shows the same information for other sectors.

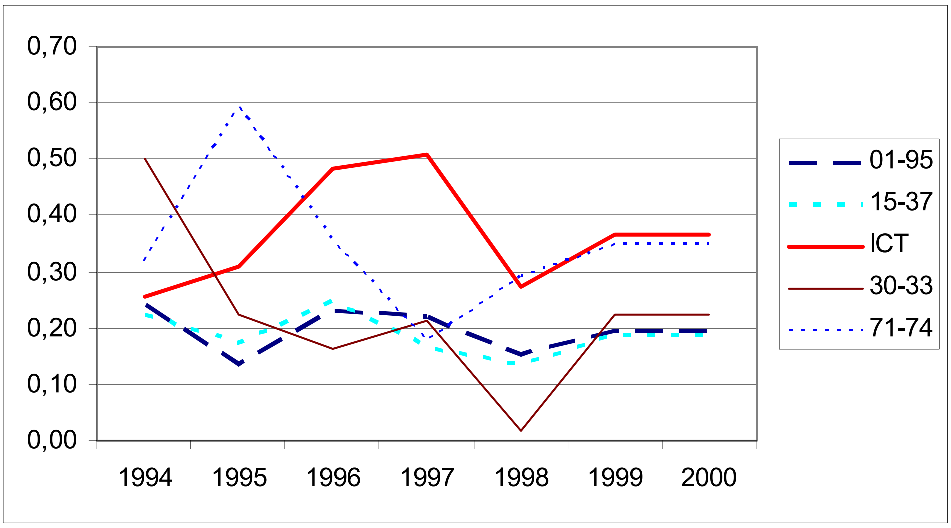
Diagram 4
Average annual contribution to ALP growth in the Business sector from changes in the composition of labor



Note: The three-dimensional diagram shows the contribution to productivity growth, as calculated by equation (A.12) in appendix A, from each labor category. Level 1 refers to the compulsory years of education (i.e., 9 years), Level 2 to three additional years after the compulsory years (i.e., 12 years), Level 3 to a bachelor's degree (i.e., 16 years of education or more), and Level 4 to a graduate/PhD degree (i.e., 21 years of education or more). Type 1 refers to the "general profile", Type 2 to the "economics profile", Type 3 to the "industry profile", Type 4 to the "caring profile", and Type 5 to the "service profile".

Diagram 5 shows the annual productivity growth contribution from changes in the composition of labor in five sectors from 1994 through 2000.

Diagram 5
Annual contribution to ALP growth from changes in the composition of labor



Note: The diagram shows the contribution to productivity growth, as calculated by equation (A.12) in appendix A. The code 01-95 refers to the Business sector, 15-37 to the Manufacturing sector, ICT to the Information & Communications technology sector, 30-33 to the Electrical & Optical Equipment sector, 71-74 to the Renting, Computer & Other business activities sector. In the diagram, two sectors that are not referred to in the paper (i.e., 30-33 and 71-74) are included just for the purpose of comparison. Note also that the labor composition effect is, due to data limitations, assumed to be the same in 1999 and 2000 as the historical average.

The annual labor quality effect inherent in Diagrams 4 and 5 can also be integrated in the usual growth-accounting tables, such as Table 2. This table presents the growth-accounting results for the period 1994–2000.

Table 2
Accounting for productivity growth – a preliminary table
The business sector (ISIC 01-95)

	94-00	94	95	96	97	98	99	00
Growth in output	4.84	5.93	6.33	1.74	4.04	3.74	6.03	6.05
Growth in hours worked	1.67	2.75	2.82	-0.15	-1.01	1.75	3.50	2.02
Growth ALP	3.17	3.18	3.52	1.89	5.05	2.00	2.54	4.03
Capital deepening	0.67	-2.03	-1.02	1.83	2.27	1.19	0.87	1.61
Buildings	-0.14	-0.59	-0.72	0.08	0.39	0.09	-0.39	0.19
Machinery excl. ICT	-0.02	-1.55	-0.81	0.55	0.90	0.31	0.14	0.32
ICT	0.83	0.12	0.52	1.19	0.99	0.79	1.12	1.09
Labor quality	0.20	0.24	0.14	0.23	0.22	0.15	0.20	0.20
Growth in TFP	2.30	4.96	4.40	-0.17	2.55	0.66	1.47	2.22

Note: In 2000 the business sector accounted for 80.16 (69.86) percent of current value GDP (hours worked). Note also that the data in this table are preliminary; it is, for example, unclear to what extent nominal ICT capital outlays have been deflated by quality-adjusted (hedonic) prices (see, for example, Edquist (2004)). As a result, ICT capital may be underestimated. In order to compensate for this, we have enlarged the user cost of capital (rather than speculated about the extent of this potential bias) so that it now equals the depreciation rate. This is, of course, not a perfect solution, but it meets our requirements for the purpose of the present study which focuses in particular on the productivity effects of a better-quality labor force.

Source: Statistics Sweden and own calculations.

The two first lines show the growth in output and the growth in hours worked. The third line shows the growth rate of output per hour worked (i.e., the labor productivity growth), which can be calculated in the table by subtracting the growth rate of labor hours in the second line from the growth rate of output in the first line. The productivity growth contribution from capital deepening, in turn, which is calculated as the growth in capital per hour multiplied by capital's share in total factor costs, is presented in line 4. Capital deepening is divided into buildings-related deepening (line 5), machinery-related deepening exclusive of ICT (line 6), and ICT-related deepening (line 7).[29] Thus, the sum of line 5, 6, and 7 equals line 4. Line 8, moreover, shows the effect of a better-quality labor force (i.e., the labor quality effect) – it thus reflects a changeover toward workers with higher marginal products. TFP growth (line 9) is finally obtained by subtracting capital deepening (line 4) and labor quality (line 8) from labor productivity growth (line 3). TFP capture true technological progress (for example, rapid improvements in the production of goods and services due to learning-by-doing or research activities or just by chance) and maybe also other factors (such as, for example, market distortion effects related to e.g. taxes, the maintenance of property rights, and monopoly power). The decomposition of labor productivity growth thus implies that the shaded rows in the table (line 4, 8, and 9) sum to labor productivity growth (line 3).

