Hours, Capital and Technology – What Matters Most?

Analyzing Productivity Growth by the Means of Growth Accounting

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Preface

This occasional study analyzes the development of productivity in various industries within the Swedish business sector and in that sector as a whole during the years 1997–2005. Based on the analysis, projections are made for the future development of productivity and value added. The study is a translation of Appendix 6 of the Long-Term Planning Commission Study 2008.

The study was prepared by a project group at the National Institute of Economic Research (NIER). The project manager was Kristian Nilsson. Other participants in the project were Christina Nyman, Åsa Olli-Segendorff, Johan Samuelsson and Anna Öster. The work has been followed by a reference group consisting of Henrik Braconier, Fredrik Bystedt, Jesper Hansson, Thomas Lindh and Tomas Lindström.

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Summary

The Swedish economy has performed comparatively well after the severe financial crisis of the early 1990's. One of the main reasons was that productivity growth in the business sector picked up in the 1990's after a relatively lacklustre period in the 1980's. The principal underlying cause of the higher productivity growth was rapid technological development, particularly in the ICT (information and communications technology) industries, but there are other explanations as well. In the early 1990's many low-productivity firms were driven out of business in the wake of the financial crisis, temporarily (to some extent) raising the rate of productivity growth. Moreover, a higher degree of internationalization and deregulation of different markets has contributed to intensified competition, stepping up the pressure for structural transformation. One very interesting question is of course whether the strong trend in productivity growth will continue. To a considerable degree, the outcome will affect how rapidly material prosperity will increase in Sweden in the years ahead.

Productivity is measured as value added per hour worked. In a long-term perspective, i. e. when cyclical variations are disregarded, the course of productivity is determined by technological progress, the improvement in the competence and skills of the labour force and the development of capital intensity in production, i. e. the increase in the input of capital services per hour worked. At the aggregate level, the development of productivity is also influenced by composition effects, as when a smaller proportion of production takes place in less productive industries and a greater proportion in more productive industries, or vice versa.

Because of growing globalization, with rapidly expanding world trade, stiffening competition and increasing numbers with access to the Internet, technological advancements tend to spread quickly throughout the world economy. This means that technological development in Sweden is affected not only by domestic factors, but also to a high degree by what is happening elsewhere in the world. Other factors as well, like the tendency of the educational level of the labour force, may impact the future growth of productivity in Sweden.

It is also clear that political decisions can influence productivity. For example, the design of the tax system affects capital formation and thus the capital intensity of production. The tax system, like the system of financial assistance to students, also impacts the economic incentives for education. Together with the design of the educational system, these factors affect the educational level and thus the productivity of the labour force. In addition, political decisions may influence, both directly and indirectly, the amount of resources devoted to research and development, with possible repercussions on technological progress. Political decisions that encourage capital formation, education and research and development can lead to higher productivity. Productivity can also be influenced by the efficiency of various institutions, such as the legal system, through legislation on competition and patents, for example. The scholarly literature on economic growth, however, does not provide general support for the conclusion that changes in systems of rules have lasting effects on productivity growth. Rather, changes in rules have lasting effects on the level of productivity; normally, therefore, productivity growth is impacted only temporarily

The driving forces behind the historical growth of productivity are central as a starting point for assessing its future development. The main purpose of this report is to analyze the development of productivity in the Swedish business sector with the use of so-called growth accounting for the years 1997–2005 and to present projections

of the trend (i. e. cyclically balanced) rate of growth in productivity and value added in the business sector. Growth accounting is a method for decomposing, or breaking down, the change in value added, and thus the change in productivity as well, into various components.

The development of productivity has differed considerably from one industry to another. To improve the precision of growth accounting, and to provide a better basis for projections of productivity, the business sector is divided into four different industries, each of which is analyzed separately: the ICT industry; the manufacturing industry excluding ICT; the other-goods industry; and the services industry excluding ICT. The ICT industry has shown exceptional productivity growth in recent years and is therefore interesting to study separately. The manufacturing industry excluding ICT has also shown substantially stronger productivity growth than the business sector as a whole; in addition, it has probably been affected by growing internationalization to a higher degree than industries more oriented toward the domestic market (the other-goods industry and the services industry excluding ICT).

There are differences in the productivity of different kinds of capital. In order to analyze these differences with growth accounting, capital is divided into three different types in each of the four industries. The three types are: machinery and equipment (including transportation, excluding hardware); buildings and structures (including housing); ICT capital. It is thereby possible to calculate for each industry a measure of so-called capital services that takes into account the differences in productivity of different kinds of capital.

Considerable emphasis is placed on analyzing the role of the composition of the labour force in the development of productivity. The labour force is therefore classified in three dimensions: age, level of education and country of birth. The resulting groups within the labour force differ in their average productivity, and through this classification consideration can be given to changes in the composition of the labour force over time. Relative wages are taken as an approximation of the relative productivity of different groups within the labour force. Differences in wages among different groups in the labour force are considered in the weighting of so-called quality-adjusted hours. Groups with high relative wages are assigned relatively heavy weights. The concept of quality adjustment is established in this context and is therefore used throughout the report. Quality adjustment of the labour force means that differences in wages, and thus in assumed productivity, attributable to age, level of education and country of birth are taken into account in the calculations.

Age can affect productivity in several ways. The productivity of older people, for example, is positively affected by their greater work experience; the productivity of younger individuals, by their more recent formal education. A higher level of education is normally accompanied by higher wages, and therefore, it is assumed, by higher productivity as well. Country of birth may also be a factor affecting wages and thus assumed productivity. One may imagine, for instance, that the work experience of those born abroad might be less relevant to Swedish conditions than the experience of equally well-educated contemporaries born in Sweden. Moreover, certain kinds of education, such as law, may be difficult to apply in a Swedish setting. Also, a deficient command of the Swedish language may limit the productivity of some of the foreign-born. A number of factors may tend to make it harder for certain individuals born outside Sweden to find work in the areas for which they are trained, and may explain why the foreign-born to a higher degree than natives of Sweden are overqualified for their current employment in terms of educational level. But even if several factors may affect the labour market situation of the foreign-born, differences in wages compared to those of Swedish natives may also be due to discrimination. The extent to which differences in wages are attributable to discrimination rather than actual differences in productivity is difficult to determine and is not analyzed in this study, where it is assumed that a difference in wages reflects a difference in productivity.

The structure and principal findings and conclusions of the report are presented below.

Driving Forces of Productivity, Growth Accounting for the Business Sector in Sweden, 1997–2005

The driving forces of productivity are briefly discussed in this chapter, and the method of growth accounting is also presented. Growth accounting is thereafter used to analyze the development of productivity in different industries within the Swedish business sector and for the business sector as a whole in the period 1997–2005. Also treated in the chapter are calculations for measures of capital services and quality adjustment of the labour force. The chapter concludes with a review of some previous growth accounting analyses for Sweden, contrasting these with the findings for certain other countries.

The productivity of the business sector as a whole increased on average by 3.3 percent per year during the period 1997–2005 (see Table S.1). Capital deepening (i. e. a greater quantity of capital services per hour worked), contributed an average of 1.0 percentage point per year, of which *more* capital accounted for just over 0.6 percentage point and *better* capital for slightly less than 0.4 percentage point. Quality adjustment of hours worked contributed on average 0.3 percentage point per year to productivity growth. This was a consequence of the change in the composition of the labour force toward more highly productive groups and, above all, it was due to an increase in the proportion of employees with post-secondary education during the period. The result was that total factor productivity (TFP) contributed an annual average of 2.0 percentage points to productivity growth. Changes in TFP follow from technical innovation and improvements in organization, among other things, and they reflect technological progress from a trend perspective. Half of the contribution from higher TFP, or 1.0 percentage point, was due to rising TFP in the ICT industry, even though this industry accounted for only about eight percent of value added in the business sector. Thus the development of the ICT industry played a crucial role.

Projections of Productivity Growth

In this chapter projections are made for productivity growth at the industry level; from these the development for the business sector as a whole can be derived. The period concerned is 2006–2020. The projections for the development of TFP are based largely on the historical trend rate of growth in TFP in the respective industry, but the views of other analysts on the international tendency are also taken into account. The uncertainty in the projected trend rates of TFP growth is naturally quite high, particularly in the ICT industry, where the trend rate of TFP growth has been soaring in recent years. For this reason, the projections of productivity growth are performed as sensitivity analyses under alternative assumptions about TFP growth in the ICT industry.

The cyclically balanced development of the number of hours worked is projected on the basis of the demographic tendency according to Statistics Sweden's population forecast, and of the NIER's education forecast. Thereafter, the number of hours worked is quality-adjusted by the same principles as for the period 1997–2005. Capital services are projected so that the cost of each type of capital is a constant percentage of the value added in the respective industry.

In the Base Scenario presented below, the trend rate of productivity growth in the business sector as a whole is 2.7 percent per year for 2006–2020 (see Table S.1). This level is about 0.7 percentage points below the actual rate in 1997–2005. The main reason for the lower level is that TFP growth is forecast to decelerate by about 30 percent in the ICT and manufacturing industries from its rapid rate during the period 1997–2005. The contribution from the improving quality of the labour force will also be a bit less in the projections. In addition, the trend of development in hours worked will be somewhat weaker in the period ahead compared to 1997–2005; for this reason, growth in value added will fall off somewhat more than growth in productivity.

Alternative Scenarios

The Base Scenario rests on a number of uncertain assumptions. For this reason, two alternative developments are analyzed. In the *Education Scenario*, it is assumed that 10 000 more persons per year will enrol in post-secondary education compared to the Base Scenario. The *Integration Scenario* analyzes the effects of gradually improved integration on the labour market of persons born outside the Nordic countries. It is assumed here that the difference in employment rate and in wages, and thus in assumed productivity, between persons born outside the Nordic countries and those born in Sweden, of the same age and with the same level of education, will be reduced by half during the period 2006–2020.

The results of the alternative scenarios are contrasted in Table S.1. In the period 2006–2020, value added rises fastest in the Integration Scenario. The principal reason is that with improved integration the number of hours worked increases more rapidly than in the other scenarios, particularly the Education Scenario. In general, the differences among the scenarios may appear fairly minor in terms of annual growth rates. But as noted above, the aggregate effect over the period is considerable. In 2020, for example, value added in the business sector is some 2.9 percent higher in the Integration Scenario than in either the Base Scenario or the Education Scenario. The corresponding figures for the number of hours worked are 2.1 and 2.7 percent, respectively.

Table S.1 Value Added, Hours Worked and Labour Productivity in the Business Sector

Average annual percentage change and percentage points, respectively

	Outcome 1997–2005	Base Scenario 2006–2020	Education Scenario 2006–2020	Integration Scenario 2006–2020
Value added	3.78	2.91	2.91	3.10
Hours worked	0.47	0.25	0.21	0.39
Labour productivity	3.32	2.66	2.70	2.71
Contribution from				
Quality adjustment of hours	0.32	0.12	0.14	0.12
Capital deepening	0.98	0.93	0.94	0.95
TFP	2.00	1.60	1.60	1.63

Source: NIER.

Productivity increases faster in the Integration Scenario than in the Base Scenario, and marginally faster than in the Education Scenario. At first, this result may seem surprising. Underlying it, of course, is the assumption that with improved integration of individuals born outside the Nordic countries, their wages, and thus the assumed increase in their productivity, will gradually rise toward the level for natives of Sweden.

In summary, it may be noted that the development of productivity varies relatively little among the three scenarios. But the differences in hours worked are much greater. In the Integration Scenario hours worked increase faster as improved integration on the labour market of persons born outside the Nordic countries drives up their employment rate, whereas hours worked show a more lacklustre tendency in the Education Scenario, with more people studying and fewer working. The effect on total hours worked is thus the principal source of the differences among the three scenarios in regard to the development of value added in the business sector.

Conclusions

The results lead to some interesting conclusions. A very much expected one is that technological development, and thus TFP, is the most important factor for growth in productivity. A number of measures may conceivably affect the development of TFP, but probably just temporarily. For example, continuing expansion of post-secondary education may go hand in hand with increased efforts in research and development and thus contribute to more rapid technological development. But it is highly uncertain whether such an element of so-called endogenous growth would arise from stepped-up efforts in education.

If the proportion of persons receiving post-secondary education continues to increase, the change in composition of the labour force will proceed more rapidly, thereby raising the rate of productivity growth. But the proportion of employees with post-secondary education will continue to go up even with post-secondary education as currently dimensioned, the reason being the generation change presently under way on the labour market. Consequently, one may not rule out the possibility that a further increase in the proportion with post-secondary education would tend to generate a surplus supply of labour in that category. If this were the case, the productivity gains from additional investment in education would be less than certain. At the same time, higher enrolment in post-secondary education would have the effect of limiting the number employed. The results imply that it is essential for additional efforts in education to be governed by demand and need if they are to contribute within a reasonable time to higher value added in the business sector than would otherwise be the case.

Improved integration of the foreign-born on the labour market can have a more immediate positive impact on the development of value added in the business sector, and here there is considerable potential. In the Integration Scenario, there is gradual reduction by half of the differences in employment rate and in wages, and thus in assumed productivity, between persons born outside the Nordic countries and those born in Sweden, given the same level of education and the same age. In this scenario, value added in the business sector will be 2.9 percent higher in 2020 than in the Base Scenario. This study does not analyze the measures and changes required for the Integration scenario to be realized, but if integration of the foreign-born on the labour market can be improved, the potential gains for the economy as a whole are considerable.

The two alternative scenarios should not be regarded as conflicting. Undeniably, improved integration of the foreign-born on the labour market would be very favourable to the development of the economy, above all through higher employment. Moreover, expansion of post-secondary education would probably have positive effects on the development of the economy as a whole, at least in the longer run. But to achieve this effect, it is important that additional investment in education be guided by the needs of the labour market.

1 Introduction

Labour productivity – the spirit of Martin Luther hovers over the words. For many, the striving to raise labour productivity, or simply productivity, is surely associated with staff cutbacks, stepped-up work pace and stress.[1] But the possibilities of increasing productivity by stepping up the pace of work are limited for natural reasons. If the rate of work is pushed up too high, the quality of performance will deteriorate. This will have a negative effect on productivity, which reflects not only the quantity of work performed, but also the quality of what is produced. Rather, the principal forces behind the development of productivity in the longer term are technological progress and improved organization of work, use of more and better equipment in production, and more advanced skills of those performing the work.

In a long-term perspective, the future progress of productivity will be decisive for furthering material prosperity. The forces driving the historical development of productivity are important as a starting point for assessing its future course. With the use of so-called growth accounting, the historical growth of productivity can be divided into one portion that results from more and better production factors, and another that results from other factors like technological progress and improved organization of work. In this study, the development in different industries within the Swedish business sector is analyzed with growth accounting for the period 1997–2005.[2] The results are then used as the basis for projections through 2020. The method makes it possible to prepare transparent and systematic projections for the development of productivity, where changes in the composition of the labour force, for example, can be considered.

1.1 Historical Development of Productivity

Productivity is the calculated value in constant prices (i. e. the volume) of the goods and services produced per hour worked, adjusted for consumption of input goods and services. Productivity is thus a measure of the value added that is created for each hour worked. Since gross domestic product, GDP, is the total of all value added in an economy, the productivity of the economy as a whole can be measured as GDP per hour worked.

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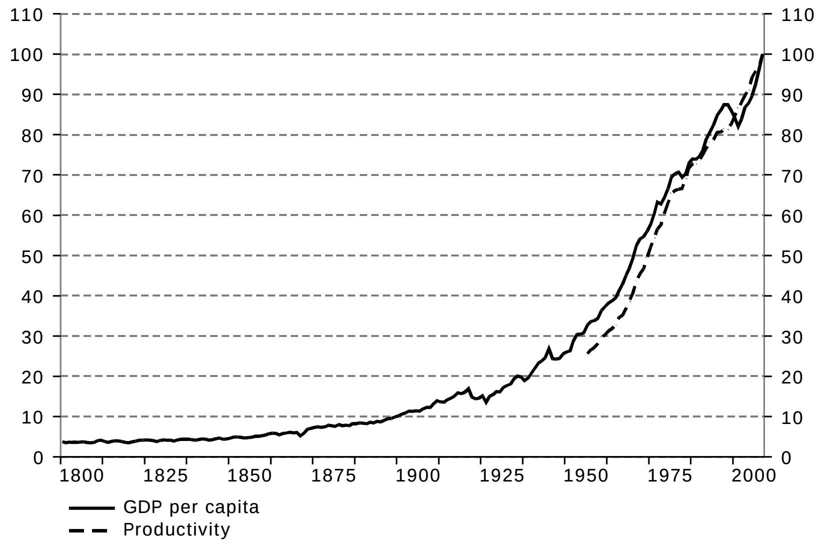
[1] Productivity is used throughout this study as a synonym for labour productivity..

[2] Productivity growth in the general government sector has been virtually zero during the period, partly for technical reasons related to the calculations. Consequently, it is of limited interest to analyze the development of productivity in the general government sector with the aid of growth accounting.

Diagram 1.1 GDP per Capita and Productivity
Index 2000 = 100



Note: Data processed by the NIER.
Source: Edvinsson, R. [2005] and NIER.

Diagram 1.1 shows the growth of per capita GDP by volume from 1800 to 2000. During the 19th century, per capita GDP increased by an annual average of 1.1 percent; this means that GDP nearly tripled in that century. In the 20th century, growth was much stronger, and per capita GDP increased almost ninefold, with an average annual growth rate of 2.2 percent. On the simplified assumption that the average time worked per person and year has remained unchanged, the growth of GDP per capita reflects the development of productivity as well. This assumption, of course, is not wholly realistic. For example, the average work week is shorter now than before. Moreover, the proportion of women in the labour force changed during the period. Consequently, the growth in per capita GDP only roughly reflects the development of productivity. For the years 1950–2000 there are comparable data for growth in productivity. Per capita GDP grew by an annual average of 2.3 percent during the period, whereas productivity rose at an average rate of 2.8 percent per year. Thus, productivity outpaced per capita GDP by an annual average of 0.5 percentage point, which means that the annual time worked decreased on average 0.5 percent per year.

Higher GDP (per capita) should not be interpreted as an unambiguous indication of improved living standards. For example, GDP growth does not reflect the depletion of non-renewable resources, destruction of the environment, depreciation of productive capital, or distribution of income, for example. But it is hardly controversial to state that there is a close relationship between greater material prosperity and a higher GDP per capita. Thus, increased productivity and increased material prosperity are interlinked. Although growth in productivity is not the only factor of importance to the development of material prosperity, it is a very significant one in a long-term perspective.