Table 2 shows, for example, that a better-quality labor force, in the sense of a substitution toward workers with higher marginal products, has contributed to labor productivity growth by about 0.2 percent per year (see line 8).[30] The table does not, however, show any details about the origins of the labor quality effect (i.e., the table does not say anything about which level-type shares of the labor force is growing (falling)) – to include that information in the table line 8 would have to be replaced by 20 separate lines (one for each level-type).

[29] Note that the data is preliminary and thus should be interpreted with care. It is, for example, unclear, at least to us, to what extent hedonic, quality-adjusted prices have been used while constructing real capital.

[30] It is implicitly assumed in the table that for 1999 and 2000, labor quality generates a 0.20 percentage point to labor productivity growth, its average contribution over 1994-1998 (lack of data precludes a computation of this quality effect for these years.)

Table 2 also shows that annual TFP growth was especially strong in 1994 and 1995, which probably has to do in part with cyclical forces (Sweden escaped from a large recession in the middle of the 1990s). Moreover, the contribution from aggregate capital deepening to labor productivity growth is sometimes negative (this is the case for 1994 and 1995). This result calls for deeper analysis, in particular as regards the construction of data. It is, of course, possible that this effect represents a surge in working hours in the aftermath of the 1991–93 recession years (that is, this is a cyclical effect) – after all, a negative capital deepening is at times to be expected in the early phases of economic recovery. Other potential explanations include difficulties concerning the measurement of capital inputs and the effective user cost of capital. For example, capital per hours worked may fall as a result of the implicit assumptions that are made in the construction of the data. Both a higher assumed computer hardware and software depreciation rate and an underestimation of the quality-adjusted price decline of computer hardware and software will lead to an underestimation of the growth rate of computer capital, which will drive down the capital-labor ratio.[31]

4.2 Caveats and Measurement Issues

The growth-accounting framework is based on many assumptions which may or may not hold, and which are important to bear in mind when analyzing the results of the exercise. If the underlying assumptions fail to hold, TFP growth will include other things than just true technological change, such as omitted intermediate factor inputs due to the improper use of value-added data (Basu and Fernald (1995)) and cyclical effects (Sbordone (1996)).

There are some results of the previous chapter that deserve additional attention. The first is the negative productivity contribution from aggregate capital deepening in 1994 and 1995. This finding appears to conflict with one of Kaldor’s (1963) stylized facts, and hence it raises a few questions as regards the construction of the real capital data. For example, if the ICT capital depreciation rate is too high, or if the price decline of ICT capital is too small, the growth rate of ICT capital will be underestimated. This would drive down the ratio of ICT capital and worked hours, leading to a smaller contribution to labor productivity growth from ICT capital deepening. In the Swedish National Accounts, both quality-adjusted prices and so-called wage-index-adjusted prices are used when computing real ICT capital (there are differences between various types of capital). Statistics Sweden is currently working on improving the price indices.

A closely related issue is the size of the residual (i.e., TFP growth) in the exercise. An underestimation of the growth of factor inputs inevitably leads to an overestimation of this residual. As the residual is a measure of our ignorance, more data work is clearly needed here.

In addition to these basic measurement issues, there are several conceptual questions that also could be addressed. One has to do with telling cyclical and structural productivity gains apart, which is of great importance when it comes to getting the macroeconomic picture right. Bearing in mind that Sweden escaped from a large recession in the middle of the 1990s, this distinction may in fact seem crucial. Another issue has to do with causality. Although the growth-accounting framework suggests that human capital formation and ICT outlays improve productivity growth, it could certainly be the other way around – i.e., that strong productivity growth encourages investments in both knowledge and ICT.

4.3 The Information Age

In the 1990s, a number of business economists launched what came to be known as the new paradigm (new era) economics. As regularly stated, this new doctrine abandoned the old idea that the threat of inflation would limit the possibilities for sustained economic growth. According to this view, rapid productivity growth combined with increased competition and global integration would imply that even considerable growth rates would not cause any

[31] Appendix B shows growth-accounting results for the goods, services, manufacturing, and ICT sector.

inflation pressures. This opinion is often casually referred to as something that has to do with the new economy. The present analysis obviously relates to the above in that it investigates the productivity contribution from enhanced labor quality and ICT capital. It does not, however, go into any details as regards the variety of new era definitions that circulate, nor does it in any ways speculate about the future prospects of the new era and its likely effects in general on society as a whole. This lies outside the scope of the analysis.

It is also worth mentioning here that the end result of a fast-growing ICT sector need not always be that favorable. The reason is that a number of offsetting productivity effects may dominate. For example, it may certainly be the case that ICT expansion merely results in reorganization of market shares – e.g., when a traditional store loses business to an on-line equal. Another possible offsetting effect is the likely increase in useless on-the-job consumption, for example when employees use their computers for video games. In addition, training costs that accompany ICT capital investments may reduce the output gains of these investments. For sure, if all of these counteracting effects are large, there may not be any linkage at all (or, for that matter, a negative linkage) between ICT investments and TFP gains.

5 Concluding Remarks

This study provides support for the view that a better-quality labor force has raised Swedish labor productivity growth throughout the 1990s. This quality effect represents a shift in the labor force toward more productive workers; labor input of some educational levels or types grows (falls) which has higher (lower) productivity than the average. In the business sector, for example, this change in the composition of the labor force has raised labor productivity growth by about 0.2 percentage points per year. The results also indicate that the productivity growth effect from improved labor has been higher in the service sector (0.24 percentage points per year on average) than in the goods sector (0.17 percentage points). In the ICT-producing sector, in turn, the productivity growth effect from better-quality labor seems to have been even larger (0.37 percentage points). This productivity growth effect appears to reflect a growing share of employees with an economics or engineering bachelor's degree – hence, this effect simply reflects the increasing educational attainment of each generation of workers. The flip side of this development, of course, is a falling share of employees with lower education.[32]

Another result has to do with the measurement of labor quality. As the data requirements are often pretty large when it comes to measuring labor quality, the decision of how much costs to invest in data acquisition must be balanced against the gains in terms of more precise results. Earlier empirical work typically make use of just a few categories of educational attainment (see e.g. Fosgerau et al. (2002), and Ho and Jorgenson (2001)). One result in the present study is that little precision is gained by expanding the number of labor categories beyond four educational levels – hence, the difference between the growth effect from better-quality labor when using the "20 level-type classification" is not that different from the effect when using just the "4 level classification".

[32] Note that, in principle, labor quality rises whenever there is a shift toward workers with higher marginal products or if workers with a higher marginal product raise their share of labor costs. This implies that the economics or engineering graduates (which in the present study were identified as the driving force behind the improved labor quality) may, in principle, have contributed to the increase in labor quality because there was a large increase in the number of these workers and/or because the earnings of these workers rose relatively to other groups. The results of the present study largely reflect that the shares of higher-educated workers have increased throughout the 1990s (see Diagrams 2 and 3).

A final conclusion is that more work is needed. For example, it would probably be useful for Statistics Sweden to:

1. **Asses the results of this and other economic research.**
   This is a key element for the successful operation of data production. While it is still early to visualize the required institutional framework given the follow-up work of the Commission on the Review of Economic Statistics (SOU 2002:118), a clear system is needed.

2. **Expand Statistics Sweden's capacity to deal with economic theory.**
   This is also a key element for the successful operation of data production.

3. **Establish a new standard for data production.**
   A permanent forum or working group needs to be established between Statistics Sweden and a number of economists to handle both current and future data issues.

Appendix A: Theoretical Framework

A.1 Comparing Output and Inputs

Consider now a general production function $Y = F(K, L, V)$ for a single firm, where Y is value-added output (i.e., gross output net of intermediate inputs). Capital and labor inputs are denoted by K and L. V is an index of the level of technology. Let the production function F be homogenous of degree γ in capital and labor, and of degree one in V. Logarithmic differentiating of F yields:

$$d\ln Y = \gamma d\ln K + \left(\frac{F_L L}{Y}\right)(d\ln L - d\ln K) + d\ln V, \tag{A.1}$$

where $d\ln Y$, $d\ln K$, $d\ln L$, and $d\ln V$ are the growth rates of Y, K, L, and V. F_L is the marginal product of labor. The homogeneity conditions $(F_K K + F_L L)/Y = \gamma$ and $F_V V / Y = 1$ have been used in the derivation of (A.1).[33]

Equation (A.1) can be simplified by making the assumptions that firms have some monopoly power in output markets (but not in the market for factor inputs), and that the behavior of firms can be approximated by a sequence of static problems. A simple expression for the ratio $F_L L / Y$ can then be found by assuming that a representative firm (now indexed by i) faces the demand function $Y_i = (P_i / P)^{-\eta}(M / P)$. The price level of firm i's output is denoted by P_i, P is the general price level, M is the monetary base, and η is the elasticity of demand.

The firms are assumed to maximize the profit function $\pi_i = P_i Y_i - wL_i - rK_i$ with respect to labor and capital inputs in every time period, and the wage rate w and capital cost r are taken as given by the firms. The two first-order conditions are:

$$\begin{aligned} P_i \mu^{-1} F_L &= w, \\ P_i \mu^{-1} F_K &= r, \end{aligned} \tag{A.2}$$

where $\mu = \eta/(\eta - 1)$ is the markup factor. Now, let α_v denote labor's share in total value-added output ($\alpha_v = wL_i / P_i Y_i$) and use the first relation in (2.2) to obtain $\mu\alpha_v = F_L L_i / Y_i$[34]. By combining the two first-order conditions with the homogeneity condition relating $(F_K K + F_L L)/Y = \gamma$, the product $\mu\alpha_v$ can now be rewritten in terms of the (internal) returns-to-scale parameter γ and labor's share in total factor costs α_c:

$$\frac{P_i Y_i}{wL_i + rK_i} = \frac{\mu}{\gamma} \quad \Leftrightarrow \quad \mu\alpha_v = \gamma\alpha_c, \tag{A.3}$$

---

[33] This model hence compares movements in output with movements in factor inputs and, accordingly, relates to the growth accounting literature originating from Solow (1957). The growth rate of technology is the Solow residual.

[34] When output and input markets are competitive, the required conditions for producer equilibrium are that the share of every input in the value of output equals the output elasticity with respect to that input.

where $\alpha_c \equiv wL_i/(wL_i + rK_i)$. Substitution of $\gamma\alpha_c$ for $F_L L/Y$ in (2.1) yields the basic equation that is used in this study:

$$d\ln Y_{it} = \gamma_{it} d\ln X_{it} + d\ln V_{it}, \tag{A.4}$$

where dX_{it} is a weighted index of input growth:

$$d\ln X_{it} \equiv \alpha_{cit} d\ln L_{it} + (1-\alpha_{cit}) d\ln K_{it}. \tag{A.5}$$

Equations (A.4) and (A.5) can be re-formulated in terms of labor productivity growth by assuming constant returns to scale and subtracting the growth rate of hours worked from both sides:

$$d\ln y_{it} = d\ln Y_{it} - d\ln L_{it} = d\ln x_{it} + d\ln V_{it}. \tag{A.6}$$