The rapid growth of productivity in Sweden since 1950 is due partly to improved efficiency in the agricultural sector. In 1950 the number employed in agriculture was 775 000, some 23 percent of the total number employed.[3] By 2000 the number work-

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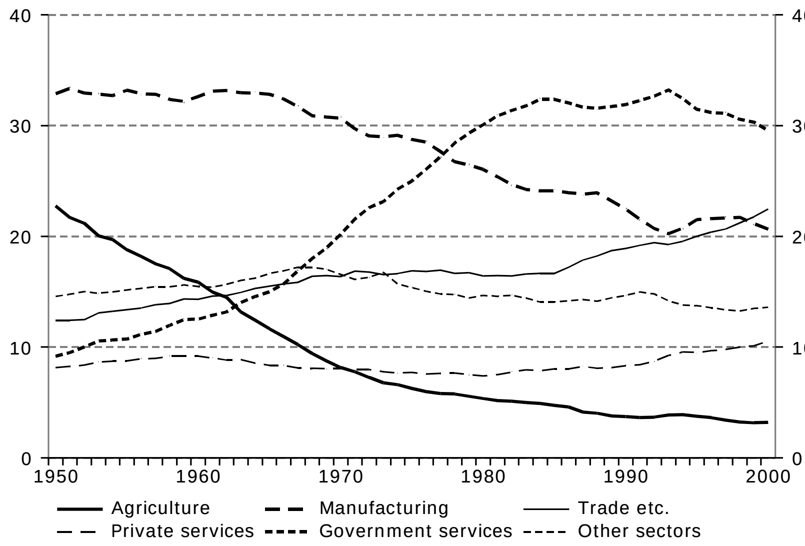
[3] Source: Edvinsson, R. [2005].

ing in agriculture had plummeted to 134 000, or only 3 percent of the total number employed. At the same time, value added in agriculture (including sideline operations) decreased in terms of volume by a total of 11 percent.[4] But with the extremely sharp drop in employment during the period, productivity soared between 1950 and 2000. Underlying the rapid rise in agricultural productivity were the usual drivers of increased productivity: improved technology – in the form of better machinery and equipment, for example – plant breeding, more knowledgeable workers in the industry and greater use of machinery and other capital.

Of course agriculture is not the only area of economic activity to show rapid growth in productivity, but it is striking how much labour was liberated from this sector to the benefit of other industries.

Diagram 1.2 Employment as a Share of Total Employment in the Economy as a Whole

Percent



Note: Agriculture includes related sideline businesses; manufacturing includes handicrafts; private services refer to reproductive services; trade etc. includes banking, insurance and other business activities. Other sectors include the construction industry, transport and communications as well as real-estate management. The data have been processed by the NIER.

Source: Edvinsson, R. [2005] and NIER.

Diagram 1.2 shows how the share of employment evolved in different industries from 1950 to 2000. As with agriculture, the employment share of manufacturing dropped during the period, from 33 percent in 1950 to 21 percent in 2000. By contrast, the employment share rose rapidly for the general government sector, from 9 percent in 1950 to 30 percent in 2000. But as of 2000 the employment share had also increased for private service industries and for trade, to 11 and 22 percent, respectively.

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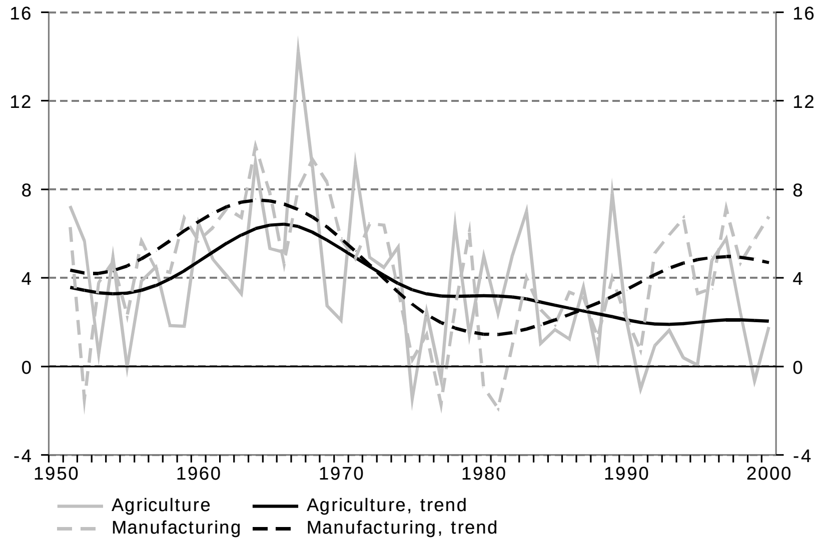
[4] However, the output of many agricultural products rose strongly during 1950-2000. See Swedish Board of Agriculture [2005]. See also Edvinsson, R. [2005].

Diagram 1.3 Productivity in Agriculture and in Manufacturing
Annual percentage change

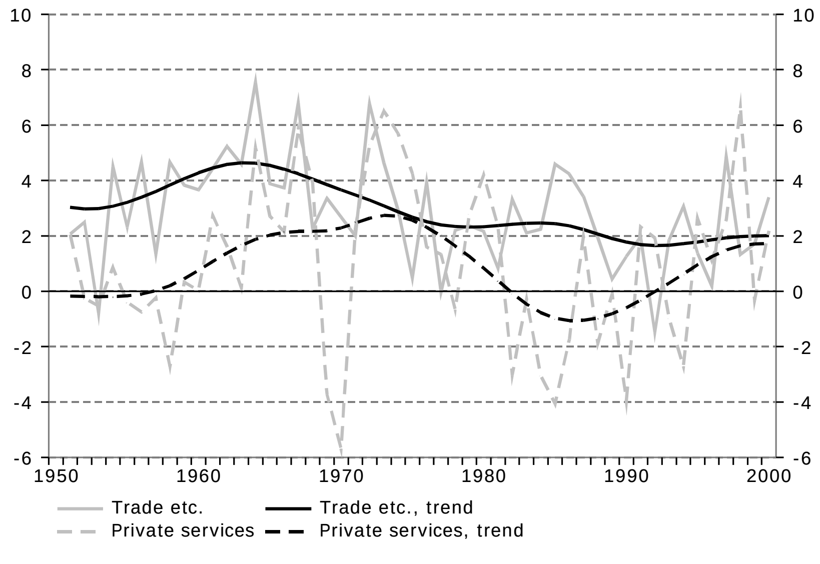


Note: Agriculture includes related sideline businesses; manufacturing includes handicrafts. Trend calculated with a so-called HP filter from annual data, smoothing coefficient =100.
Source: Edvinsson, R. [2005] and NIER.

The declining employment share in manufacturing, as in agriculture, has accompanied a strong tendency in productivity. In manufacturing, productivity increased by an annual average of 4.4 percent from 1950 to 2000, while in agriculture it rose by an annual average of 3.7 percent during that period (see Diagram 1.3).

In trade and especially in the private services industries, the productivity tendency has been weaker than in agriculture and manufacturing. The average annual growth of productivity in these industries was 2.9 and 1.0 percent, respectively, during the 1950–2000 (see Diagram 1.4).

Diagram 1.4 Productivity in Trade and Private Services
Annual percentage change



Note: Trade etc. includes banking, insurance and other business activities. Trend calculated with so-called HP filter from annual data, smoothing coefficient =100.
Source: Edvinsson, R. [2005] and NIER.

The development of productivity in the general government sector is not reported, as it has been very close to zero.[5] On average, the productivity of the general government sector rose by 0.2 percent per year during the period. At the same time, since the general government sector has grown rapidly in proportion to the economy as a whole, the low growth of productivity in that sector has limited the development of productivity reported for the economy as a whole.

In the business sector, the period from 1950 to 2000 was characterized by comparatively stronger productivity growth in the portions of the economy where the share of employment had decreased, and by comparatively weaker productivity growth where the share of employment had risen. In manufacturing, moreover, the level of productivity (in current prices) was higher than in trade and the private services sector. This means that the decreasing employment share in manufacturing, in favour of trade and the private services sector, tended to curtail overall growth in productivity during the period. It is important to note, however, that the changed composition of the business sector is due to the evolution of demand for different goods and services. With rising material prosperity, it is natural that demand for services should increase by roughly the same degree as demand for goods, perhaps even somewhat faster. Since the goods-producing industries have comparatively high productivity growth, it follows that the trend in the employment share should decrease in these industries, even if developments are also affected by changes in the balance of trade.

In the past decade the growth of productivity in the ICT industry (information and communication technology) has been spectacularly high.[6] On average, productivity rose by 14.4 percent per year in 1997–2005, many times more than in the business sector as a whole, where the corresponding figure was 3.3 percent; see Diagram 1.5. The high productivity growth of the ICT industry has gone hand in hand with an extremely high rate of technical development and rapid improvement in the quality of the goods and services produced in the industry.

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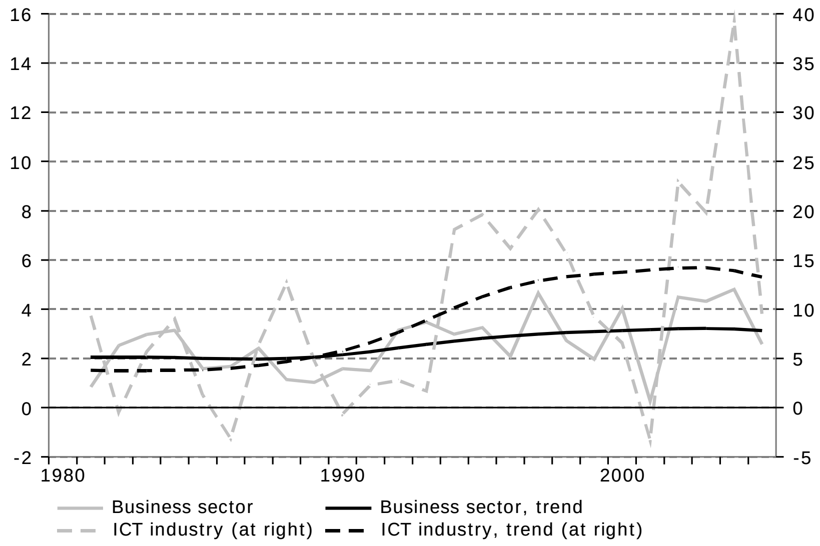
[5] The National Accounts through the second quarter of 2007 have calculated the value of the output of the general government sector as its total cost of production. The development of production costs by volume follows the development of the input of production factors, i. e. hours worked and capital stocks. Productivity growth may differ from zero because of changed employee composition and changed capital intensity in production. Beginning with the publication of the National Accounts for the third quarter of 2007, the volume of output is projected in certain portions of the general government sector, from 2002 onward, according to new methods that permit better calculations of productivity; see Statistics Sweden (2007a).

[6] The ICT industry includes both goods-producing industries, such the electrical manufacturing industry, and service-producing industries like telecommunications and computer and related activities (30–33, 64.2 and 72, according to the Swedish Standard Industrial Classification (SNI), which is based on the Classification of Economic Activities in the European Community (NACE)

Diagram 1.5 Productivity in the Business Sector and in the ICT Industry
Annual percentage change



Trend calculated with HP filter from annual data, smoothing coefficient =100.
Source: Statistics Sweden and NIER.

Rapidly rising productivity in the ICT industry has also led to decreasing prices of the industry's products. For this reason, among others, investment (by volume) in ICT capital has risen substantially in all portions of the business sector. The growing use of cheaper and better ICT capital has contributed to rising productivity in other industries. Thus, surging productivity in the ICT industry has spread to other areas of the economy.

The tendency in the ICT industry can justifiably be considered the main reason why business sector growth rose to a higher level during the 1990's after a comparatively lacklustre tendency in the 1980's, but there are other explanations as well.[7] During the severe financial crisis of the early 1990's, numerous low-productivity businesses were forced to close, with a partly temporary pick-up in productivity growth. Moreover, a higher degree of internationalization, in combination with deregulation of different markets, has contributed to stiffening competition and thus increased pressure for structural change.[8] Changes in the composition of the labour force have also influenced the development of productivity in the last two decades. Enrolment in post-secondary education has been going up rapidly since the mid-1980's. Consequently, the proportion of employees with post-secondary education gradually rose during the 1990's and 2000's. Since education and higher productivity normally go hand in hand, the rising level of education has helped to speed up productivity growth. To add an historical perspective, a high level of immigration since the outset of the 1990's may also have affected the development of productivity.

An important question is of course whether the strong trend of productivity growth in the Swedish economy in the past decade will continue. The answer will depend heavily on the pace of further technological development. Owing to greater globalization, entailing among other things rapid expansion of world trade, increasing

[7] See, for example, Lind [2002] for an analysis of the effects of driving companies out of business during the crisis of the 1990's, and Melander, Savvidou, Gunnarson [2004] for an analysis of the importance of higher ICT investment and increased human capital to the acceleration of productivity during 1986–1995.

[8] The recorded development of productivity has also been affected by changes in methods of measurement.

competition and growing numbers with access to the Internet, technological progress will tend to spread rapidly throughout the world economy. As a consequence, technological advancement in Sweden will be affected not only by domestic factors, but also to a substantial extent by what happens elsewhere. In addition, the changing composition of the labour force, in terms of educational level, for example, will have an impact on the future growth of productivity in Sweden.

1.2 Purpose and Contents

The primary aim of this report is to analyze the development of productivity in different industries within the Swedish business sector and for the business sector as a whole in the years 1997–2005, and from there, to generate projections of the trend (i. e. cyclically balanced) rate of development for productivity and value added in the period 2006–2020. Considerable emphasis will be placed on analyzing the importance of various characteristics of the labour force in this regard. For this purpose, the labour force is classified in three dimensions: age, level of education and place of origin. Average productivity may differ for different groups in the labour force, and this classification makes it possible to consider changes in the composition of the labour force over time. Differences in average wages among the various groups are used as an approximation of differences in average productivity. With this method, the labour force is subjected to so-called quality adjustment. The concept of quality is well established in this kind of context and is therefore used throughout the report. Quality adjustment of the labour force means that differences in factors that co-vary among different groups with differences in wages, and thus in assumed productivity, are considered in the calculations. With the aid, for example, of Statistics Sweden's population forecasts and the NIER's education forecasts, the report analyzes how changes in the composition of the labour force in these three dimensions contribute to the development of productivity in the projections.

In addition to a Base Scenario for the trend rate of growth in productivity and value added in the business sector, two alternative scenarios are presented. The Education Scenario analyzes the effects of a higher number of persons receiving post-secondary education compared to the Base Scenario. The Integration Scenario analyzes how improved integration on the labour market of persons born outside the Nordic countries would affect the tendency.

In order to enhance the precision of the calculations, and to permit explicit analysis of the role of the ICT industry, the business sector is divided into four industries, one of which is the ICT industry. Furthermore, capital is classified into three different types, which differ in their productivity. With this classification, measures of so-called capital services, which take the differences into account, can be calculated.

The analyses are conducted with so-called growth accounting and a neoclassical growth model. This means that the method is based on a growth model where total factor productivity (TFP), which reflects technological development, is assumed to be an exogenous driving force for productivity growth. If, for example, the educational level of the labour force goes up, the level of productivity will rise by virtue of the enhanced quality of the labour force. It is assumed, however, that TFP is not affected by changes in the educational level of the labour force, as can be the case in so-called endogenous growth models. The scenarios described in this report should be viewed in light of this assumption.

The report is organized as follows: Chapter 2 treats, among other things, the forces that drive productivity. In addition, it briefly presents the neoclassical growth model, as well as the method of growth accounting. The development of productivity in the Swedish business sector is then analyzed for the period 1997–2005. Also reported are the calculations of the measures of capital services and quality adjustment of the labour force. The chapter concludes with a review of several previous growth accounting studies for Sweden, which are contrasted with the findings for certain other countries.

Chapter 3 presents the Base Scenario of developments during the period 2006–2020 for the four industries in the business sector and for that sector as a whole. The projections of capital services, quality-adjusted hours worked and TFP are shown and are discussed in detail. Also presented is a sensitivity analysis for an alternative development of TFP in the ICT industry.

Chapter 4 describes the two alternative scenarios. In the Base Scenario, it has been assumed that the surge in the proportion of employees with post-secondary education would recede as the number of younger persons entering post-secondary education stagnated. The first alternative scenario analyzes the effects on productivity and value added in the business sector when more persons receive post-secondary education than in the Base Scenario. In the latter scenario, it is also assumed that the lower employment ratio for the foreign-born in relation to persons born in Sweden will continue in the years ahead. In addition, the difference in wages, and thus in assumed productivity, between the foreign-born and natives of Sweden, given the same level of education and age, is assumed to persist in the Base Scenario. The other alternative scenario analyzes how improved integration on the labour market of persons born outside the Nordic countries, with the ensuing reduction of differences in employment ratio and wages, would affect the development of productivity and growth in value added in the business sector.

In Chapter 5, the conclusions of the study are presented.

2 Driving Forces of Productivity, Growth Accounting for 1997–2005

Productivity is measured as value added per hour worked. Productivity can therefore be calculated directly from the National Accounts, which report both value added and number of hours worked. In a long-term perspective, that is, when cyclical variations are disregarded, the development of productivity is determined by technological progress, by improvement in the competence and skills – i. e. the quality – of the labour force and by the development of capital intensity in production – i. e. of the input of capital services per hour worked.[9] At the aggregate level, the development of productivity is also subject to composition effects, such as those resulting from a decrease in the proportion of output provided by less productive industries and a higher proportion from more productive industries, or vice versa.

Obviously, productivity can be affected by political decisions. For example, the design of the tax system impacts capital formation and thus the capital intensity of production. The tax system, like the system of financial aid to students, also influences the economic incentives for education. These, together with the design of the educational system, have implications for the educational level of the labour force and thus its productivity. Moreover, political decisions may have both direct and indirect effects on the quantity of resources devoted to research and development, with possible effects on technological development. Political decisions that encourage capital formation, education and research and development can raise the level of productivity, which can also be affected by the efficiency of various institutions, such as the legal system through legislation on competition and patents, for example. The academic literature on economic growth, however, does not provide general support for a conclusion that changes in regulations can have lasting effects on the growth of productivity. Rather, changes in rules have enduring effects on the level of productivity and therefore normally just a temporary impact on productivity growth.[10]

2.1 Growth Accounting – Method

Growth accounting is a method for breaking down the change in value added into its components.[11] It can therefore be used to analyze the development of productivity. On the other hand, growth accounting does not explain the underlying forces driving productivity. This section provides a brief description of the basic model and the method. For a more detailed description, see Appendix A.

The starting point is the neoclassical growth model. In terms of productivity, Y/H, an equation for productivity growth can be written as:

$$\Delta \ln(Y_t / H_t) = \Delta \ln A_t + \nu_{K,t} \cdot \Delta \ln(K_t / H_t) + \nu_{L,t} \cdot \Delta \ln(L_t / H_t) \qquad (2.1)$$

[9] See, for example, Jorgenson, D. & Z. Griliches [1967].

[10] See, for example. Jones, C. (2002).

[11] The method of growth accounting was established by Solow, R. M. [1957].

where *Y* is value added, *H* is hours worked, *K* is capital services, *L* is quality adjusted hours and $\Delta \ln$ corresponds (approximately) to percentage change. The two production factors of capital services and quality-adjusted hours worked are analyzed in detail below. The parameters $v_{K,t}$ and $v_{L,t}$ are numbers between 0 and 1 and are assumed to add up to 1, meaning that the underlying production function has constant returns to scale. Thus, if the inputs of capital services and quality-adjusted hours, for example, are doubled, output will double as well. The parameters indicate the relative marginal productivity of capital and labour costs, respectively, and are measured as the compensation for capital and labour costs, respectively, in proportion to value added. *A* is an index that represents technology and is normally termed total factor productivity (TFP). Changes in TFP, i. e. in technological development, reflect technical innovations and improvements in organization, among other things. In this regard, there is an important distinction: To the extent that technological development and increased knowledge are "embodied" in the two production factors, so that their quality changes over time, this development is not captured in TFP. The latter increases only when technological development gives rise to an increase in value added over and above what is captured in the two production factors. In other words, rising TFP may be viewed as "manna from above" and increases value added without giving rise to any measurable costs.