Equation (A.6) splits labor productivity growth into capital deepening in the sense of capital per hour worked and total factor productivity growth. The growth of weighted inputs per worked hour is defined as:

$$d\ln x_{it} = d\ln X_{it} - d\ln L_{it} \equiv (1-\alpha_{cit}) d\ln k_{it}, \tag{A.7}$$

and

$$d\ln k_{it} = d\ln K_{it} - d\ln L_{it}. \tag{A.8}$$

A.2 Capital

In the empirical analysis below, the real stock of capital is split into three categories: 1) buildings (denoted by subscript B), 2) machinery and equipment, exclusive of ICT equipment (subscript M), and 3) ICT equipment (subscript ICT). Splitting capital into these three parts yields a detailed analogue of equation (A.7):

$$d\ln x_{it} \equiv \beta_{Bit} d\ln k_{Bit} + \beta_{Mit} d\ln k_{Mit} + \beta_{ICTit} d\ln k_{ICTit}, \tag{A.9}$$

where the beta coefficient represents each capital's share in total costs:

$$\beta_{jit} = (1-\alpha_{cit}) \frac{r_j K_{jit}}{\sum_j r_j K_{jit}}, \quad J = B, M, ICT. \tag{A.10}$$

r_j is the user cost of capital.

Following Hall and Jorgenson (1967), firm i's user cost of asset j can be computed according to[35]

$$r_{ji} = \frac{1 - ITC_{ji} - \Gamma_j}{1-\tau} (\delta_j + \rho - \pi_j), \tag{A.11}$$

where $\rho - \pi_j$ is the real rate of return required on capital, and δ_j is the economic rate of annual depreciation. The investment tax credit ITC_i^j measures the proportion of the original

---

[35] The user cost of capital is the price that would be charged if capital was rented for one period of time.

investment cost that is subsidized. The present value of depreciation allowances for an investment is captured by Γ^{j}. τ is the corporate tax rate.[36]

Note, however, that due to a number of measurement difficulties, estimates of the cost of capital are at best good approximations of the true cost of capital – and it is normally "safer" to underestimate this cost than the opposite since capital is generally less cyclical than labor.[37] One concern has to do with the rate of depreciation; according to the so-called technological obsolescence hypothesis, machines that are yet productive are sometimes nonetheless withdrawn from the market since they are no longer close to the technical frontier.[38] If users of capital predict this too early capital retirement, this will have an effect on the economic rate of depreciation. Yet, a thorough analysis of the true user cost of capital lies outside the scope of this study.

A.3 Labor

Now, let A be the set of different labor types, and L_a the quantity of labor of type $a \in A$. The average wage for labor of category a is w_a. Dividing labor into these categories hence expands equation (2.9) to:

$$d \ln x_{it} \equiv \beta_{Bit} d \ln k_{Bit} + \beta_{Mit} d \ln k_{Mit} + \beta_{ICTit} d \ln k_{ICTit} + \sum_{a \in A} \gamma_{ait} d \ln l_{ait}, \quad \text{(A.12)}$$

where l_{ait} is the share of category a in total labor (i.e., $l_{ait} = L_{ait} / \sum_a L_{ait}$), and the gamma coefficients represent each factor's share in total cost:

$$\gamma_{ait} = \alpha_{cit} \frac{w_{ait} L_{ait}}{\sum_a w_{ait} L_{ait}}. \quad \text{(A.13)}$$

Equation (A.6) and (A.12) capture the essence of the basic model that is used below.

---

[36] Note, however, that we simplify this user cost calculation in the present study (i.e., when we tabulate the growth-accounting results) since there are some questions about to what extent the data is deflated by quality-adjusted (hedonic) prices. Hence, the preliminary growth-accounting output in the study should be interpreted with care.

[37] The reason why this is "safer" is that spurious cyclical measurement errors in the baseline equation (2.6) are less likely to show up when labor's share in total costs is large.

[38] See, for example, Whelan (2002).

Appendix B: The composition of the labor force

This appendix shows information that lies behind the calculations of the labor quality effect. In the tables below, the third column shows the labor share in the sense of the share of employees with this particular combination of education level and type. Column 4 shows the corresponding wage share for each group. Row 2 to 4 consist of missing values, indicating that this particular combination of education level and type does not exist. The fifth column shows the average annual, nominal wage measured in the Swedish Krona (SEK). The last column shows the number of employees with this particular combination of education level and type.

Table B.1
The composition of labor
The goods sector (ISIC 01-45)

Level	Type	L-share	W-share	Wage	#
9	G	30.92	27.47	172,689	304,806
9	E	0	0		0
9	I	0	0		0
9	C	0	0		0
9	S	0	0		0
12	G	4.43	3.94	173,271	43,759
12	E	8.11	7.33	175,966	80,071
12	I	33.55	34.71	201,168	331,316
12	C	4.74	3.49	143,234	46,803
12	S	3.03	2.33	149,192	30,046
16	G	1.05	1.02	190,345	10,341
16	E	3.53	5.17	285,188	34,861
16	I	8.95	12.24	266,008	88,494
16	C	1.05	1.18	219,273	10,366
16	S	0.29	0.37	246,730	2,861
21	G	0.01	0.01	207,148	121
21	E	0.01	0.03	375,356	142
21	I	0.27	0.56	403,052	2,678
21	C	0.06	0.14	451,338	579
21	S	0.01	0.01	302,245	64

Note: The column labelled L-share shows the average share (%) of employees from each educational group. The column labelled W-share shows the average wage share (%) in total wage costs for each group. The column labelled Wage shows the average wage in nominal SEK for each group. The last column shows the number of employees in each group.

Source: Statistics Sweden and own calculations.