Equation 2.1 breaks down productivity growth into three elements. The first source of increased productivity is capital deepening, which involves using more capital services per hour worked; in other words, there is an increase in *K/H*. Capital deepening can be divided in turn into contributions from additional capital and contributions from a change to better, i. e. more productive, capital; see Appendix A. Moreover, productivity can rise because the number of quality-adjusted hours, *L*, increases faster than the actual number of hours worked, *H*. Such a development would reflect an improvement in the quality of the labour force as a whole, due to a higher level of education, for example. Finally, productivity can increase as a result of rising TFP. With growth accounting, TFP is calculated as a residual since it is not observable. TFP thus captures the technological development that cannot be attributed directly to the other production factors; however, it also captures measurement errors in the data.

The precision of growth accounting depends wholly on the accuracy with which the different contributions are measured. The better the measures of capital services and quality-adjusted hours, the more precise the calculated contribution of these production factors to productivity growth, and the more accurate the calculation of TFP as well. Industries differ in regard to levels of productivity, productivity growth and composition of production factors. Therefore, if different industries change in size over time, relative to each other, the development of productivity will be affected at a more aggregate level.

Box

Box 1: Different Points of Departure for Analysis of TFP

In the neoclassical growth model, which serves as a starting point in this study, it is assumed that the development of TFP is an exogenous process. Thus, TFP is not explicitly modelled as a function of its underlying driving forces, such as improved technology, improved organization of labour or a higher level of education in the work force.

In a so-called endogenous growth model, by contrast, the development of TFP is regarded as an (endogenous) process driven by factors that can be included in the model, such as a rising level of education. For instance, stepped-up efforts in research and development, which in themselves require more people with post-secondary education, may conceivably be accompanied by positive externalities or increasing returns to scale, so that value added increases more than would be warranted by the additional input of production factors alone. Added investment in research and development, increasing the proportion of persons with higher education, will then go hand in hand with greater TFP. Depending on the assumptions made in such a model, the faster productivity growth may be either permanent or temporary.[12] In an endogenous growth model, a higher level of education can bring higher productivity both through greater quality adjustment of hours worked and through the effect on TFP.

It is also conceivable that TFP is affected by changes in the composition of the labour force for other reasons. If quality-adjusted hours of labour with a different level of education, for example, are not interchangeable, productivity and TFP can be impacted if the compositions of the labour force changes.[13] It is therefore possible that TFP will be negatively affected by an increase in the proportion with post-secondary education, for example, if the relationship between those with high and low levels of education thereby becomes less compatible with the needs of the labour market for the respective groups.

As a practical matter, a number of different factors, in addition to education and investment in research and development, can affect the development of TFP. For example, the spread of technology – via international trade and the Internet, increased use of ICT capital, as well as institutional changes – can affect the development of TFP. Modelling TFP is thus a very complex task. Since the outcome data in this study are limited to a 10-year period, it is hardly meaningful to attempt analyzing what has driven the historical development of TFP.

In an analysis of the historical development of productivity using growth accounting, the development of TFP is calculated as a residual, and whether or not TFP is regarded as an exogenous process does not affect the results. In projections of productivity growth, by contrast, the view of TFP makes a difference. The projections in Chapters 3 and 4 are based on the neoclassical growth model with Cobb-Douglas technology (see Appendices A and C). TFP growth is thus regarded as an exogenous process, and quality-adjusted hours are assumed to be fully substitutable between the different categories of the labour force that produce them. Thus, no consideration is

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[12] See, for example, Chapter 8 in Jones, C. [2002].

[13] See, for example, Schön [2000] for effects of complementarity between different production factors.

given in the projections to the possibility that a change in the composition of the labour force might affect the development of TFP.

2.2 Growth Accounting for the Business Sector in Sweden, 1997–2005[14]

This section reports the results of growth accounting for the Swedish business sector for the period 1997–2005. The brevity of this period is due to the limited availability of statistics. With such a short period, it is not meaningful to adjust the development for cyclical variations. Consequently, growth accounting is applied to actual data.

As we saw in Chapter 1, the growth of productivity in the Swedish business sector shifted to a higher level during the 1990's, and the rapid progress of technology in the ICT industry was one major explanation. The business sector is divided into four industries; see Section 2.2.1. Section 2.2.2 shows the calculations of quality-adjusted hours, whereas the calculations of capital services in each industry are presented in Section 2.2.3. Finally, the results of growth accounting are reported in Section 2.2.4, both for the business sector as a whole and for the four industries taken separately.

2.2.1 CLASSIFICATION OF INDUSTRIES

The development of productivity followed highly varied paths in the different industries of the business sector during 1997–2005. In order to improve the accuracy of the growth accounting and to establish a better basis for projections of productivity, the business sector is divided into the following four industries, each of which is analyzed separately (see Appendix B for details on this classification):[15]

- the ICT industry
- the manufacturing industry except for ICT
- the other-goods industry
- the services industry except for ICT

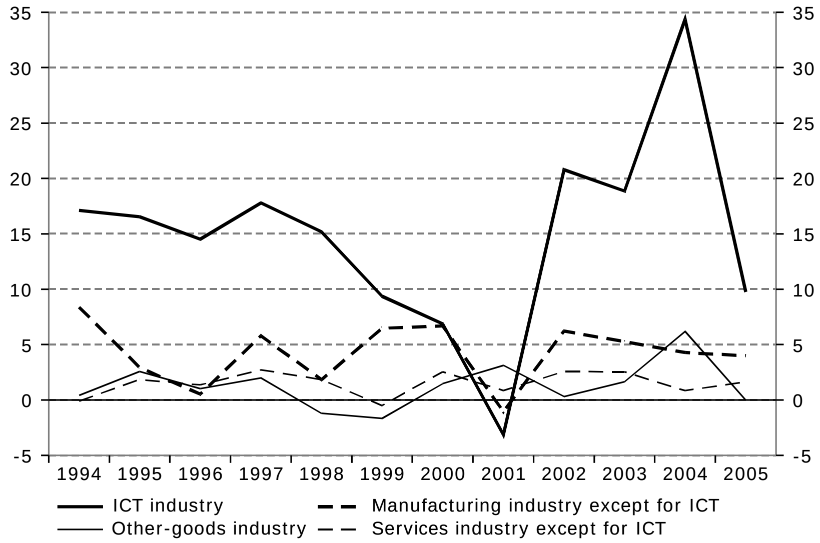
The ICT industry includes both goods-producing industries, like the manufacture of electrical equipment, and service-producing industries, such as telecommunications and consultancies in computers and other business activities. The other-goods industry comprises agriculture and forestry, mining, the energy industries and the construction industry. The industry classification was chosen partly on the basis of available data and partly because of the substantial differences among the four industries in regard to the development of productivity (see Diagram 2.1). The ICT industry has shown an exceptional increase in productivity and is therefore interesting to study separately. Manufacturing except for ICT has also had much stronger productivity growth than the business sector as a whole, and it has probably been affected by growing internationalization to a higher degree than industries more oriented toward

[14] All National Accounts data are from the spring of 2007.

[15] The ICT industry comprises the following categories in the Swedish Standard Industrial Classification (SNI), in conformity with the European NACE code: 30-33, 64.2, 72. The services industry except for ICT consists of SNI 50-95. Manufacturing except for ICT includes SNI 15-29 and 34-37. The other goods industry comprises SNI 01-14, 40-41 and 45.

the domestic market (the other-goods industry and the services industry except for ICT).

Diagram 2.1 Productivity in Different Industries
Annual percentage change



Source: Statistics Sweden.

2.2.2 QUALITY ADJUSTMENT OF HOURS WORKED

The people who make up the labour force contribute to output to varying degrees. A well-educated person with long experience normally contributes more to value added than a young, inexperienced individual with little relevant training.[16] In this sense the former is more productive. If there is an increase in the proportion of well-educated people with long experience in the labour force, the average level of productivity will probably be higher as well.

In the quality adjustment of the number of hours worked, consideration is given to differences in productivity in different parts of the labour force, i. e. to the fact that they differ in regard to value added per hour worked. In this study the labour force is classified in three dimensions:

- age
- level of education
- country of birth

In the classification by age, the labour force is divided into one group for each annual age cohort, from ages 18 through 64. In the education dimension, there are four highest levels of education attained: primary or lower secondary education, upper secondary education, post-secondary education, and post-graduate education. Successful completion of studies is not a prerequisite for inclusion in the different categories, and the classification follows the Swedish educational nomenclature (SUN 2000), which is also used in the Wage Structure Statistics for the private sector, which constitute the

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[16] See Denison, E. F. [1962].

data base used. The Wage Structure Statistics are described in Appendix B, where Table B. 2 shows the distribution of the four educational groups, as well as subgroups, for business sector employees in 2005. The classification used was chosen in order to reflect differences in wages, and thus in assumed productivity (see below), among various groups with different levels of education. The classification is largely consistent with other studies where growth accounting is used on Swedish data; see, for example, Forsling & Lindström (2004) and Hagén & Skytesvall (2005), although the latter study classifies education according to five levels.

In the country of birth dimension, the labour force is divided into four groups: born in Sweden, born in the Nordic countries except Sweden, born in Europe except the Nordic countries, and born outside Europe. One of the factors guiding the classification in the original dimension was the division used in Statistics Sweden's Labour Force Surveys (LFS), which are taken as a starting point for the projections; see Chapter 3. The classification differs somewhat from that used by Hagén & Skytesvall (2005), who divide employees into five groups of origin. In this dimension as well, the division was made for the purpose of reflecting differences in wages, and thus in assumed productivity, among different groups of employees in the business sector. In total, the labour force is thereby divided into 752 (47×4×4) different groups.[17]

The results of quality adjustment depend of course on the degree of detail in classifying the labour force. As a practical matter, however, the classification must have its limits, for even the 752 different groups in the labour force cannot be regarded as internally homogenous in all respects. For example, the group born outside Europe includes some people with English as a mother tongue and others who can speak no English at all. Those with a good knowledge of English probably find it easier to enter the labour market in Sweden. On the other hand, the subgroup of highly educated individuals born abroad may well consist to a relatively large extent of persons with peak competence in various areas.[18] If the composition of the group of foreign-born changes over time in these respects, productivity for that group as a whole may be affected without this change being captured in quality adjustment. It is also possible that productivity is dependent not only on the level of education, but also on the subject studied. The results of quality adjustment should be interpreted with these aspects of homogeneity and heterogeneity in mind. On the other hand, Forsling & Lindström (2004), using data for Sweden for 1994–2000, show that the contribution of post-secondary education to productivity is not affected very much if consideration is also given to the focus of education.

Age can affect productivity for several reasons. On the one hand, relevant work experience often increases with age. On the other hand, older individuals may tend to have less energy and stamina, possibly limiting their productivity. Moreover, the productivity of younger individuals may be favoured by the more recent date of their formal education.

Geographic origin may also impact productivity in several different ways.[19] For instance, the work experience of persons born abroad may conceivably be less relevant, on average, in a Swedish setting than is the case with Swedish-born persons of the

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[17] The labour force is not divided up by gender, as there is no obvious reason why productivity should depend on gender.

[18] In Ds 2007:4, educational levels are shown for different groups of immigrants.

[19] A sample of studies treating differences in earnings, and various factors that affect earnings, between natives of Sweden and the foreign-born would be Edin, P-A., P. Fredriksson & O. Åslund [2003], Nekby L. [2002], Rooth, D-O. [2007], SOU 2004:73 and Wadensjö, E. [1996].

same age and the same educational level. Furthermore, certain kinds of education may be difficult to apply in Sweden, such as the study of law. Deficient knowledge of the Swedish language may limit the productivity of certain individuals born abroad. A number of factors may tend to make it harder for the foreign-born to find work in the field for which they have been educated, and thereby explain why they are more likely than natives of Sweden to be overqualified for their current jobs in terms of educational level.[20] Although several factors may affect the labour market situation and the level of wages for the foreign-born, differences in comparison to natives of Sweden may also be due to various forms of discrimination.

Productivity is assumed to depend on level of education as well. Generally speaking, two different theories about the usefulness of treating education separately can be distinguished. Both are based on the assumption that more education is associated with higher wages. According to the so-called theory of human capital, an individual does better work after acquiring more education and longer work experience.[21] The theory of human capital thus emphasizes the productivity-enhancing effect of education. By contrast, the so-called signalling theory[22] disregards the productivity-enhancing effect and focuses on the role of education in disseminating information. In the application of this theory, it is assumed that the there are differences in the original productivity of individuals. Through post-secondary education the individual sends a signal that he/she has higher original productivity and therefore receives more pay.[23]

According to the theory of human capital, more education is accompanied by higher productivity as well as higher wage. With the so-called signalling theory, more education does not lead to higher productivity for the individual, but is still associated with higher wage. In its pure form, however, the signalling theory does not provide a particularly realistic description of reality. The most reasonable standpoint, in the end, is that education more or less goes hand in hand with higher productivity.

Relative Wage as a Measure of Relative Productivity

In this study, the term ”relative wage” is used as a measure of the relative productivity of different groups in the labour force. This assumption is a normal one that is supported by economic theory. Provided perfect competition prevails on goods markets and factor markets, a profit-maximizing firm will employ staff up to the point where the cost of labour (wage) is equal to the value of marginal productivity.[24] According to this basic competitive model for wage formation, the wage rate is determined entirely by the productivity of employees. In this model, differences in the wages of different employees are due solely to their differences in regard to productivity.

The basic model is highly simplified, and there are several reasons why relative wages need not fully reflect the differences in the productivity of different individuals.

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[20] According to Berggren K. & A. Omarsson [2001], in 2000 only 40 percent of those holding university degrees and born abroad, who came to Sweden in 1991–1997, had relevant work based on their education. A somewhat brighter picture is painted by Ekberg, J. & D-O Rooth [2003], who report that 60 percent of those born abroad had work that matched their qualifications.

[21] The theory of human capital is described, for example, in Björklund, A., et al. [2006].

[22] See, for example, Arrow, K. [1973], Spence, M. [1973].

[23] The relationship between wages and education according to the theory of human capital and the signalling theory, respectively, are problemized in Weiss,. A [1995], for example.

[24] The profit-maximization principle means that the cost of labour is equal to the value of marginal productivity. As a practical matter, the cost of labour is not the same as employee wages, owing to various payroll charges. However, the difference between wages and cost of labour is of minor importance when relative wage are used to approximate relative productivity.

Many firms, for example, operate on goods markets without perfect competition, i. e. where firms have market power in one form or another. Then the result in the basic model of competition, that firms employ personnel up to the point where wage equal the value of marginal productivity, may no longer apply.

Moreover, with imperfect competition on the labour market, wages may not always reflect productivity. Such may be the case, for example, if employers have monopsoni power. For wages to reflect productivity, the labour market must be quite flexible in terms of both geographic mobility and wage determination. Further, collective bargaining agreements in Sweden are negotiated in large part at the central union level, with only a lesser element of local negotiation. These features of the Swedish model of pay negotiations may be one reason why wages do not always reflect the productivity of different individuals.

There is also another reason, the obvious one of discrimination. In itself, discrimination does not always mean that wages do not reflect productivity. For example, if there is discrimination where individuals with foreign backgrounds have difficulty finding jobs that match their competence, *both* productivity and wages may be affected. With wage discrimination in its pure form, i. e. when individuals earn less *precisely because they were born abroad*, wages do not reflect productivity. It is difficult to determine to what extent differences in wages depend on discrimination or on actual differences in productivity, and this question is not analyzed in the present study, where differences in wages are assumed to reflect differences in productivity.

Thus, there are a number of reasons why wages in practice may differ between two individuals who are equally productive. Even though relative wages are not an exact measure of relative productivity, they nevertheless provide the best available approximation and are also the measure most commonly used in economic literature.[25] The problems illustrated above are probably much more substantial at the individual level and in particular industries than at more aggregate levels. But the results of quality adjustment of hours worked should be interpreted with these problems in mind.

Wage Structure Statistics

Information on level of education, earnings and degree of service for persons employed, classified by age and geographic origin, is taken from data on individuals in the *Wage Structure Statistics* for the private sector, which are described in Appendix B. This is an annual sample survey of registry data on firms published by Statistics Sweden.[26] The Wage Structure Statistics cover employed individuals aged 18–64 and contain detailed information on such attributes as level of education, age, country of birth, occupation, industry, form of earnings, county and municipality, agreed work hours and overtime hours, as well as various definition of wage.

For each of the 752 groups of persons employed, relative productivity is approximated by the average wage of the group relative to the average wage of all employed individuals. Wages are measured as full-time equivalent monthly wages.[27] The total number of hours worked by each group is approximated by the average degree of service and the number employed in the group. The degree of service indicates how

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[25] See, for example, Björklund, A., et al. [2006].

[26] In this study, only the years 1996–2005 are used, one reason being the lack of information on education for certain groups prior to 1996.

[27] Full-time equivalent monthly wages mean that monthly wages are calculated on the basis of a full-time position. For an individual who works part time, wages are recalculated so as to correspond to the full-time wage.

much a person works as a percentage of the full-time equivalent and thus ranges from 0 to 100 percent. In order to calculate an implicit measure of hours worked, the degree of service is multiplied by the normal number of hours worked per month for a full-time employee.[28]

Table 2.1 shows how full-time equivalent monthly wages differ on average for persons with different levels of education in the period 1996–2005. As expected, individuals with post-secondary education have higher wages, on average, than individuals of the same origin but with a lower level of education. On average, individuals with primary or lower secondary education earn about 10 percent less than individuals with upper secondary but no additional education. For individuals with post-secondary education, the difference is much greater and also varies considerably depending on the individual's geographic origin. A native of Sweden with post-secondary education earns on average 38 percent more than one with only upper secondary education. For persons born abroad, the difference is less, particularly for those born outside the Nordic countries, for whom the corresponding figure is about 26 percent. A native of Sweden with a graduate degree earns almost twice as much as one with no more than upper secondary education. For individuals from elsewhere in Europe, the corresponding figure is about the same, whereas it is somewhat lower for those born outside Europe. All factors considered, there is a clear correlation between monthly wages and the highest level of education achieved. In addition, it is worth noting that the dispersion of wages resulting from differences in educational level has a similar profile within the four categories of origin.

Table 2.1 Monthly Wages and Wages in Proportion to Those of Persons with Secondary Education

SEK and percent, respectively

	Sweden		Nordic countries excl. Sweden		Europe excl. Nordic countries		Outside Europe	
	SEK	Percent	SEK	Percent	SEK	Percent	SEK	Percent
Primary and lower secondary education	18 228	90.0	17 915	92.6	17 172	92.3	16 129	90.0
Upper secondary education	20 255	100.0	19 342	100.0	18 606	100.0	17 926	100.0
Post-secondary education	27 920	137.8	26 054	134.7	23 575	126.7	22 494	125.5
Postgraduate education	38 983	192.5	37 188	192.3	36 711	197.3	32 283	180.1

Note: Full-time equivalent monthly wages, mean value 1996–2005, persons aged 18–64. All annual age cohorts are weighted equally in the calculation.

Source: Wage Structure Statistics, Statistics Sweden and NIER.