Table B.2
The composition of labor
The service sector (ISIC 50-95)

Level	Type	L-share	W-share	Wage	#
9	G	23.71	19.59	151,148	307,796
9	E	0	0		0
9	I	0	0		0
9	C	0	0		0
9	S	0	0		0
12	G	8.98	7.85	160,284	117,503
12	E	16.85	15.71	171,057	219,437
12	I	15.07	15.82	192,347	196,781
12	C	6.82	5.57	149,607	89,313
12	S	5.05	3.66	132,806	66,068
16	G	3.74	3.52	172,604	49,043
16	E	9.62	14.22	270,837	125,977
16	I	6.19	8.88	263,308	81,071
16	C	2.93	3.57	223,308	38,320
16	S	0.66	0.84	231,212	8,685
21	G	0.03	0.04	231,179	368
21	E	0.07	0.16	433,505	862
21	I	0.22	0.41	347,553	2,876
21	C	0.07	0.15	387,664	934
21	S	0.01	0.01	255,656	119

Source: Statistics Sweden and own calculations.

Table B.3
The composition of labor
The manufacturing sector (ISIC 15-37)

Level	Type	L-share	W-share	Wage	#
9	G	31.48	27.75	177,035	227,678
9	E	0	0		0
9	I	0	0		0
9	C	0	0		0
9	S	0	0		0
12	G	5.07	4.50	178,398	36,815
12	E	9.26	8.27	179,516	67,135
12	I	30.73	31.50	205,934	222,933
12	C	3.28	2.69	164,696	23,804
12	S	3.30	2.52	153,274	24,013
16	G	1.18	1.17	199,494	8,569
16	E	4.20	6.05	288,792	30,536
16	I	9.93	13.29	269,105	72,109
16	C	0.78	0.93	239,724	5,661
16	S	0.33	0.43	257,502	2,437
21	G	0.02	0.02	205,438	119
21	E	0.02	0.03	378,021	129
21	I	0.34	0.69	404,511	2,505
21	C	0.07	0.17	461,846	529
21	S	0.01	0.01	314,197	58

Source: Statistics Sweden and own calculations.

Table B.4
The composition of labor
The ICT-sector (ISIC 30, 313, 32, 331, 642, and 72)

Level	Type	L-share	W-share	Wage	#
9	G	12.92	9.77	183,893	16,131
9	E	0	0		0
9	I	0	0		0
9	C	0	0		0
9	S	0	0		0
12	G	6.54	5.66	211,142	8,401
12	E	11.12	9.23	202,326	14,204
12	I	23.14	22.34	234,845	29,503
12	C	2.86	2.13	181,107	3,677
12	S	2.57	1.82	172,583	3,317
16	G	1.60	1.49	227,628	2,066
16	E	14.56	17.43	291,848	18,758
16	I	22.53	27.30	295,570	28,906
16	C	0.84	0.88	254,982	1,082
16	S	0.66	0.83	308,323	847
21	G	0.01	0.01	326,544	10
21	E	0.06	0.10	396,923	75
21	I	0.58	0.96	403,138	749
21	C	0.02	0.03	414,185	24
21	S	0.01	0.01	406,680	11

Source: Statistics Sweden and own calculations.

Appendix C: Growth Accounting

Table C.1
Accounting for productivity growth – a preliminary table
The goods sector (ISIC 01-45)

	94-00	94	95	96	97	98	99	00
Growth in output	6.15	8.32	8.96	1.77	4.69	4.85	6.72	7.77
Growth in hours worked	0.68	1.99	4.25	-1.40	-1.88	0.88	1.31	-0.41
Growth ALP	5.48	6.33	4.71	3.16	6.58	3.96	5.42	8.18
Capital deepening	0.88	-1.74	-1.62	2.15	2.99	1.39	1.38	1.58
Buildings	-0.07	-0.34	-0.64	0.14	0.34	0.12	0.04	-0.14
Machinery excl. ICT	0.29	-1.53	-1.20	1.03	1.89	0.70	0.43	0.73
ICT	0.65	0.13	0.22	0.98	0.76	0.57	0.91	0.99
Labor quality	0.17	0.19	0.13	0.22	0.17	0.14	0.17	0.17
Growth in TFP	4.43	7.88	6.20	0.79	3.41	2.43	3.87	6.43

Note: In 2000 the goods sector accounted for 31.82 (28.33) percent of current value GDP (hours worked). Its share of value-added (hours worked) in the business sector was 39.14 (40.55) percent. Note also that the data in this table are preliminary; it is, for example, unclear to what extent nominal ICT capital outlays have been deflated by quality-adjusted (hedonic) prices (see, for example, Edquist (2004)). As a result, ICT capital may be underestimated. In order to compensate for this, we have enlarged the user cost of capital (rather than speculated about the extent of this potential bias) so that it now equals the depreciation rate. This is, of course, not a perfect solution, but it meets our requirements for the purpose of the present study which focuses in particular on the productivity effects of a better-quality labor force.

Source: Statistics Sweden and own calculations.

Table C.2 Accounting for productivity growth – a preliminary table
The service sector (ISIC 50-95)

	94-00	94	95	96	97	98	99	00
Growth in output	3.93	4.33	4.48	1.71	3.58	2.98	5.56	4.89
Growth in hours worked	2.39	3.33	1.71	0.81	-0.35	2.39	5.09	3.71
Growth ALP	1.55	0.99	2.77	0.90	3.93	0.59	0.48	1.18
Capital deepening	0.44	-2.39	-0.56	1.48	1.57	0.98	0.49	1.52
Buildings	-0.29	-0.89	-0.60	-0.12	0.33	-0.02	-0.87	0.12
Machinery excl. ICT	-0.20	-1.60	-0.71	0.29	0.11	0.08	0.15	0.29
ICT	0.94	0.10	0.76	1.31	1.13	0.93	1.21	1.11
Labor quality	0.24	0.34	0.16	0.25	0.26	0.17	0.24	0.24
Growth in TFP	0.87	3.04	3.17	-0.83	2.10	-0.56	-0.24	-0.58

Note: In 2000 the service sector accounted for 48.34 (41.53) percent of current value GDP (hours worked). Its share of value-added (hours worked) in the business sector was 60.86 (59.45) percent. See also the note to Table C.1.