This does not mean, however, that persons with the same education in the groups of different origin have the same wages. Table 2.2 shows how monthly wages differ, on average, for persons of different origins in the period 1996–2005. Regardless of educational level, it may be noted that someone born in other Nordic countries earns slightly less, on average, than a native of Sweden. For persons born outside the Nordic countries, the gap in relation to natives of Swedish is generally larger. Since the figures

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[28] There is information on hours worked in the Wage Structure Statistics. However, this information is not structured in such a way that it would be usable in this study. In the quality adjustment of hours worked, therefore, use is made of implicit calculated earnings based on the reported degree of service for each category of persons employed.

are calculated as unweighted averages for different ages – i. e. each annual age cohort is weighted equally – the results do not depend on differences in age distribution. As discussed above, there are a number of reasons why persons of foreign origin may have lower productivity than natives of Sweden with the same level of education, thus justifying lower wages. But the differences may also be due to various forms of discrimination. The respective degrees to which differences in wages are the result of discrimination or of actual differences in productivity are not analyzed in this study, where differences in wages are assumed to reflect differences in productivity.

Table 2.2 Monthly Wages and Wages in Proportion to Those of Persons Born in Sweden

SEK and percent, respectively

	Sweden	Nordic countries excl. Sweden		Europe excl. Nordic countries		Outside Europe	
	SEK	SEK	Percent	SEK	Percent	SEK	Percent
Primary and lower secondary education	18 228	17 915	98.3	17 172	94.2	16 129	88.5
Upper secondary education	20 255	19 342	95.5	18 606	91.9	17 926	88.5
Post-secondary education	27 920	26 054	93.3	23 575	84.4	22 494	80.6
Postgraduate education	38 983	37 188	95.4	36 711	94.2	32 283	82.8

Note: Full-time equivalent monthly wages, mean value 1996–2005, persons aged 18–64. All annual age cohorts are weighted equally in the calculation.

Source: Wage Structure Statistics, Statistics Sweden and NIER.

Wages are also affected by differences in age. Table 2.3 shows how monthly wages vary on average with age for persons with post-secondary education in the period 1996–2005. For those aged 20–24, monthly wages are largely the same regardless of origin, i. e. roughly SEK 17 000. For persons born in the Nordic countries, wages rise rapidly with age, and persons aged 25–39 earn about 50 percent more than those aged 20–24. The increase in wages is much less for persons born outside the Nordic countries; the corresponding figure is 28 percent for those born in Europe outside the Nordic countries and 23 percent for those born outside Europe. For ages 40–54 the gap widens further between persons born in the Nordic countries and those born outside. One explanation why wages do not rise as much with age for persons born outside the Nordic countries may be that their career progress is more limited. This might be due to discrimination, but not necessarily. Another reason for the lower seniority premium for the foreign-born may be that for various reasons they have worked only briefly in Sweden, possibly because of more and longer periods of unemployment. For such individuals, their age does not as accurately reflect their experience of working life.

Table 2.3 Monthly Wages and Wages in Proportion to Those of Persons Aged 20–24 with Post-Secondary Education

SEK and percent, respectively

	Sweden		Nordic countries excl. Sweden		Europe excl. Nordic countries		Outside Europe	
	SEK	Percent	SEK	Percent	SEK	Percent	SEK	Percent
Age 20–24	16 775	100.0	17 068	100.0	17 244	100.0	17 350	100.0
Age 25–39	25 453	151.7	24 994	146.4	21 991	127.5	21 395	123.3
Age 40–54	31 617	188.5	28 334	166.0	25 071	145.4	23 523	135.6
Age 55–64	31 647	188.7	28 717	168.2	26 870	155.8	25 173	145.1

Note: Full-time equivalent monthly wages, mean value for business sector1996–2005. All annual age cohorts are weighted equally in the calculation.

Source: Wage Structure Statistics, Statistics Sweden and NIER.

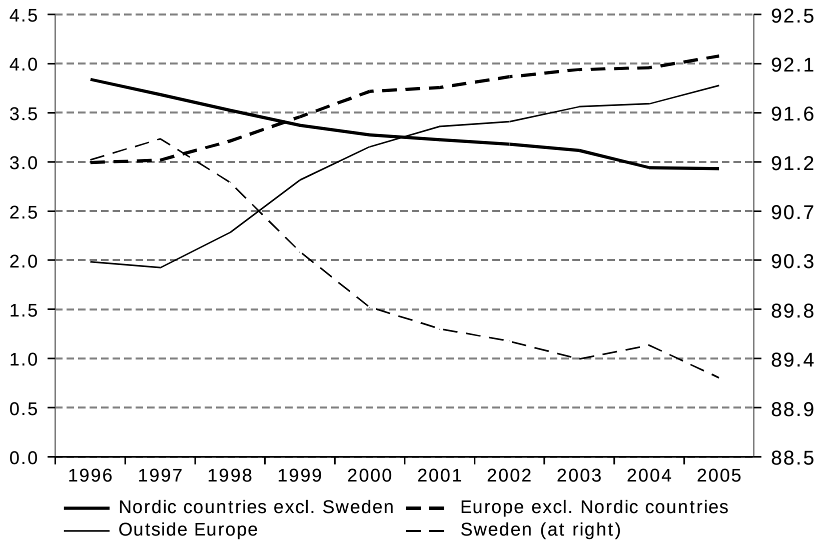
Appendix B contains the tables corresponding to Table 2.3 for primary and lower secondary education, upper secondary education and graduate studies. In general, age-related differences in wages increase with a rising level of education. Except for persons with postgraduate studies, there remains the pattern where wages increase the most with age for persons born in the Nordic countries.

The data described above are averages for the period 1996–2005. If the composition of those who perform the hours worked is constant over time in the dimensions covered by the quality adjustment, and if there is no change in relative wages either, the contribution of quality to the development of productivity will be zero by definition. On the other hand, quality adjustment will be positive if there is a gradual shift among those who perform the hours worked toward comparatively higher-paid (highly productive) groups of employees. It is therefore interesting to study how the composition of the employed changed over the period in the dimensions considered.

Diagram 2.2 shows how the proportion of persons employed in the business sector changed in the geographic-origin dimension during 1996–2005.

Diagram 2.2 Persons Employed Classified by Geographic Origin

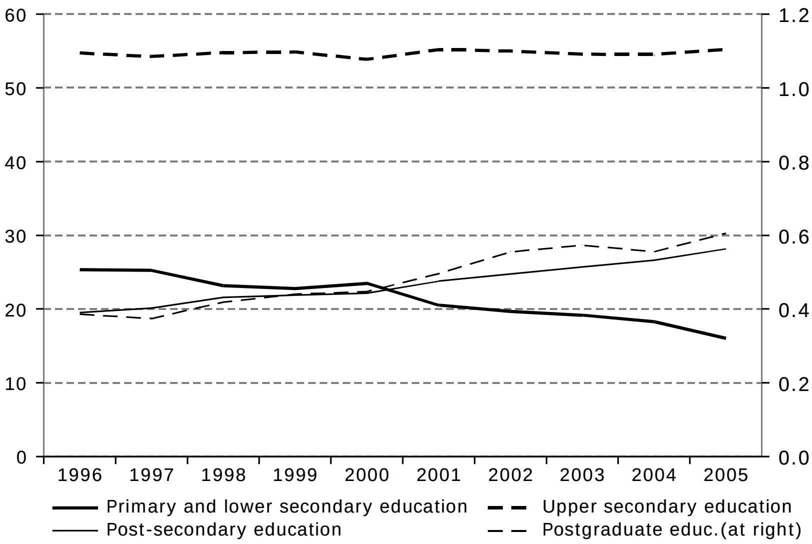
Percent of total number employed, ages 18–64



Source: Wage Structure Statistics, Statistics Sweden.

The proportion of employed persons with origins outside the Nordic countries rose from 2 percent in 1996 to nearly 4 percent in 2005. The proportion of the employed from Europe outside the Nordic countries also increased, but not quite as much: from 3 percent in 1996 to 4 percent in 2005. This means that the proportion of employed persons born in Sweden and the other Nordic countries decreased during the period, from 91 percent in 1996 to 89 percent in 2005 for natives of Sweden and from 4 percent to 3 percent for persons born in other Nordic countries. As shown in Table 2.2, persons born in Sweden and in other Nordic countries are more highly paid on average, and are consequently assumed to have higher productivity, than those born outside the Nordic countries. It is probable, therefore, that the decreasing tendency in the proportion of employed persons born in Sweden and the other Nordic countries has had a limiting effect on productivity growth in 1997–2005.

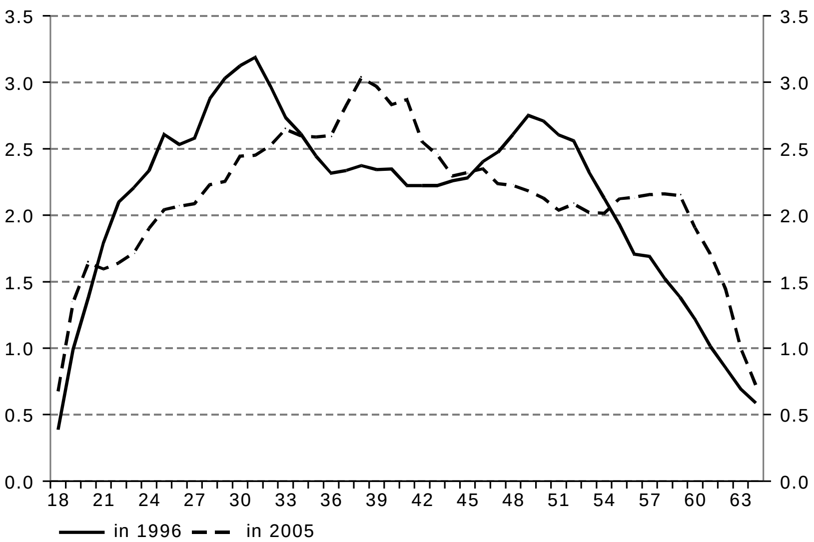
Diagram 2.3 Persons Employed Classified by Level of Education
Percent of total number employed, ages 18–64



Source: Wage Structure Statistics, Statistics Sweden and NIER.

In Diagram 2.3, employees are classified according to education. The proportion with post-secondary education rose strongly during the period, from 20 percent of those employed in 1996 to 28 percent in 2005. Moreover, the proportion with postgraduate education went up slightly from 0.4 percent to 0.6 percent. The proportion with upper secondary but no further education fluctuated around 55 percent for the entire period. On the other hand, the proportion with only primary or lower secondary education dropped sharply, from 25 percent in 1996 to 16 percent in 2005. As shown in Table 2.1, higher education is accompanied by higher wages and thus higher assumed productivity. The rising proportion with higher education can therefore be considered to have contributed positively to productivity growth during 1996–2005.

Diagram 2.4 Persons Employed Classified by Age, Ages 18–64
Percent of total number employed, ages 18–64, annual age cohorts



Source: Wage Structure Statistics, Statistics Sweden.

Finally, Diagram 2.4 shows the development in the age dimension. Here the tendency is harder to interpret. The age distribution in 1996 peaked around age 30 and again around age 50; in other words, a relatively large share of those employed were born in the mid-1960's and mid-1940's, respectively. For natural reasons, these peaks have advanced with passing years, and in 2005, there was a high point around age 40 and another one, slightly less pronounced, just before age 60. The median age of persons employed rose from 39.6 years to 40.8 years between 1996 and 2005. As shown in Table 2.3, wages, and therefore probably productivity as well, increase with age. Consequently, the rising tendency in average age may have had a positive impact on the development of productivity during 1996–2005.

Method for Quality Adjustment of Hours Worked

In the quality adjustment of hours worked, the change in hours worked for each group is weighted by the group share of total wage cost (see Appendix A). If firms in substituting labour take on more employees with higher pay, and thus higher assumed productivity, quality-adjusted hours will increase faster than actual hours worked.

BOX

Box 2: Quality Adjustment

For each group (752 in total) in the labour force (*j*), the number of hours worked (*H*) is the same as the number of quality-adjusted hours (*L*), i. e:

$$L_{j,t} = H_{j,t}$$

The growth in the total number of quality-adjusted hours is calculated as follows:

$$\Delta \ln L_t = \sum_j \bar{v}_{j,t} \cdot \Delta \ln H_{j,t}$$

$$\bar{v}_{j,t} = \frac{1}{2} \cdot \left(\frac{w_{j,t} \cdot H_{j,t}}{\sum_j (w_{j,t} \cdot H_{j,t})} + \frac{w_{j,t-1} \cdot H_{j,t-1}}{\sum_j (w_{j,t-1} \cdot H_{j,t-1})} \right)$$

where $w_{j,t}$ $w_{j,t}$ is the average wage in group *j* at time *t* and $\bar{v}_{j,t}$ is the weight assigned to labour in group *j* at time *t*. The weights thus reflect the share of total wage income of the various groups.

The contribution to productivity growth is calculated as follows:

$$\bar{v}_{L,t} (\Delta \ln L_t - \Delta \ln H_t)$$

where $\bar{v}_{L,t}$ is the labour-cost share of value added, $\Delta \ln L_t$ is the change in quality-adjusted hours and $\Delta \ln H_t$ is the change in number of hours worked.

The contribution to productivity from the composition of the labour force is calculated as the difference between the growth in quality-adjusted hours and the growth in actual hours worked, weighted by the labour-cost share of value added, i. e. the labour-cost share.

As a practical matter, hours worked according to the Wage Structure Statistics (described above) differ from hours worked according to the National Accounts. In calculating the contribution of a higher-quality labour force to labour productivity, the hours worked are those used in the Wage Structure Statistics, whereas labour productivity in itself is calculated with hours worked according to the National Accounts. The Wage Structure Statistics do not necessarily contain observations for all groups and every year; observations may be lacking for different groups in different years. In order to include as much information as possible in the calculations, use is made of overlapping data for two consecutive years. Thus, data sets that are not equally large and are differently composed can be used for different years.

The calculations are performed separately for the four industries and for the business sector as a whole.[29] The average wage of the respective groups in the labour force for the business sector as a whole are used in the calculation of quality-adjusted hours for individual industries. Any differences in average wage for the same group in the labour force in different industries will thus be due to factors other than differences in age, country of origin and level of education.

Development of Quality-Adjusted Hours

From 1997 to 2005, the quality of the labour force improved by an average of 0.54 percentage point per year. Quality-adjusted hours are calculated as the total of hours worked according to the National Accounts and the calculated quality adjustment based on the Wage Structure Statistics.

As shown in Diagram 2.5, quality adjustment has varied considerably over the period. In 1999 and 2000, the adjustment was virtually zero. The economy was then in a phase of rapid growth, and employment was rising rapidly. On average, cyclically caused variations in unemployment are greater among the foreign-born, young persons and individuals with a lower level of education. Consequently, employment rises relatively quickly for these groups in a cyclical upswing. On average, these groups also have comparatively low wages and thus low assumed productivity. It is therefore natural that the quality adjustment is more limited in a situation of rapidly rising employment. In 2001 the economy slowed sharply, and in the years that followed many firms carried out extensive cost-cutting programmes; to a substantial degree, these involved the disappearance of low-productivity labour from the ranks of the employed. Quality-adjusted hours therefore showed a much stronger tendency than hours worked.

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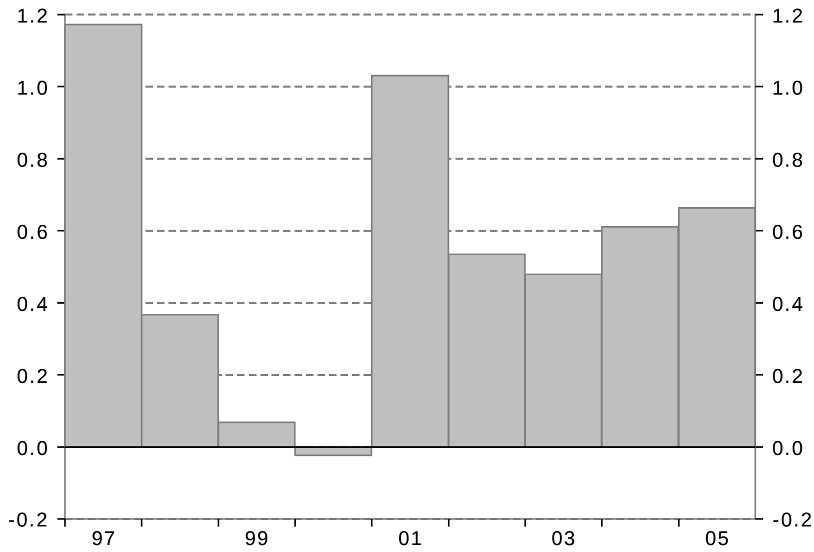
[29] This means that more data are used for the business sector as a whole than for each of the industries taken separately. Thus, the total of the contributions from the respective industries will not be identical with the contribution for the business sector as a whole.

Diagram 2.5 Difference between Growth in Quality-Adjusted and Actual Hours Worked

Percentage points



Source: Wage Structure Statistics, Statistics Sweden and NIER.

All industries show positive quality contributions from changes in the composition of the labour force (see Table 2.4). Viewed over the entire period, the quality of the labour force improved most in the ICT industry. In 2001, the ICT bubble burst, with sweeping consequences particularly for the ICT industry. Employment dropped sharply, and in the goods-producing ICT industry, with a labour force whose level of education and wages were comparatively low, many firms went out of business. In the years that followed, the changed composition of the labour force meant that its quality improved substantially in the ICT industry. For the other industries, the change in quality of the labour force was roughly the same on average during the period 1997–2005, whereas hours worked developed very diversely, decreasing in manufacturing but increasing in the service industries.

Table 2.4 Quality-Adjusted and Actual Hours Worked1997–2005

Average annual percentage change and percentage points, respectively

	Quality-adjusted hours (1=2+3)	Hours worked (2)	Change in quality (3)
ICT industry	1.72	0.98	0.74
Manufacturing industry excl. ICT	–0.26	–0.71	0.45
Other-goods industry	0.26	–0.11	0.37
Services industry excl. ICT	1.66	1.08	0.58
Business sector	1.01	0.47	0.54

Source: Statistics Sweden and NIER.

In the calculations of quality-adjusted hours, relative wages have varied over time; in other words, the various groups in the labour force are weighted differently in different periods. If the wage structure in 1996 is retained, and only changes in the composition of the labour force are allowed to affect the results, quality-adjusted hours increase somewhat more slowly than is shown in Table 2.4. The quality of the labour force in the business sector as a whole then goes up by an annual average of 0.5 percentage point instead of 0.54 percentage point. This indicates that changes in the relative-wage structure have played a minor part. What contributes most to the rising quality of the labour force during the period is the increasingly high level of education (see Section 2.2.2).

2.2.3 CALCULATION OF CAPITAL SERVICES

Different types of capital vary in useful life, as well as in other ways, and therefore do not generate the same return, or *capital service*, per monetary unit invested in a given period of time.[30] It is obvious, for example, that one krona invested in machinery contributes more to output per unit of time than one krona invested in a building. A building will normally have a much longer useful life than a machine, particularly if the latter is ICT capital. Therefore, a machine must contribute in a given period of time much more in higher value added for each krona invested than an investment of the same amount in a building. In other words, the marginal productivity must be higher per krona invested for a machine than for a building if the investment is to be made.

To calculate accurately the quantity of capital services used in production, it is important to consider that different types of capital have different marginal productivity. Ideally, the relative marginal productivity of the various types of capital would be used in their aggregate weighting in a measure of capital services. But the marginal productivity of different kinds of capital is not directly observable. Therefore, the so-called user cost is used as an approximation. This approximation is fully analogous to the use of relative wage in the quality adjustment of hours worked. On the assumption of perfect competition on goods and factor markets, the user cost of capital reflects the total economic cost (alternative cost) of using capital, and it takes into account how rapidly the capital depreciates, the changes in the price of investment goods and the return on alternative investments. The more rapidly the capital is consumed, the higher the return on alternative investments and the weaker the tendency in prices of investment goods, the higher will be the user cost. In weighing together different types of capital in capital services, types of capital with a comparatively high user cost, and thus with a higher assumed marginal productivity, will be assigned a higher weight than types of capital with a relatively low user cost. In this way, differences in marginal productivity between different types of capital will be captured in calculations of capital services.

In this study, capital is divided into three types for each of the four industries:

- machinery, including transportation equipment but excluding hardware
- housing, buildings and structures
- ICT capital (hard- and software)

An additional type of capital, referred to as ”other,” is reported in the National Accounts. This category consists primarily of software, but since all software is categorized as ICT capital, the item termed “other” is very minor. For this reason, “other” is included as machinery in the respective industries. The calculations of capital services are performed for the period 1993–2005, for the different industries and for the busi-

[30] See, for example, Jorgenson, D. [1963] & Jorgenson, D. & Z. Griliches [1967].

ness sector as a whole. All data not taken from the regular statistics of the National Accounts have been prepared especially for the NIER by Statistics Sweden.

Method for Calculation of Capital Services

In calculating the flow of capital services, the change in each type of capital is weighted by its share of total user cost of capital utilization. This user cost is determined by the required return, by the rate of capital deprecation and by the change in the value of the capital; see Appendix A. The flow of capital services is calculated separately for each industry.

BOX

Box 3: Capital Services

As described in greater detail in Appendix A, the change in capital services for the respective types of capital *(K_i)* is assumed to be the same as the change in the equivalent physical stock of capital *(S_i)* expressed in constant prices:

$$\Delta \ln K_{i,t} = \Delta \ln S_{i,t}$$

An index of capital services by industry (and for the business sector as a whole) is calculated, where the change in each type of capital, in constant prices, is weighted by its share of the total user cost:

$$\Delta \ln K_t = \sum_i \left(\overline{v}_{i,t} \cdot \Delta \ln S_{i,t} \right)$$

where $\overline{v}_{i,t}$ is the weight for type of capital *i* at time t. The difference between $\Delta \ln K_t$ and $\Delta \ln S_t$ constitutes the change in the quality of capital.
Types of capital with a relatively high user cost are assigned relatively high weights, which are calculated as:

$$\overline{v}_{i,t} = \frac{1}{2} \left(\frac{\mu_{i,t} \cdot P_{i,t}^S \cdot S_{i,t}}{\sum_i \left(\mu_{i,t} \cdot P_{i,t}^S \cdot S_{i,t} \right)} + \frac{\mu_{i,t-1} \cdot P_{i,t-1}^S \cdot S_{i,t-1}}{\sum_i \left(\mu_{i,t-1} \cdot P_{i,t-1}^S \cdot S_{i,t-1} \right)} \right)$$

where $P_{i,t}^S \cdot S_{i,t}$ is the capital stock in current prices. The user cost for a particular type of capital measures the price of utilizing that capital for a specific period of time; the user cost can therefore be considered equivalent to a rental expense. For type of capital i, the nominal user cost in percent for period t for one krona invested is yielded by:

$$\mu_{i,t} = r_t + \left(\frac{1 + \delta_{i,t}}{1 + \pi_{i,t}} \right) - 1 \approx r_t + \delta_{i,t} - \pi_{i,t}$$

where r_t designates a nominal rate of interest, i. e. the required return, $\delta_{i,t}$ is the rate of depreciation for type of capital *i* and $\pi_{i,t}$ is the change in prices for investment goods of type of capital *i*.

Appendix A describes different ways of calculating the required rate of return.[31] In the following calculations, the required return has been determined as a residual, so that the average user cost for the period is equal to the operating surplus of the business sector as a whole.[32]

For the different industries, however, it is assumed that the required return varies, as the risk premium may differ from industry to industry. The risk premium is assumed to be somewhat greater for the ICT industry and for manufacturing excluding ICT than for the industries more oriented toward the domestic market, i. e. services excluding ICT, and the other-goods industry. A higher risk premium in ICT and in manufacturing excluding ICT is warranted by the more extensive international involvement of these industries; here, for example, variations in exchange rates constitute an added risk. In the period 1993–2005, the required return was higher in manufacturing excluding ICT than in the business sector as a whole, whereas it was lower in the ICT industry. In the latter, however, the return has varied greatly; it was even negative in 2001. With developments unfolding faster in the ICT industry, they are harder to assess; it is therefore reasonable to require a higher return on investments in this industry. However, the required return is assumed to be the same for all types of capital in a particular industry since it appears less likely than investors would require in advance different rates of return on different types of capital. The fact that the returns realized differ for the various types of capital is another matter.

The data on changes in the price of investment goods are taken from the National Accounts. The rate of depreciation is also based on data in the National Accounts.[33]

Stocks of Capital

The development of the aggregate capital stock, both by industry and for the business sector as a whole, is affected considerably by the fact that buildings as a type of capital account for a significant portion of the value of the total capital stock. In manufacturing excluding ICT, buildings constituted about half of that value in the period 1993-2005. The corresponding shares for the other-goods industry excluding ICT, the services industry and the ICT industry were 80 percent, 90 percent and 70 percent, respectively. For the business sector as a whole, buildings account for roughly 80 of the total value.

At the same time, however, the various capital stocks developed very differently over the period (see Diagrams 2.6, 2.7, 2.8 and 2.9). The growth in the capital stocks is relatively slow. It is hardly surprising that capital stocks have grown the fastest in ICT. The substantial investments in ICT capital in the mid-1990's show clearly how rapidly these capital stocks were growing until 2001. After the ICT bubble burst, the stocks of ICT capital have increased much more slowly. In certain industries, investment in ICT capital has been so low that after depreciation the capital stock even decreased in one or more years. In the period 1993–2005, ICT capital in the business sector increased by about 140 percent, whereas the stocks of other capital showed a much more modest tendency. These developments mean that the composition of total capital stocks

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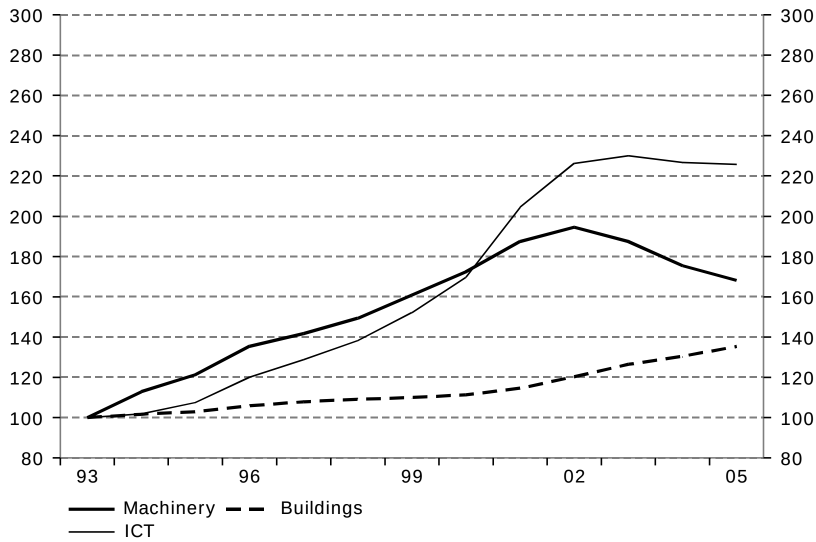
[31] Baldwin et al. [2005] analyze the effects of the calculated flow of capital services and TFP depending on which method is used to calculation the cost of capital utilization.

[32] In the EU KLEMS project (see Timmer et al. [2007]), the required return is calculated so that the utilization cost in SEK is equal to the operating surplus of the respective industry. Thus, the required return varies among different industries.

[33] See Appendix A for the method.

changed markedly during the period 1993–2005. With these changes toward more productive capital, capital services have increased faster than capital stocks in all industries and in the business sector as a whole. Thus, the quality of capital has been enhanced.

Diagram 2.6 Stocks of Capital, ICT Industry
Index 1993 = 100



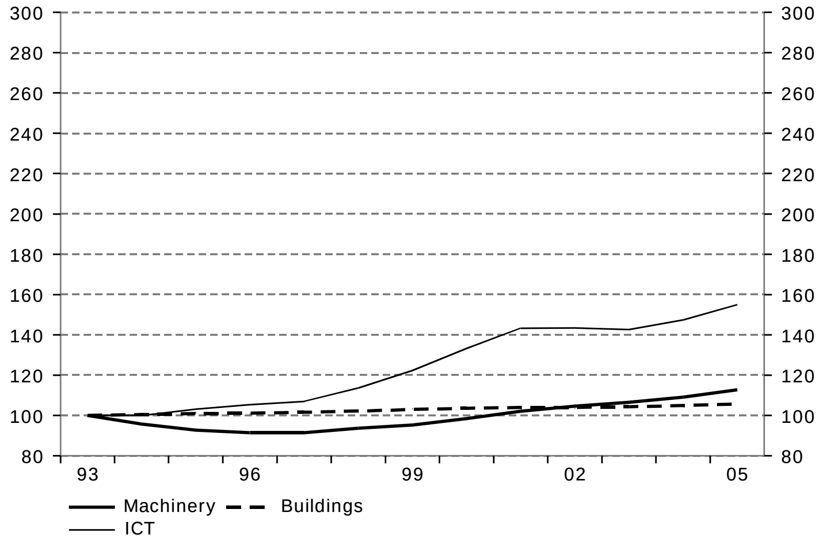
Note: Capital stocks as of 1 January of the respective year.
Source: Statistics Sweden

Diagram 2.7 Capital Stocks, Manufacturing Industry excl. ICT
Index 1993 = 100

Note: Capital stocks as of 1 January of the respective year.
Source: Statistics Sweden

Diagram 2.8 Capital Stocks, Other-Goods Industry

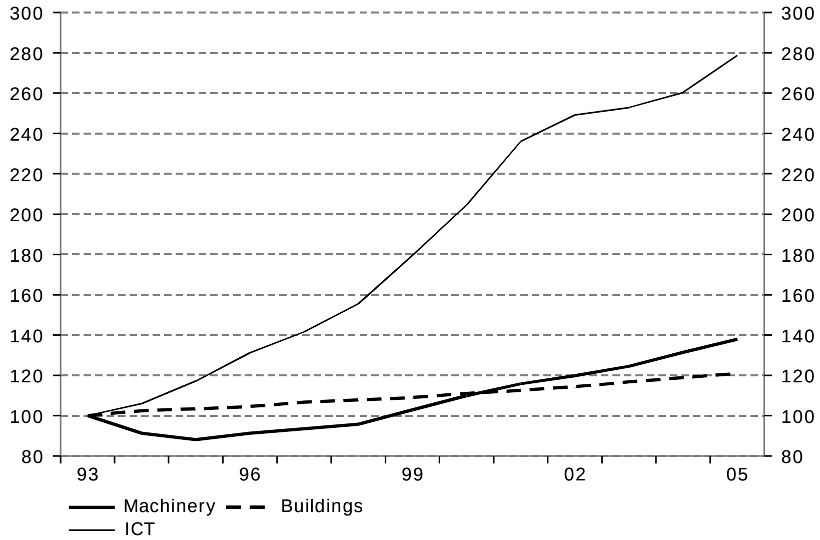
Index 1993 = 100



Note: Capital stocks as of 1 January of the respective year.
Source: Statistics Sweden

Diagram 2.9 Capital Stocks, Services Industry excl. ICT

Index 1993 = 100



Note: Capital stocks as of 1 January of the respective year.
Source: Statistics Sweden

User Cost and Capital Services

Owing to differences in productivity among the various types of capital, user cost also differs from one type of capital to another (see Table 2.5). As mentioned above, it is assumed that the required rate of return varies from industry to industry, but that it is the same for different types of capital within an industry. ICT capital has a high rate of depreciation, unlike buildings, which remain productive for a long time. With a high rate of depreciation, user cost will be higher. As shown in Table 2.5, the rate of depreciation for the same type of capital differs from industry to industry. The explanation is that the composition, or mix, of the types of capital differs among industries.[34] The tendency in the price of ICT capital was negative during the period. This statement applies generally to the all the industries, although certain differences are due to the fact that different industries used different types of hard- and software. If the price tendency is negative, user cost will be higher, all else being equal.

Table 2.5 User Costs

Percent

	ICT industry	Manufacturing industry excl. ICT	Other-goods industry	Services industry excl. ICT
Required return	15.2	14.2	11.1	11.1
Machinery				
User cost	30.6	28.6	21.8	26.3
Depreciation	18.9	14.9	13.0	15.5
Price tendency	3.7	1.7	2.0	1.6
Buildings				
User cost	14.5	15.6	10.2	9.4
Depreciation	2.5	3.1	2.4	1.7
Price tendency	3.4	1.9	3.3	3.0
ICT				
User cost	46.3	46.5	42.3	44.9
Depreciation	21.8	29.6	22.5	31.4
Price tendency	-6.7	-3.2	-5.1	-4.7

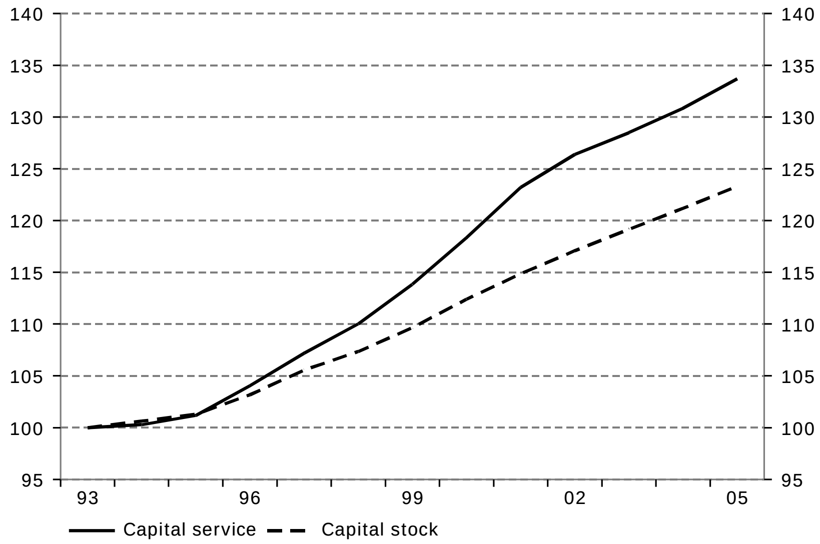
Note: Price tendency refers to the development of prices of investment goods for the respective type of capital.

Source: NIER.

With the high user cost of ICT capital, this type of capital is heavily weighted in the calculation of capital services. Diagram 2.10 clearly illustrates the difference between an index for ordinary capital stocks and an index for capital services.

[34] In the lowest of Statistics Sweden's levels of aggregation for capital, the rate of depreciation is independent of the industry.

Diagram 2.10 Flow of Capital Services and Capital Stock in the Business Sector
Index 1993 = 100



Source: Statistics Sweden and NIER.

Capital services increased much more rapidly than capital stocks in all industries except the other-goods industry, where they only increased a little faster (see Table 2.6). This is a consequence of the shift in composition of capital stocks toward more productive types of capital, i. e. those that also have a high utilization cost. The capital stock has increased the most in the ICT industry, whereas the largest contribution from change in composition is found in the services industry excluding ICT. One reason for the substantial quality effect in the services industry is that buildings make up 90 percent of the capital stock in that industry (where housing is included in the stock of buildings). During the period under study, housing investment was slack, whereas investment in ICT capital surged. Consequently, there is a sizable difference in tendencies between capital services and the capital stock.

Table 2.6 Flow of Capital Services and Capital Stock 1993–2005
Average annual percentage change

	Flow of Capital services (K)	Capital stock (S)	Difference, quality effect
ICT industry	4.43	3.72	0.72
Manufacturing industry excl. ICT	2.46	1.91	0.55
Other-goods industry	0.76	0.59	0.17
Services industry excl. ICT	2,74	1,89	0,85
Business Sector	2,45	1,76	0,69

Source: Statistics Sweden and NIER.

2.2.4 CONTRIBUTION TO PRODUCTIVITY GROWTH

This section presents the results of growth accounting for 1997–2005. During that period, value added in the business sector grew by an annual average of 3.8 percent. The increase is explainable largely by higher productivity (see Table 2.7), and the number of hours worked accounted for a rather small portion. The period 1997–2005 includes an economic upswing, with a surge in employment and a period of mild economic expansion in 2000, as well as an economic downturn in the years that followed. In Table 2.7 the growth in labour productivity has been decomposed with the use of growth accounting. The greatest contribution, averaging 2.0 percent per year, to the rise in productivity was from increased TFP. The ICT industry provided more than half of this increase, even though that industry accounts for only about 8 percent of value added in the business sector. The contribution of capital deepening, i. e. the change in capital services per hour worked, was substantial during the period. The capital deepening is explainable primarily by a larger capital stock, but a change in the composition of capital stocks toward more productive, i. e. better, capital, played a significant part as well. There was also a significant contribution from improvement in the quality of the labour force.

Thus, the ICT industry has played a decisive role in the aggregate productivity growth of the business sector. If that industry should decrease in size, or productivity growth there slow down substantially, the development of productivity in the business sector as a whole would be noticeably affected in the years ahead.

Table 2.7 Value Added, Hours Worked and Productivity in the Business Sector, 1997–2005

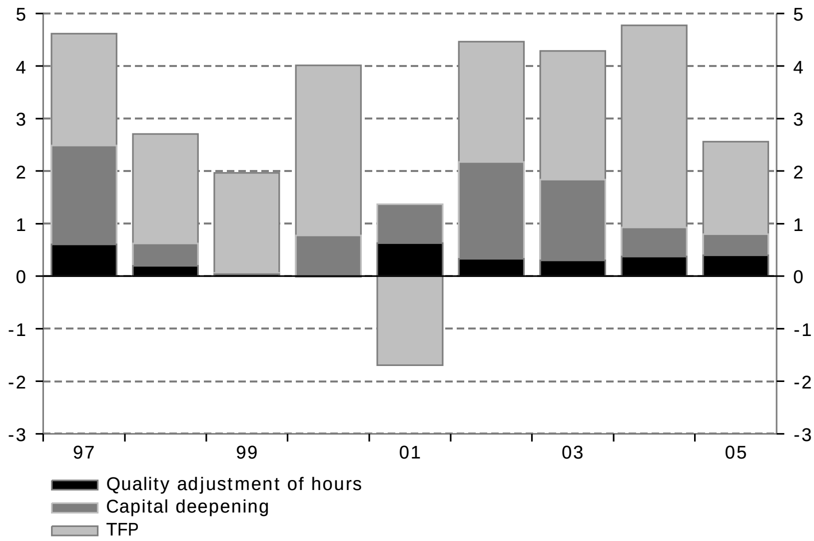
Average annual percentage change and percentage points, respectively

	1997–2005	1997–2000	2001–2005
Value added	3.78	4.98	2.83
Hours worked	0.47	1.60	–0.44
Labour productivity	3.32	3.34	3.29
of which contribution from			
Quality adjustment of hours	0.32	0.21	0.41
Capital deepening	0.98	0.78	1.14
More capital	0.62	0.27	0.90
Better capital	0.36	0.51	0.24
TFP	2.00	2.34	1.73
ICT industry	1.04	1.17	0.94
Other industries	0.96	1.17	0.79

Source: Statistics Sweden and NIER.