Source: Statistics Sweden and own calculations.

Table C.3
Accounting for productivity growth – a preliminary table
The manufacturing sector (ISIC 15-37)

	94-00	94	95	96	97	98	99	00
Growth in output	8.99	13.90	11.92	3.37	7.18	7.72	8.59	10.25
Growth in hours worked	1.51	4.58	6.35	-0.60	-1.33	1.87	0.11	-0.39
Growth ALP	7.47	9.32	5.57	3.97	8.50	5.84	8.48	10.64
Capital deepening	1.08	-2.11	-1.58	2.66	2.88	1.26	2.31	2.15
Buildings	-0.05	-0.35	-0.43	0.11	0.16	-0.01	0.07	0.09
Machinery excl. ICT	0.31	-1.71	-1.24	1.25	1.73	0.63	0.82	0.70
ICT	0.82	-0.05	0.09	1.29	0.99	0.64	1.42	1.36
Labor quality	0.19	0.23	0.17	0.25	0.17	0.14	0.19	0.19
Growth in TFP	6.20	11.20	6.97	1.06	5.45	4.45	5.98	8.30

Note: In 2000 the manufacturing sector accounted for 23.03 (18.13) percent of current value GDP (hours worked). Its share of value-added (hours worked) in the business sector was 28.28 (25.95) percent. See also the note to Table C.1.

Source: Statistics Sweden and own calculations.

Table C.4
Accounting for productivity growth – a preliminary table
The ICT-sector (ISIC 30, 313, 32, 331, 642, and 72)

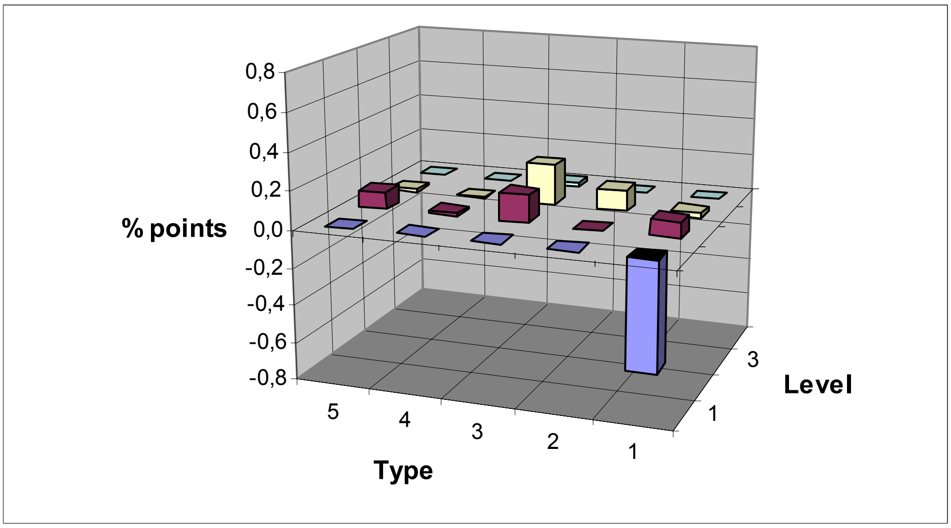
	94-00	94	95	96	97	98	99	00
Growth in output	22.72	23.01	26.92	22.38	23.59	20.54	19.20	23.40
Growth in hours worked	8.39	5.56	12.30	6.91	4.93	7.86	10.01	11.14
Growth ALP	14.33	17.44	14.62	15.47	18.66	12.68	9.19	12.25
Capital deepening	-1.41	-1.93	-3.82	-0.07	-0.71	-1.39	-1.18	-0.78
Buildings	-0.36	-0.21	-0.72	-0.25	-0.22	-0.41	-0.43	-0.29
Machinery excl. ICT	0.13	0.71	-0.13	0.50	0.03	-0.01	-0.08	-0.13
ICT	-1.18	-2.44	-2.97	-0.31	-0.52	-0.98	-0.67	-0.37
Labor quality	0.37	0.26	0.31	0.48	0.51	0.27	0.37	0.37
Growth in TFP	15.37	19.12	18.13	15.05	18.85	13.80	10.00	12.67

Note: In 2000 the ICT sector accounted for 6.03 (4.58) percent of GDP (hours worked). Its share of value-added (hours worked) in the business sector was 7.57 (2.05) percent. See also the note to Table C.1.

Source: Statistics Sweden and own calculations.

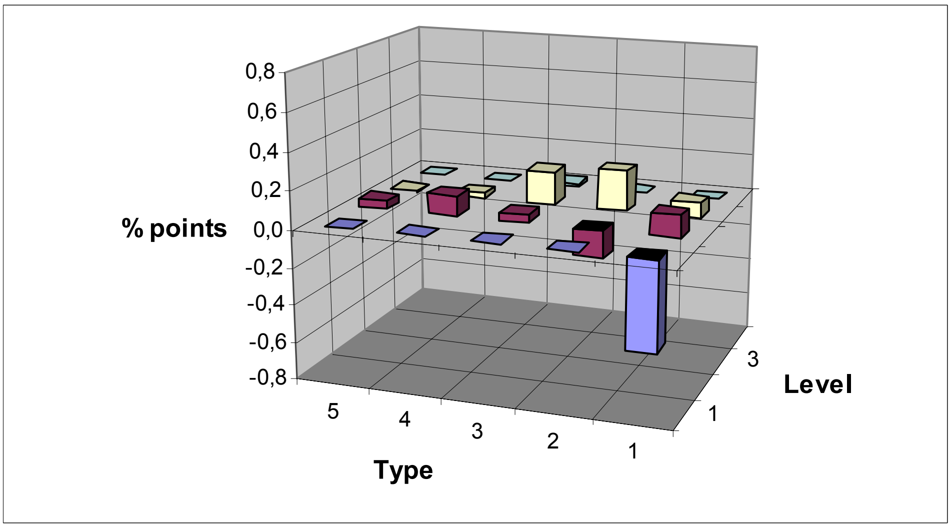
Appendix D: Growth Contribution from Labor quality