Productivity growth follows a distinctly cyclical pattern (see Diagram 2.11). In the short run, firms are normally able to increase output with a given stock of capital and a given labour force when demand rises rapidly, and productivity growth will accelerate. If demand continues to surge, firms will need to adjust their capital stock and their labour force, and then productivity growth will normally fall off. These types of short-term (procyclical) fluctuations in labour productivity will be measured partly as variations in TFP, as TFP is calculated as a residual.

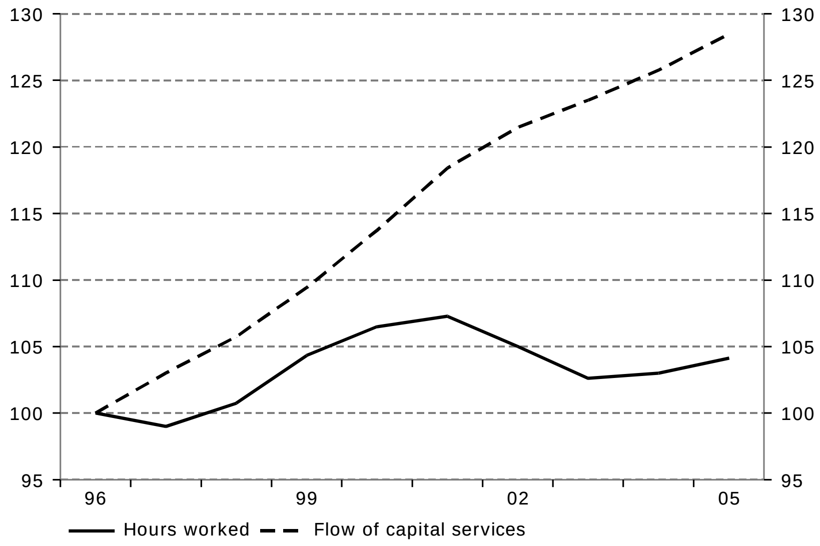
Diagram 2.11 Contribution to Productivity Growth in the Business Sector
Percentage points



Source: Statistics Sweden and NIER.

While also varying sharply over an economic cycle, capital deepening follows a countercyclical pattern. Hours worked have varied more than the calculated flow of capital services (see Diagram 2.12). Firms have thus adjusted the number of hours worked to demand more rapidly than they have adjusted the quantity of their capital. This means, for example, that hours worked will increase more than capital when demand rises rapidly, and that capital deepening is thereby slowed. Here it is important to remember that variations in the utilization of capital stock are not captured in the calculated measure of the flow of capital services, but in TFP (se appendix A). The *calculated* marginal productivity of capital is in principle the same whether it is used or not; the same is true of the labour force. This is one reason why growth accounting is not very well suited for analysis of cyclical variations in productivity.

Diagram 2.12 Hours Worked and Flow of Capital Services in the Business Sector
Index 1996 = 100



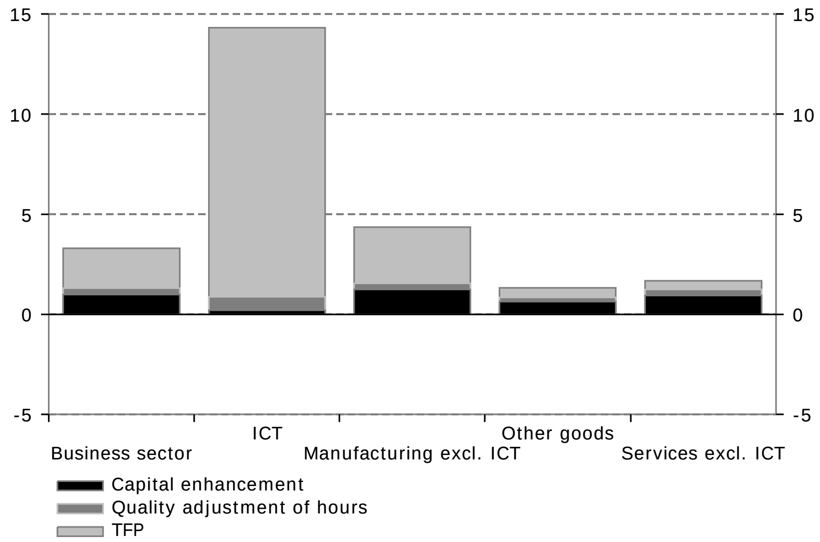
Source: Statistics Sweden and NIER.

Despite substantial variations in productivity growth from year to year, average annual productivity growth was about equally high in 1997–2000 and in 2001–2005 (see Table 2.7). In the first half of the period, 1997–2000, employment rose strongly, while productivity growth was high. However, the contribution to productivity growth from the improved quality of the labour force was minor (less than the average for the entire period 1997–2005).

In the period 2001–2005, hours worked decreased and the improved quality of the labour force provided a larger contribution to productivity growth. During that time, firms carried out sweeping cost-cutting programmes, particularly in the ICT industry, and the composition of the labour force changed in favour of better-paid (higher-productivity) labour.

Diagram 2.13 Contribution to Annual Productivity Growth in Different Industries, 1997–2005

Percentage points



Note: Other goods = Other goods industries excl. ICT
Source: Statistics Sweden and NIER.

The development of productivity growth has differed greatly among the various industries (see Diagram 2.13). Productivity growth was clearly fastest in the ICT industry, averaging a full 14.4 percent per year (see Table 2.8). Hours worked also rose strongly, by an annual average of 1.0 percent, compared to 0.5 percent for the business sector as a whole. The vigorous growth of productivity is explainable almost entirely by higher TFP. It is also remarkable that the contribution was greater from improved quality of the labour force than from capital deepening.

Productivity growth was strong in manufacturing excl. ICT as well, averaging 4.4 percent per year. But there high productivity growth was accompanied by a decreasing number of hours worked. The reduction in hours worked, however, was partly offset by improvement in the quality of the labour force. Consequently, annual growth in value added averaged only 3.6 percent. TFP growth provided the largest contribution to productivity growth, but the relative importance of capital deepening was greater in manufacturing excl. ICT than in the ICT industry.

Both the other-goods industry excl. ICT and the services industry excl. ICT showed considerably weaker productivity growth than the business sector as a whole. In the services industry excl. ICT, hours worked showed a strong increase, whereas they decreased in the other-goods industry. In both the other-goods industry and in the services industry excl. ICT, capital deepening contributed more than growth in TFP to productivity growth. In the other-goods industry the capital deepening is due almost solely to more physical capital in production. In the services industry excl. ICT, on the other hand, half of the contribution to capital deepening came from changes in composition/quality. The contribution of capital deepening in the services industry excl. ICT is remarkably large. As shown in Diagram 2.9, there has been growth in all types of capital in the industry, but above all, ICT capital has increased very rapidly.

Table 2.8 Value Added, Hours Worked and Productivity in the Business Sector, 1997–2005

Average annual percentage change and percentage points, respectively

	ICT industry	Manufacturing excl. ICT	Other-goods industry	Services industry excl. ICT
Value added	15.15	3.63	1.20	2.76
Hours worked	0.98	–0.71	–0.11	1.08
Labour productivity	14.42	4.39	1.32	1.67
of which contribution from				
Quality adjustment of hours	0.67	0.29	0.20	0.31
Capital deepening	0.20	1.25	0.64	0.94
More capital	0.07	1.05	0.49	0.45
Better capital	0.14	0.19	0.15	0.48
TFP	13.44	2.81	0.49	0.43

Source: Statistics Sweden and NIER.

In this report no attempt is made to explain TFP growth or differences in it between different industries. But one explanation normally advanced is that industries with a high proportion of ICT capital in production have higher TFP growth.[35] Among the industries studied here, the share of ICT capital is greatest in the ICT industry, where ICT capital equals approximately 34 percent of value added. It is also in this industry that productivity growth is highest. The next highest share of ICT capital is found in manufacturing excluding ICT (where the corresponding proportion is about 12 percent). The services industry excluding ICT has almost as high a share of ICT capital in production as the manufacturing industry (about 9 percent), but much lower TFP growth. The other-goods industry has a very small proportion of ICT capital in production (around 2 percent) as well as low TFP growth. Thus, industries with a high share of ICT capital in production have been more successful in raising productivity.

2.3 Growth Accounting – Other Studies

This section briefly presents a number of studies that have applied growth accounting to Sweden and other countries. In comparing different studies, it is important to be aware of differences in the way that growth accounting is implemented. Differences in the calculation of the contribution from capital deepening, and whether consideration is given to improved quality of the labour force, will lead to different results for the development of TFP since the latter is calculated as a residual.

Lack of data is probably one explanation for the relative scarcity of studies where growth accounting is used in analyzing Swedish productivity growth. The studies that exist cover somewhat different periods, but one feature in common is the finding that ICT has played an important part in the development of productivity in the Swedish business sector, both through high TFP growth and through the increase in the proportion of ICT capital. The contribution from improved quality of the labour force varies between 0.2 and 0.4 percentage point per year, and TFP growth varies between 1.5 and 2.3 percent per year. The results of the present study are within these intervals.

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[35] See, for example,. Hagén & Skytesvall [2006].

Lindström (2003) is the first study applying growth accounting to Swedish data where the flow of capital services is used instead of the capital stock. The study covers the business sector in the period 1994–1999. However, no consideration is given in the study to changes in the quality of the labour force. The work of this study is carried further in Forsling & Lindström (2004), where the change in the quality of the labour force is also analyzed. In this study, the labour force is classified by level and focus of education. The capital stock is divided into three types of capital: machinery excluding ICT, buildings and ICT capital. In the period studied, 1994–2000, productivity in the business sector as a whole rose by an annual average of 3.17 percent.[36] Capital deepening contributed 0.67 percentage point. As the contribution from ICT capital was somewhat greater, 0.83 percentage point, the contribution of other capital was negative. Changes in the quality of the labour force contributed 0.20 percentage point, whereas increased TFP contributed a full 2.30 percentage points. Improved quality of the labour force provided a larger contribution in the services industries than in the goods industries, 0.24 percentage point and 0.17 percentage point, respectively. The contribution from improved quality of the labour force in the ICT industry was greater, 0.37 percentage point. In that study the ICT industry was not excluded from the services industry and the goods industry. Underlying the improved quality of the labour force is a growing number of employees with post-secondary education who have earned degrees in business or engineering. A concomitant tendency has been the decreasing proportion with only primary or lower secondary education, a factor that has helped to raise the quality of the labour force even further.

Hagén & Skytesvall (2005) analyze the development of productivity in the business sector for the period 1994–2004. Productivity is analyzed as gross output per hour worked; consumption of inputs is thus included in the production function. Consequently, it is difficult to compare the results with other studies. In this study, too, capital and labour are quality-adjusted. Labour is divided into five age groups, five levels of education, two different educational specializations and five ethnicity groups. Capital is divided into machinery excluding ICT, transport equipment, buildings and ICT. Some results are also reported for the development of value added. Value added in the business sector as a whole increased by an annual average of 3.88 percent in the period 1994–2004. The change in the flow of capital services contributed 1.25 percentage points, of which ICT capital accounted for 0.67 percentage point. The change in quality-adjusted hours contributed 0.60 percentage point, and increased TFP provided 2.03 percentage points. On average, quality-adjusted hours increased 0.35 percentage point faster per year than hours worked.

In previous studies,[37] the NIER has analyzed productivity growth in the business sector, but without quality-adjusting the labour force.

In these studies as well as the present study, the findings for Sweden appear more like those of other analysts for the United States than for Europe. In the EU KLEMS project, van Ark et al. (2007) used growth accounting on a large number of countries based on data prepared to facilitate comparison among different countries. The method is the same as in the present report; i. e. labour and capital are quality adjusted. According to van Ark et al. (2007), labour productivity in the business sector increased in the period 1995–2004 almost as fast in Sweden as in the US, whereas productivity rose much more slowly in the EU (see Table 2.9). Sweden and the US differ from the EU mainly in regard to development of TFP.

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[36] Since the present study was published, the outcome for productivity growth in the business sector has been revised in the National Accounts.

[37] NIER [2005], NIER [2006a].

Table 2.9 Labour Productivity and Value Added in the Business Sector, 1995–2004

Average annual percentage change and percentage points, respectively

	Sweden	EU	United States
Labour productivity	3.1	1.8	3.4
Value added	3.3	2.2	3.7
Contribution to value added from			
Hours worked	0.2	0.4	0.3
Quality adjustment of hours	0.4	0.2	0.3
Capital	1.3	1.2	1.4
ICT capital	0.7	0.6	0.8
Other capital	0.6	0.6	0.6
TFP	1.5	0.3	1.6

Source: EU KLEMS.

Productivity growth in the United States began to pick up in the second half of the 1990's, following two lacklustre decades.[38] The tendency gained momentum in the early 2000's. The results show that the new ICT technology played a major part in the upswing of productivity in the US.

If anything, the tendency in Europe has been the opposite of that in the US.[39] Growth in labour productivity has gradually fallen off in recent decades and was still doing so in the early years of the new millennium. During the period 1995–2005, productivity growth was lower in the EU/EMU than in the US for the first time in the post-war period. Although the increased importance of the new ICT technology is discernible in the second half of the 1990's in the EU/EMU as well, the effects have been more limited than in the US. The principal factors in the slowdown of productivity growth in the EU/EMU have been smaller contributions from capital deepening and lower TFP growth in industries other than ICT.

[38] See, for example, Jorgenson, Ho & Stiroh [2007], Van Ark & Inklaar [2005], Gordon [2006].

[39] Van Ark & Inklaar [2005], Gordon [2006], Gomes-Salvador, Musso, Stocker & Turunen [2006].

3 Projections of Productivity Growth

In Chapter 2, growth accounting was used to decompose the historical development of productivity in 1997–2005 in terms of capital deepening, changed quality of the labour force and growth in TFP.

In this chapter, projections are made for productivity growth at the industry level; from these, the projected development for the business sector as a whole can be calculated. The period covered is 2006–2020. The projections and quality adjustment of hours worked are shown in Sections 3.2–3.4, and the projections of productivity are presented in Section 3.5.

The projections show the cyclically balanced development. The historical trend of development for TFP in the different industries is used as a guide to the future course of TFP, although the views of other analysts on the international tendency are also taken into account. But if, as in the neoclassical growth model, the development of TFP is regarded as exogenously given, there is no obvious way to perform the projections. Essentially, growth in TFP is driven by the rate of technological progress, which in itself is difficult to forecast. The uncertainty in the projections of the growth trend is therefore quite substantial, particularly for the ICT industry, where the trend rate of TFP growth has been very high in recent years. Consequently, projections for productivity growth are performed as a sensitivity analysis, with alternative assumptions about TFP growth in the ICT industry.

The projection of quality-adjusted hours is of course uncertain as well. But the population forecast of Statistics Sweden, for example, provides a solid foundation for such projections. Together with the NIER's education forecast and model for demographic projections, the population forecast makes it possible to perform projections of the development trend in hours worked for the 752 different groups of labour. Thus, the development trend of quality-adjusted hours can also be calculated.

It is assumed in the projections that differences in employment rate among different population groups will remain at their cyclically balanced levels for 2006. Average hours worked in different groups of labour are also assumed to remain the same. Moreover, the relative productivity, as approximated by relative wage, of different groups is taken as constant over time. As a practical matter, however, these variables may be affected by different factors. For example, the group born outside Europe is extremely heterogeneous in ways other than those captured by age and education. For example, different individuals have different motives for immigrating to Sweden. Depending on whether immigration consists primarily of refugees or of people who have come to Sweden mainly to look for work, the employment rate of the group will be affected. In the projections, it is implicitly assumed that immigrants on average have the same level of education, the same employment rate and the same average hours worked as people who already live in the country.

Changes in composition of the labour force, due for example to changes in level of education or in age structure, can also affect the complementarity, or fit, among the various groups of labour. For example, if the demographic tendency features an unusually larger number of young, inexperienced people in the labour force, the employment rate and relative wages may decrease for these individuals. Similarly, changes in the distribution of education may conceivably affect the employment rate and the relative wage of different groups in the labour force.[40] But if changes in the distribution of education are governed by the development of demand, the effects should be more limited.

It is of course hard to determine the degree to which changes of this kind will affect cyclically balanced development in the years ahead. With the short time series of historical data, there is no meaningful way to use them as a basis for modelling the tendency. As mentioned above, it is assumed in the projections that the cyclically balanced differences as of 2006 between different groups in regard to employment rate and average hours worked will persist, as will differences in relative wages (although in the so-called Integration Scenario presented in Chapter 4, these assumptions are relaxed). In addition, these assumptions have the advantage of being extremely transparent. In the projections, it is assumed that production technology is of the so-called Cobb-Douglas type. This means, for instance, that the cost of the capital services used in production accounts for a constant share of value added. On the basis of the projections for the development trend of TFP and of quality-adjusted hours, the development of capital services can be calculated as a residual so that this condition is satisfied. The projections of capital services in both the Base Scenario and the alternative scenarios follow this principle (see Appendix C).

3.1 Projections of Productivity for Other Countries

This section briefly presents some studies that have used growth accounting as the starting point for projections of productivity growth in the US and EU. The results of these studies are important as a basis for projections of TFP growth, particularly in the Swedish business sector. To make meaningful use of the TFP assumptions of other analysts, the growth accounting must be done in similar ways, in regard to quality adjustment of capital and labour, for example.

Jorgenson, Ho & Stiroh (2007) perform projections of productivity growth in the US business sector for 2005–2015. As in the present study, it is assumed that the profit share is constant and that labour and capital are quality-adjusted. In the former study, the business sector as a whole is analyzed. In the US, the business sector includes a large portion of operations that would belong to the public sector in Sweden. For this reason, productivity growth may differ for the Swedish and US business sectors even if it is identical at the industry level. Jorgenson, Ho & Stiroh use three different scenarios for the variables considered most difficult to forecast. These are: TFP growth in the ICT industry and in other industries, respectively, and improvement in the quality of capital. The optimistic scenario is based largely on the assumption that the tendency in 1995–2005 will continue, whereas in the pessimistic scenario it is assumed that the tendency will slacken and resemble the one in the period 1973–1995 (see Table 3.1).

In the Base Scenario, business sector productivity increases by 2.5 percent annually in 2005–2015. TFP in the ICT industry is then assumed to rise by 9.5 percent per year. Not even in the optimistic scenario is productivity as high as in 2000–2005. In the

[40] Changes in educational level can also affect the average productivity of different groups of labour for other reasons. For example, if a larger proportion of the population receives post-secondary education, this change could tend to limit the productivity of that group if those joining it most recently are less well prepared to draw on the education that they receive. But it could also mean that the average productivity of the group with upper-secondary education decreases, provided those who leave this group to enrol in post-secondary education are the most productive in the group. The effects on relative productivity, which is of greatest interest in this study, are thus unclear.

pessimistic scenario, productivity growth drops to 1.4 percent, almost as low as in the period 1987–1995. Even so, productivity growth in this pessimistic scenario is higher than it was in the EU in 2000–2005.

Table 3.1 Output and Productivity in the Business Sector, United States, 2005–2015

Annual percentage change and percent, respectively

	Pessimistic scenario	Base scenario	Optimistic scenario
Growth in value added	2.12	3.25	3.76
Growth in labour productivity	1.36	2.49	3.00
		Same assumption	
Growth in hours worked	0.76	0.757	0.76
Growth in quality of labour	0.15	0.149	0.15
Capital share (= profit share)	0.42	0.423	0.42
Share of output, ICT industry	0.05	0.046	0.05
		Different assumption	
TFP growth, ICT industry	8.05	9.52	10.77
Growth in quality of capital	0.86	1.72	2.05

Source: Jorgenson, Ho & Stiroh [2007].

Each year the Congressional Budget Office (CBO) publishes a report assessing the short- and medium-range tendency of the economy. In the report of January 2007, the projections extend to 2017. For the period 2009–2017, potential, i. e. cyclically balanced, growth is projected, based on the results of growth accounting. Consideration is given to changes in the quality of capital, but not of labour. All else being equal, TFP growth will thus be higher than in the study by Jorgenson, Ho & Stiroh. In the CBO (Congressional Budget Office) study, value added in the business sector is expected to increase by an annual average of 3.0 percent in 2007–2017. Hours worked are estimated to contribute 0.5 percentage point, and the flow of capital services, 1.1 percentage points. TFP increases by 1.4 percent, equalling the average for the period 1950–2006, according to the CBO. Productivity growth in the business sector is 2.3 percent, somewhat higher than in the period 1950–2006, owing to a larger contribution from capital deepening.

Jorgenson, Ho & Stiroh present an array of projections for US productivity (see Table 3.2).The time horizons differ, and the assessments vary considerably. The projected annual productivity growth ranges from 2.0 to 2.6 percent. For the next ten years, the average estimated productivity growth in the business sector is 2.4 percent per year.

Table 3.2 Projections of Productivity in the Business Sector, United States

Annual percentage change

	Published	Horizon, years	Productivity
JP Morgan (2006)	Sep 2006	4	2.0
Gordon (2006)	Sep 2006	25	2.1
CBO (2007)	Jan 2007	10	2.3
Survey of Professional Forecasters (2007)	Feb 2007	10	2.2
Jorgenson, Ho, Stiroh (2007)	Oct 2006	10	2.5
Kahn, Rich (2006)	Dec 2006	3	2.5
Goldman Sachs (2006)	Jul 2006	4	2.6
CEA (2007)	Feb 2007	6	2.6

Source: Jorgenson, Ho and Stiroh [2007].

The European Commission (2005) has prepared projections of productivity through 2050 for 25 EU member countries.[41] These are used as a basis for projections of age-related expenditure. Growth accounting has been applied to the economy as a whole. Neither capital nor labour is quality-adjusted. In the projections, use is made of a production function with a constant labour cost share of 65 percent. Productivity is measured as value added per employee. Employment is assumed to develop in line with the potential labour force. The capital stock is assumed to grow at the same rate as value added. Productivity growth is thus determined entirely by growth in TFP. It is assumed that the rates of TFP growth in different countries will converge, so that in 2050 TFP will be growing by 1.1 percent annually in all countries and thus in the economy as a whole as well, equalling the historical growth rate for 1970–2004. Depending on the extent of the differences in initial levels of TFP, different rates of convergence among different countries are assumed. For Sweden it is assumed that productivity growth in the economy as a whole will average 2.5 percent per year during a period of adjustment from 2011 through 2020, corresponding roughly to 3.3 percent in the business sector.[42] For the economy as a whole, TFP is assumed to increase by annual average of 1.8 percent during the period of adjustment, with a contribution of 0.7 percentage point from capital deepening. For the 25 EU countries as a whole, productivity growth averages 2.0 percent per year in 2011–2020. TFP growth averages 1.3 percent per year, and the contribution from capital deepening is 0.7 percentage point. Since the method differs significantly from the one used in the present study, the results are not directly comparable. The study that most closely resembles the present one in regard to method is Jorgenson, Ho & Stiroh.

[41] An example of another study that has used growth accounting in projecting productivity growth is Musso et al. [2005].

[42] The latter is the NIER's assessment. It is based on value added in the business sector in proportion to total value added in the economy and on the NIER's forecast for productivity growth in the general government sector.

3.2 Projection of Hours Worked in Sweden's Business Sector

The projections of hours worked in this report are based on the assumption of a cyclically balanced labour market in 2006. Differences among different groups of labour in regard to employment rate and average hours worked are assumed to remain unchanged at their cyclically balanced levels of 2006. The number of hours worked is thus governed by the demographic trend in the projections. As labour force participation, unemployment and average hours worked vary among different population groups, the number of hours worked will be affected both by population growth and by the development of the proportions of the different groups to the population as a whole. In addition to these factors, the projection of hours worked will be affected by various reforms relating to the labour market that will stimulate labour supply and employment.

Potential employment (i. e. the number employed when the economy is in cyclical balance) is calculated as the potential supply of labour (the labour supply in a cyclically balanced economy) minus equilibrium unemployment (i. e. the unemployment prevailing in a cyclically balanced economy). The potential number of hours worked is determined as potential employment multiplied by potential average hours worked (i. e. average hours worked in a cyclically balanced economy).

Labour supply is determined by the population, its composition and its propensity to participate in the labour force. Within the working-age population, the younger and the older age groups show both lower labour force participation, because of studies or retirement, respectively, and lower average hours worked, than age group 25–54.[43] The average hours worked of younger people are limited as many of them do extra work during periods of study, when average hours worked are often very low. The average hours worked of older individuals are curtailed since more of them start working part time when they grow older.

With the age aspect taken into account, the foreign-born show lower labour force participation, on average, than natives of Sweden.

The demographic tendency also affects equilibrium unemployment, as different age groups are unemployed to a different extent. Unemployment is higher in age group 18–24 than in older groups. Consequently, if of younger persons constitute a growing share of the working-age population, equilibrium unemployment will tend to be higher. The degree of unemployment also varies among individuals with different countries of birth. Persons born outside Sweden are unemployed to a significantly higher extent than persons born in Sweden. A larger proportion born abroad may contribute to higher equilibrium unemployment.

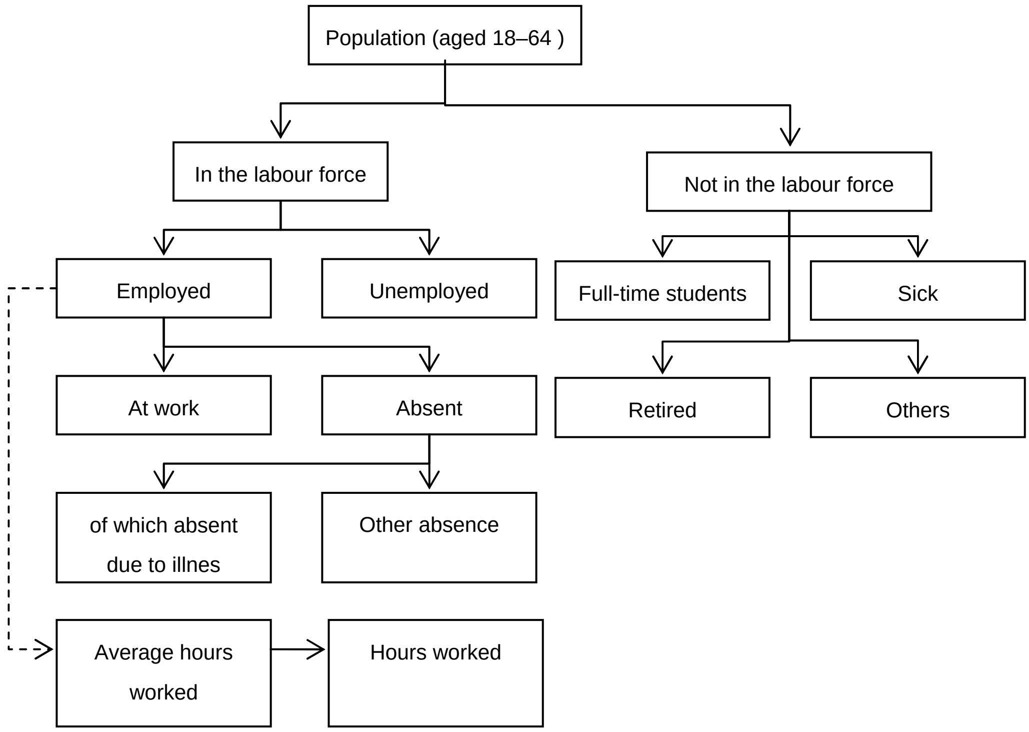
3.2.1 Data and Method

The NIER calculates the trend on the labour market, starting with the 2007 population forecast of Statistics Sweden and the labour market situation in 2006 according to

[43] Working age is defined in the Labour Force Surveys (LFS) as ages 16–64. Since a distribution of education levels is required for each group in the quality adjustment of hours worked, 16- and 17-year-olds are excluded from this study, as they are not covered in the Wage Structure Statistics used in determining the distribution of education levels

the Labour Force Surveys (LFS). In the LFS the labour market is divided up as shown in Figure 3.1:

Figure 3.1 Labour Market as Classified in the LFS



The working-age population is divided up into groups according to age (one age group for each annual age cohort from 18 to 64) and national origin (born in Sweden, born in the Nordic countries except Sweden, born in Europe outside the Nordic countries and born outside Europe). Through this procedure, the labour market is divided in Figure 3.1 into a total of 188 groups (47 age groups, 4 groups for origin).

The model used for projection, KAMEL,[44] is so designed that the proportions of the population aged 18–64 in all 188 groups and in each box according to Figure 3.1 are kept constant over time; in other words, they maintain the values assigned to them for 2006. Based on these proportions, the labour market tendency is then projected, with the population developing in accordance with the population forecast. For example, the number of employed 25-year-olds born in Sweden as a share of the potential number employed in the same group from 2006 is multiplied by the number of Swedish-born 25-year-olds for each year of the period 2007–2020. The corresponding calculations are performed for all 188 groups. Since the size and composition of the population change over time, so also do the number of persons in the labour force, the number employed, the number unemployed etc. In addition, average hours worked are assumed to be constant in the projections from the starting values of 2006 for each of the 188 groups. Thus, because of changes in the composition of the population, the number of hours worked does not develop at the same rate as the population aged 18–64.

The population forecast of Statistics Sweden shows the tendency for both Swedish-born and foreign-born. Since the labour market situation is different, for example,

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[44] The NIER's Labour Market Equations for Long-Term Calculations.

for natives of the Nordic countries than for persons born outside Europe, it is important to take into account how different groups of the foreign-born will develop over time. The population forecast of Statistics Sweden for the foreign-born is therefore subdivided into three groups: persons born in the Nordic countries outside Sweden, persons born in Europe outside the Nordic countries and persons born outside Europe; see also Section 3.2.2.

Two further adjustments are made in the projections. The starting values set for 2006 are adjusted because resource utilization on the labour market is judged to have been slightly on the low side that year. Thus, the projection is based on a cyclically balanced labour market; see Box 4. Moreover, the projections are adjusted for anticipated structural changes on the labour market. In the past year, a number of reforms have been implemented or decided that will affect the labour market and in the NIER's opinion will impact potential employment and thus the potential number of hours worked.

Box 4: Cyclical and Structural Adjustment

Cyclical Adjustment

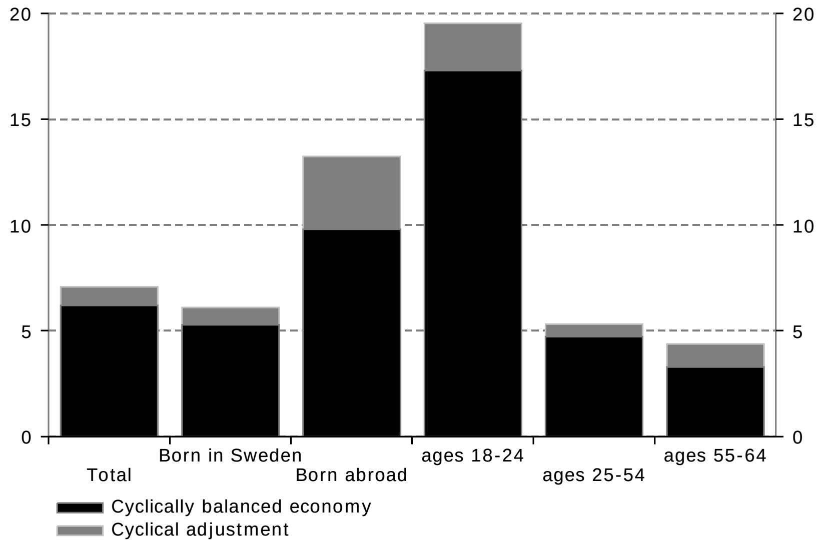
Cyclical adjustment of the number of hours worked results in the trend rate of development, i. e. the trend with the effect of cyclical variations removed. The projection must therefore start with a labour market that is in cyclical balance. As for 2006, it is considered a year with a slightly negative labour market gap;[45] i.e., resource utilization on the labour market was assessed as slightly on the low side. In 2006, the unemployment rate was 7.1 percent, measured by the ILO definition, and in 2006 that rate was 1.0 percentage point higher than the equilibrium unemployment rate estimated by the NIER. At that time, the number of persons in the labour force was 4 671 000, or 21 000 below the NIER's assessment of the potential labour force in 2006. The starting values for 2006 have therefore been adjusted to reflect a cyclically balanced economy. First, the number of persons unemployed and the number in the labour force have been adjusted so that unemployment is equal to the estimated equilibrium unemployment rate and the labour force is equal to the potential labour force.

Thereafter, adjustment is made for the fact that foreign-born and younger individuals are normally hit harder on the labour market in an economic downturn (see Diagram 3.1). The aggregate effect is that potential employment in 2006 is higher than actual employment by the equivalent of 63 000 persons.

[45] The labour market gap summarizes the NIER's assessment of resource utilization on the labour market and is defined as the deviation of the actual number of hours worked from potential hours worked.

Diagram 3.1 Actual and Cyclically Balanced Unemployment, 2006

Percent of labour force in each group



Note: Actual unemployment is the total of cyclically balanced unemployment and cyclical adjustment.
Source: Statistics Sweden and NIER.

Adjustment for Structural Reforms

The projections of hours worked from the cyclically adjusted starting values, using the KAMEL model, follow only the demographic tendency. In the past year, however, a number of reforms have been implemented or decided that in the NIER's opinion will affect the development of potential employment and thus potential hours worked in the years ahead [see NIER (2006a) and NIER (2007a)]. As these effects are not captured in the demographic projection with the KAMEL model, they must be adjusted for afterwards.

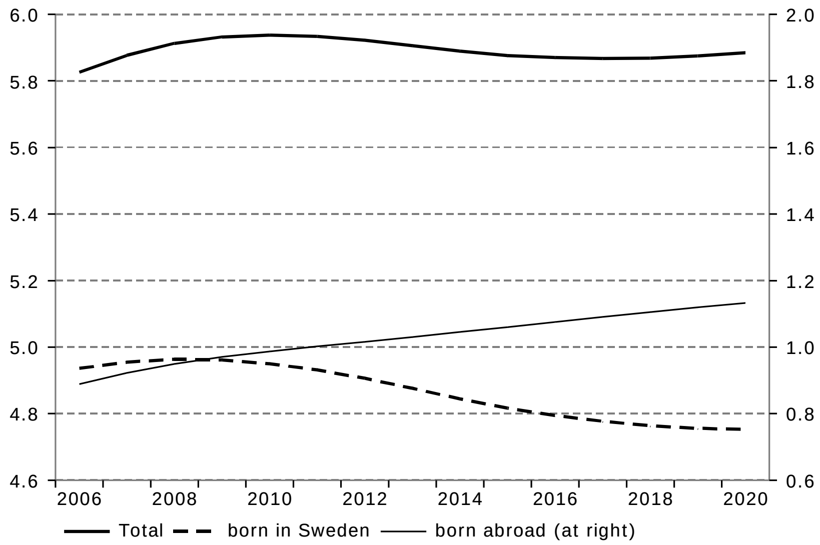
The demographically caused development of the number of hours worked has therefore been adjusted upward by a total of 1.8 percent, equivalent to the estimated effect of the reforms on hours worked. The impact of the reforms will be gradual through 2010 and is assumed to be equally great, proportionally, for the different groups within the labour force.

This is of course an approximation, but the distribution of the effects of the various reforms among different groups is very hard to assess. Since it is desirable for the assumptions made to be transparent, an assumption of proportionality is considered preferable.

3.2.2 Development of the Population

According to the latest population forecast of Statistics Sweden, the population aged 18–64 will increase until 2010 and then decrease.[46] The number of working age in 2020, however, will still be almost 60 000 higher than in 2006. The population born in Sweden will decrease by about 180 000, and the population born abroad will increase by some 240 000 during 2006–2020 (see Diagram 3.2). Thus, the number born abroad will gradually rise as a share of the working-age population, from 15.3 percent in 2006 to 19.2 percent in 2020. In total, the working-age population is forecast to be 5 890 000 in 2020.[47]

Diagram 3.2 Population Aged 18–64
Millions of persons



Source: Statistics Sweden.

The Statistics Sweden forecast for the group born abroad is based on various assumptions about immigration and emigration for persons born in different parts of the world. Statistics Sweden present an aggregate forecast for the group of foreign-born as a whole. In the present study the foreign-born population is divided into subgroups: born in the Nordic countries outside Sweden, born in Europe outside the Nordic countries and born outside Europe (see Chapter 2). As a whole, the group of foreign-born is projected according to the Statistics Sweden forecast. The relative development of the various groups of foreign-born in the population is calculated with Statis-

[46] See Statistics Sweden [2007].