Diagram D.1
Average annual contribution to ALP growth in the Goods sector from changes in the composition of labor



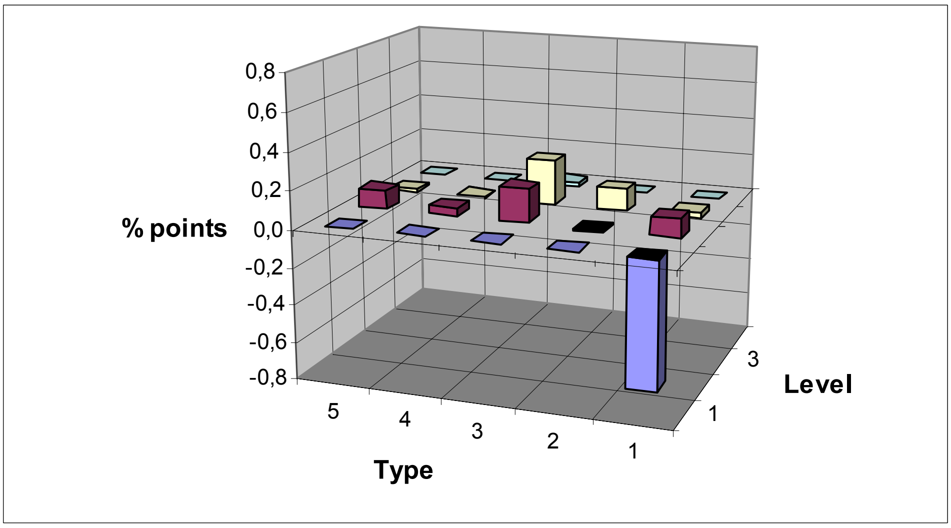
Note: The three-dimensional diagram shows the contribution to productivity growth, as calculated by equation (A.12) in appendix A, from each labor category. Level 1 refers to the compulsory years of education (i.e., 9 years), Level 2 to three additional years after the compulsory years (i.e., 12 years), Level 3 to a bachelor's degree (i.e., 16 years of education or more), and Level 4 to a graduate/PhD degree (i.e., 21 years of education or more). Type 1 refers to the "general profile", Type 2 to the "economics profile", Type 3 to the "industry profile", Type 4 to the "caring profile", and Type 5 to the "service profile".

Diagram D.2
Average annual contribution to ALP growth in the Services sector from changes in the composition of labor



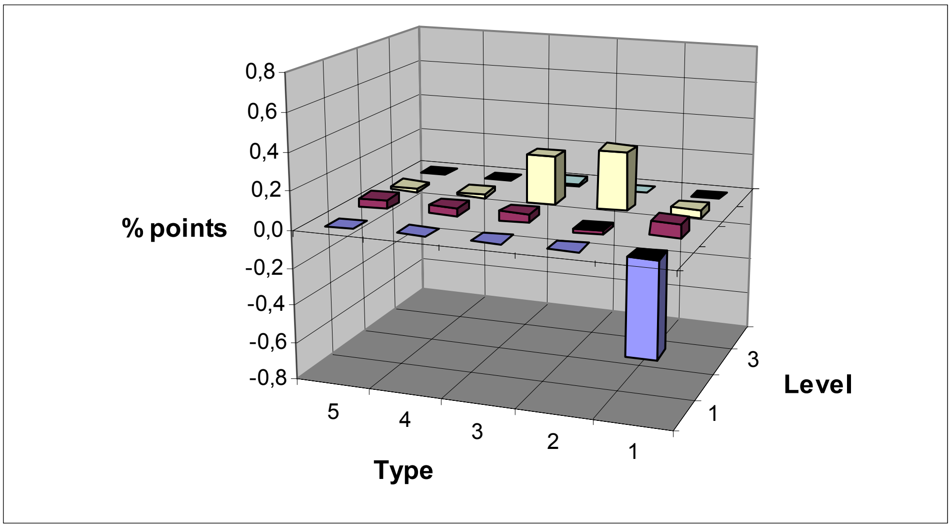
Note: Same as in Diagram D.1.

Diagram D.3
Average annual contribution to ALP growth in the Manufacturing sector from changes in the composition of labor



Note: Same as in Diagram D.1.

Diagram D.4
Average annual contribution to ALP growth in the Information & Communications Technology (ICT) sector from changes in the composition of labor



Note: Same as in Diagram D.1.

References

Baily, M. N. and Robert J. Gordon (1988). “The Productivity Slowdown, Measurement Issues, and the Explosion of Computer Power”, in *Brookings Papers on Economic Activity*. Washington, DC, The Brookings Institution, pp. 347–431.

Barro, Robert, J. and Sala-i-Martin (1995). *Economic Growth*, McGraw-Hill, Inc., New York, NY.

Basu, Susanto and J G. Fernald (1995). “Are Apparent Productive Spillovers a Figment of Specification Bias?”, *Journal of Monetary Economics* 36, pp. 165–188.

Benhabib J. and B. Jovanovic (1991). “Externalities and Growth Accounting”, *American Economic Review*, 81, pp. 82–113.

Bentolila, S. and G. Saint-Paul (1998). “Explaining Movements in the Labour Share”, CEPR Working Paper No. 1958.

Berman, E., J. Bound and Z. Griliches (1994). “Changes in the Demand for Skilled Labor Within U.S. Manufacturing: Evidence from the Annual Survey of Manufactures”, *Quarterly Journal of Economics*, 109, pp. 367–398.

Bernanke B. S. and M. L. Parkinson (1991). “Procyclical Labor Productivity and Competing Theories of the Business Cycle: Some Evidence from the Interwar U.S. Manufacturing Industries”, *Journal of Political Economy*, 99, pp. 439–459.

Card, Davis and John E. DiNardo (2002). “Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles”, Journal of Labor Economics, vol. 20(4), pp. 733–783.

Colecchia, Allesandra and Paul Schreyer (2002). “ICT investment and Economic Growth in the 1990s: is the United States a Unique Case?”, ***Review of Economic Dynamics***, 5, pp. 408–442.

Edquist, Harald (2004). “The Swedish ICT Miracle – Myth or Reality”, SSE/EFI Working Paper, No. 556, Dept. of economics, Stockholm School of Economics, Stockholm, Sweden.

Fosgerau, Mogens, Hougaard Jensen, Svend, and Anders Sorensen (2002). “Measuring Educational Heterogeneity and Labor Quality: A Note”, *Review of Income and Wealth*, 48(2), pp. 261–269.

Grilishes, Zvi (1994). “Productivity, R&D, and the Data Constraint”, *American Economic Review*, 84, 1–23.

Hall, Robert E. and Dale W. Jorgenson (1967). “Tax Policy and Investment Behavior”, *American Economic Review*, 57(3), pp. 391–414.

Hansen, Sten and Tomas Lindström (2003). ”Is Rising Returns to Scale a Figment of Poor Accounting Data?”, manuscript, the Ministry of Finance and the National Institute of Economoic Research, Stockholm, Sweden.

Hansson, Pär (1997). “Trade, Technology, and Changes in Employment of Skilled Labor in Swedish Manufacturing”, in Fagerberg, J. et al. *Technology and International Trade*, Edward Elgar, pp. 200–216.

Islam, N. (1995). “Growth Empirics: a Panel Data Approach”, *Quarterly Journal of Economics*, 110(4), pp. 1127–1170.

Jalava, Jukka (2002). “Quantifying the New Economy: Challenges for Economic Statistics, manuscript, Statistics Finland.

Jalava, Jukka and Matti Pohjola (2002). “Economic Growth in the New Economy”, Information Economics and Policy, 14, pp. 189–210.

Jorgenson, Dale W. and Kevin J. Stiroh (1999). “Information Technology and Growth”, *American Economic Review*, Paper and Proceedings, 89(2), pp. 109–115.

Jones, Charles I. (2002). “Sources of U.S. Economic Growth in a World of Ideas”, *American Economic Review*, 92(1), pp. 220–239.

Judson, Ruth (2002), “Measuring Human Capital Like Physical Capital: What Does it Tell Us?, *Bulletin of Economic Research*, 54(3), pp. 209–231.

Lindström, Tomas (2002). "The Role of High-tech Capital Formation for Swedish Productivity Growth", in *Development and Improvement of Economic Statistics*, SOU 2002:118.

Lucas, Robert, E. (1988). "On the Mechanics of Development Planning", *Journal of Monetary Economics*, 22(1), pp. 3–42.

Mankiw, N. G., Romer, D. and Weil, D. N. (1992). "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics*, 107(2), pp. 407–438.

Mulligan, Casey B. and Xavier Sala-i-Martin (2000). "Measuring Aggregate Human Capital", *Journal of Economic Growth*, 5, pp. 215–252.

OECD (2001a). "Measuring Capital: OECD Manual on Measurement of Capital Stocks, Consumption of Fixed Capital and Capital Services".

OECD (2001b). "Measuring Productivity: OECD Manual on Measurement of Aggregate and Industry-level Productivity Growth".

Oliner S. D. and D. E. Sichel (2000). "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?", *Journal of Economic Perspectives*, 14 (4), pp. 3–22.

Sbordone, A. M. (1996). "Cyclical Productivity in a Model of Labor Hoarding", Journal of Monetary Economics, 38, pp. 331–361.

Schreyer, Paul (2000). "The Contribution of Information and Communication Technology to Output Growth: A Study of the G7 Countries", manuscript, OECD.

Solow, Robert M. (1957). "A Contribution to the Theory of Economic Growth", *Quarterly Journal of Economics*, 70, pp. 65–94.

Stiroh, Kevin J. (2002). "Are ICT Spillovers Driving the New Economy?", *Review of Income and Wealth*, 48(1), pp 33–57.

Oliner, Stephen D. and Daniel E. Sichel (2000). "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?", *Journal of Economic Perspectives*, 14(4), pp. 3–22.

Whelan, Karl (2002). "Computers, Obsolescence, and Productivity", *Review of Economics and Statistics*, 84(3), pp 445–461.

2004:01 Hjälpverksamhet. Avrapportering av projektet Systematisk hantering av hjälpverksamhet

2004:02 Report from the Swedish Task Force on Time Series Analysis

2004:03 Minskad detaljeringsgrad i Sveriges officiella utrikeshandelsstatistik

2004:04 Finansiellt sparande i den svenska ekonomin. Utredning av skillnaderna i finansiellt sparande Nationalräkenskaper, NR – Finansräkenskaper, FiR Bakgrund – jämförelser – analys

2004:05 Designutredning för KPI: Effektiv allokering av urvalet för prismätningarna i butiker och tjänsteställen. Examensarbete inom Matematisk statistik utfört på Statistiska centralbyrån i Stockholm

2004:06 Tidsserieanalys av svenska BNP-revideringar 1980–1999

ISSN 1650-9447

Statistical publications can be ordered from Statistics Sweden, Publication Services, SE-701 89 ÖREBRO, Sweden (phone: +46 19 17 68 00, fax: +46 19 17 64 44, e-mail: publ@scb.se). If you do not find the data you need in the publications, please contact Statistics Sweden, Library and Information, Box 24300, SE-104 51 STOCKHOLM, Sweden (e-mail: information@scb.se, phone: +46 8 506 948 01, fax: +46 8 506 948 99).

www.scb.se