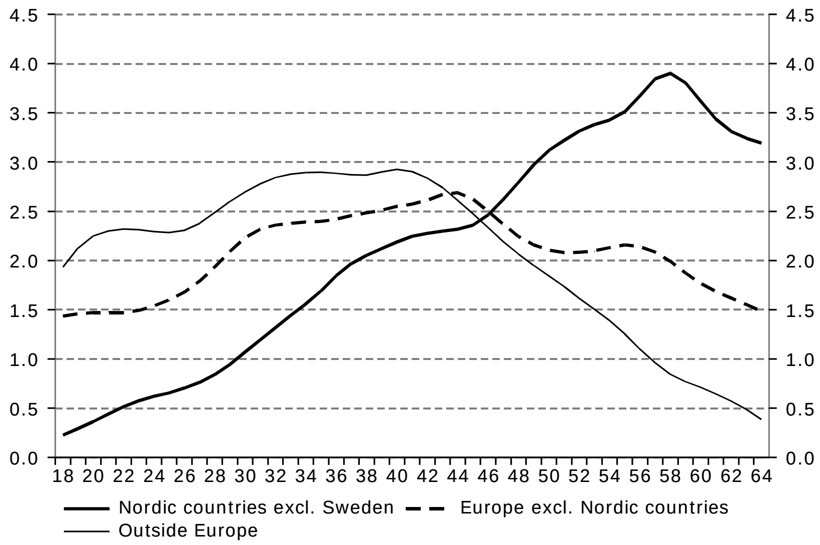
[47] The population forecast of Statistics Sweden is linked to the LFS definition of population. In the population forecast of Statistics Sweden, year-end values are used, that is the values as of December 31 of the respective year. In the LFS, mid-year values are used. The development of the population in the LFS is therefore projected as the mean of the values in the current and preceding forecasts according to Statistics Sweden's population forecast.

tics Sweden's assumptions of immigration and emigration, which serve as the basis for its population forecast.[48]

The distribution of age within the various groups of foreign-born differs markedly. Those born in Nordic countries outside Sweden show a relatively large proportion of older individuals, and those born outside Europe have a relatively sizable share of younger persons (see Diagram 3.3). The age distribution of the group born in Europe outside the Nordic countries is fairly even. Roughly 50 percent of those who belonged in 2006 to the group born in the Nordic countries outside Sweden will have reached 65 by 2020 and therefore have left the labour force. The corresponding figures for persons born in Europe outside the Nordic countries and those born outside Europe are about 30 percent and 15 percent, respectively.

Diagram 3.3 Age Structure 2005

Percent of the respective population group, aged 18–64, annual age cohorts



Source: Statistics Sweden.

According to Statistics Sweden's population forecast, in the years ahead approximately 10 000 persons will immigrate annually in two of the respective groups: born in the Nordic countries outside Sweden and born in Europe outside the Nordic countries. In the group born outside Europe, immigration is expected to be almost 35 000 per year.

The high average age of the group born in the Nordic countries outside Sweden, in combination with relatively low immigration, means that the number of persons of working age will decrease within this group in the years ahead (see Diagram 3.4). The groups born in Europe outside the Nordic countries and outside Europe presently consist largely of relatively young individuals. Taken together with immigration forecasts, this means that these groups will increase rapidly in proportion to the total working-age population, from a total of 12.2 percent in 2006 to 17.1 percent in 2020. As an overall effect, the proportion born in Sweden will drop from 84.5 percent in 2006 to 80.5 percent in 2020.

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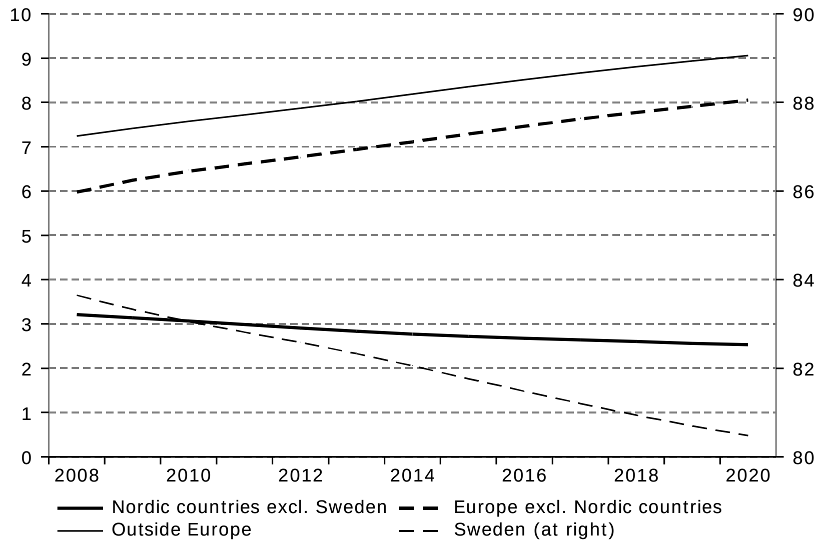
48 See Statistics Sweden [2006] and Statistics Sweden [2007].

Diagram 3.4 Population Aged 18–64

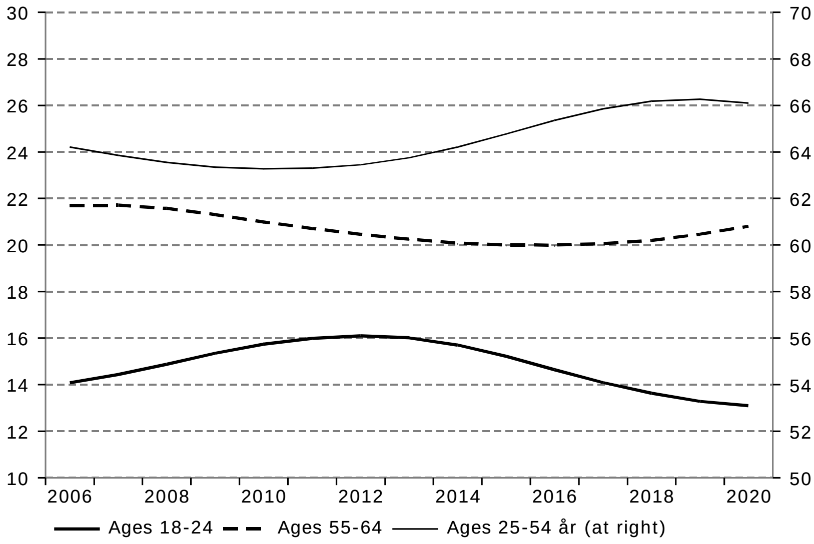
Percent of total population aged 18–64



Source: Statistics Sweden and NIER.

As the share of foreign-born increases, the age structure of the total working-age population will change. The proportion aged 18–24 will rise somewhat through 2012 and then drop back slightly, whereas the proportion aged 55–64 will decrease slightly through 2016 and thereafter increase a little. The proportion aged 25–54, the group with the highest labour force participation, will recede somewhat in the next few years, but advance again in the 2010's, so that by 2020 it will be more than 2 percentage points higher than in 2006 (see Diagram 3.5).

Diagram 3.5 Population Aged 18–64
Percent of total population aged 18–64



Source: Statistics Sweden.

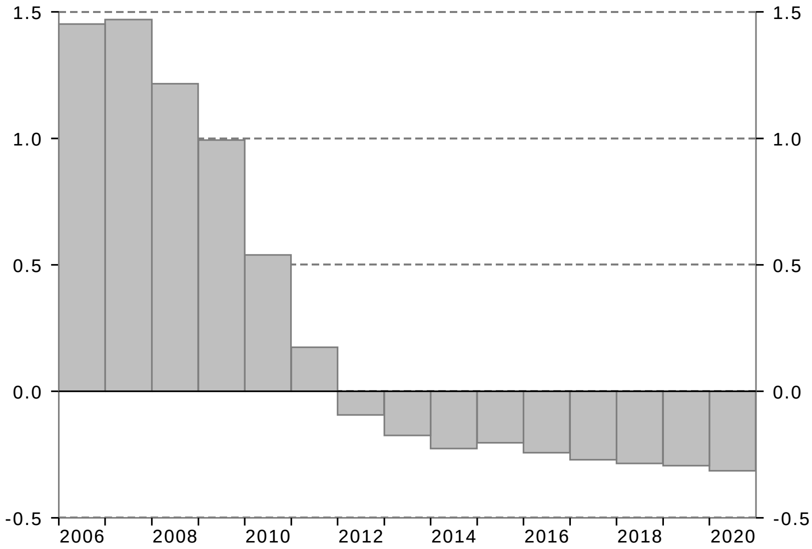
3.2.3 HOURS WORKED

The projection of hours worked with the KAMEL model covers the entire economy and is measured according to the LFS. The number of hours worked in the business sector is calculated as the difference between the number of hours worked in the economy as a whole and the number of hours worked in the general government sector. The number of hours worked in the general government sector is assumed to develop so that staffing intensity per service utilized in that sector remains the same through 2020.

Diagram 3.6 shows the cyclically balanced development of the number of hours worked in the business sector.[49] The strong rise through 2010 largely follows the estimated effects on the labour market of the reforms implemented or decided in the past year. In total, the number of hours worked will increase by 3.7 percent in 2007–2020, of which 1.8 percentage points will be due to the reforms. The assessment of the effects of the reforms is thus a major source of uncertainty in the projections of hours worked. The average annual increase in hours worked during the period will be 0.25 percent. The increase will be heavily concentrated in 2006–2010, one reason being that the reforms are expected to have had close to their full effect by 2010. In the years 2011–2020 the number of hours worked will decrease by an annual average of 0.19 percentage point.

[49] The projection of hours worked is based on a labour supply consistent with the NIER's education forecast; see Section 3.3.

Diagram 3.6 Cyclically Balanced Hours Worked in the Business Sector



Annual percentage change
Source: Statistics Sweden and NIER.

3.3 Forecast for Education

The number of hours worked as described above has been projected with the age and origin of the labour force taken into account. In the calculation of quality-adjusted hours, consideration has also been given to fact that the level of education differs among the various groups and that it changes over time.[50] Thus, the projection of quality-adjusted hours is strongly affected by the education forecast.

It is important to emphasize that the education forecast covers only persons employed in the business sector. As before, these employees are divided into four groups according to the highest educational level attained: primary and lower secondary education, upper secondary education, post-secondary education and postgraduate education; see also Appendix B. The education forecast is intended for use in projecting the proportion of persons employed, of different ages and national origins, with the respective highest levels of education in the years ahead. The education forecast describes the development on the assumption of a cyclically balanced labour market. With a cyclically weak labour market, relatively large numbers tend to begin studying, whereas the opposite is true in an expanding economy.

The education forecast is based partly on the development of the distribution of education levels in the latest decade. As shown in Diagram 3.7, the proportion of employees with only primary or lower secondary education showed a decreasing trend between 1996 and 2005. This tendency is expected to continue, and the proportion of employees with only primary or lower secondary education is forecast to drop from 16 percent in 2005 to 10 percent in 2020. The decrease is explained by the relatively large proportion of older persons employed in 2005 with only primary or lower secondary education. As these retire in the years ahead, the proportion with only primary or lower secondary education will decline since the share of younger persons entering the labour force with only primary or lower secondary education is much smaller. In 2005, 5.0 percent of 30-year-olds employed in the business sector had only primary or lower

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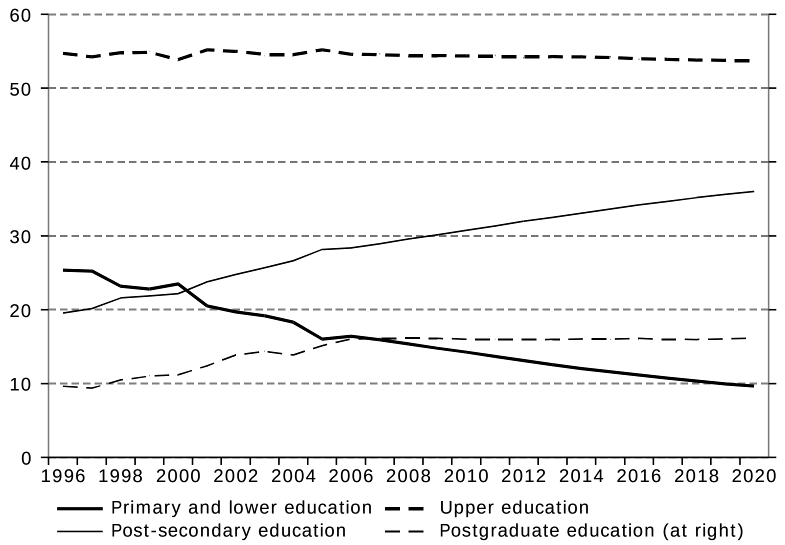
[50] See Section 2.2.2 for a description of the method for calculating quality-adjusted hours.

secondary education. The great majority who receive upper secondary education have done so by the time they reach 30. The proportion of 5.0 percent is therefore assumed to be the share of employed 30-year-olds who will still have only primary or lower secondary education at that time. This percentage is used as a reference value in the projections for 2006–2020 of the share of employed 30-year-olds who will still have no more than primary or lower secondary education.

For those whose highest education is post-secondary, the trend is the opposite (see Diagram 3.7). In proportion to the number employed in the business sector, those with post-secondary education as their highest level will increase from 28 percent in 2005 to 36 percent in 2020. The rising trend from 1996–2005 will thus continue.

Diagram 3.7 Distribution of Education

Percent of total number employed in the business sector



Source: Statistics Sweden and NIER.

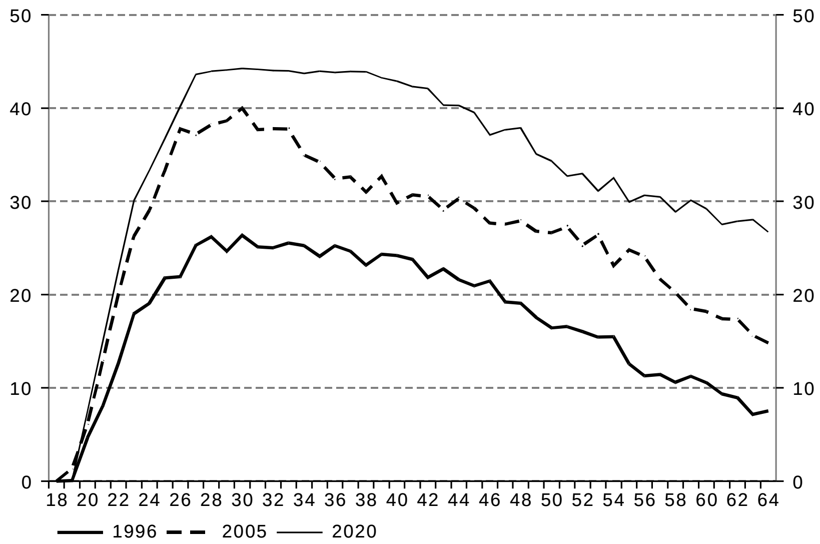
Post-secondary education includes more than college and university education, but these forms predominate; see also Table B.2 in Appendix B. In 2005, for example, 87 percent of 30-year-olds with education beyond the secondary level and employed in the business sector had some form of college or university education. The rapid historical rise in the proportion of employees with post-secondary education is thus attributable largely to the increase in the number attending colleges and universities. In the 1980's and 1990's, the number of students registered in undergraduate college and university education soared by some 80 percent.[51] A similar tendency is shown by post-graduates, whose share of the number employed in the business sector rose from 0.4 percent in 1996 to 0.6 percent in 2005.

As can be seen Diagram 3.8, the proportion of employed 30-year-olds with post-secondary education was more than 26 percent in 1996. The proportion is highest among persons around age 30, an indication that the great majority of those completing post-secondary studies had done so by the time they reached 30. In 2005 the corresponding figure had risen to 40 percent, and the entire distribution of education had shifted upward between 1996 and 2005. The shift is explained partly by the relatively large number who entered college or university during the period, and partly by the

[51] Source: Statistics Sweden.

generation change under way on the labour market. With the passing of time, as older employees with comparatively lower levels of education retire from the labour force and are replaced by younger, better-educated individuals, the distribution of education in Diagram 3.8 is tending to shift upward.

Diagram 3.8 Persons Employed with Post-Secondary Education
Percent of total number employed, annual age cohorts



Source: Wage Structure Statistics, Statistics Sweden and NIER.

In recent years the number of students at universities and colleges has decreased slightly, as has the number of entering students. In 2006 the number of entering students was about 67 000, if exchange students are excluded, or some 4 000 less than four years earlier, but about 7 000 more than eight years earlier.[52] According to the NIER's assessment, 2006 was a somewhat weak year on the labour market, with unemployment slightly above its equilibrium level. In such a cyclical situation, it is normal for a larger number to begin studying than when the economy is in cyclical balance. For 2006, therefore, the cyclically balanced equivalent number entering universities and colleges is estimated at 66 000, and this figure is used as the starting point for projecting the distribution of education.[53] As noted above, the proportion of business-sector employees with post-secondary education consists predominantly of former students at colleges and universities; see further Table B.2 in Appendix B. The assumption that the number entering colleges and universities will stagnate in the period ahead thus accounts for much of the projected fall-off in the proportion of persons employed with post-secondary education in the years ahead.

In the NIER's projections it is assumed that those completing post-secondary studies will have done so by the time they reach 30. The continued increase in the number entering colleges and universities between the mid-1990's and the early 2000's is a factor in the assessment that the proportion of 30-year-olds with post-secondary education will continue to increase, from 40 percent in 2005 to 44 percent in 2012, and to stagnate thereafter (see Diagram 3.8). This does not mean, however, that the

[52] Source: Statistics Sweden and NIER.

[53] In the projections the reference values are allowed to vary with the demographic tendency.

total proportion of employees with post-secondary education will stagnate. The current generation change will be accompanied by a continued rise in the overall proportion of business sector employees with post-secondary education beyond 2012 to 36 percent in 2020 (see Diagram 3.7).

The proportion of employees with post-secondary education varies greatly among population groups of different origin. Persons born in the Nordic countries other than Sweden had the highest proportion in 2005, but natives of Sweden also showed a proportion slightly above average. For persons born in Europe outside the Nordic countries, the proportion was slightly below the average, while for those born outside Europe it was somewhat lower still. These structural differences remain for the most part in the projections, as do origin-related differences in regard to other educational levels.

Postgraduate students are assumed to complete their education by age 35. The number of new post-graduate students has decreased markedly in the latest five-year period, and in 2006 it was on par with the average for the 1990's, i. e. slightly less than 3 000 new students per year.[54] As a result, the previous rise in the proportion of business sector employees with post-graduate education has ceased and is expected to stagnate at around 0.6 percent in the projections (see Diagram 3.7).

All these factors considered, the proportion employed with no more than upper secondary education – calculated as a residual – will show a slight gradual decrease from 55 percent in 2005 to 54 percent in 2020 (see Diagram 3.7).

3.4 Quality-Adjusted Hours

As shown in Section 3.2, hours worked, are quality-adjusted through 2020 by the same method as hours for outcome years 1997–2005 (see Section 2.2.2). The relative wage structure is held constant in the projections. The average relative wage structure for 1997–2005 is used in order to reduce any problems with cyclical variations.

The rapidly rising proportion of employees with post-secondary education means that there will be a gradual shift toward more of them with comparatively higher wages, and thus with higher assumed productivity. It is assumed in the calculations that the rising proportion with higher education will not affect the relative wages of groups with different levels of education. It is thus assumed indirectly that demand for labour with higher education will rise with supply. Nor will relative wages in the projections be affected by changes in the composition of employed groups in respect to age and origin. It is thereby assumed that changes in the composition of labour supply will be met by corresponding changes in demand without requiring changes in relative wages. This is of course a powerful assumption, but as a practical matter, modelling relative wages for all 752 groups in the labour force is hardly realistic or meaningful. The assumption also means that the analysis will be more transparent. As shown in Chapter 2, the change in the structure of wages played only a marginal part in quality adjustment for 1997–2005.

The rising level of education will contribute to a gradual increase in the quality of the labour force during 2006–2020. Diagram 3.9 shows the development of hours worked as calculated in Section 3.2, together with quality-adjusted hours. Actual hours worked will rise sharply in 2006–2010, but decrease beginning in 2012. For 2006–2020 as a whole, they will go up by an annual average of 0.25 percent. Quality-adjusted

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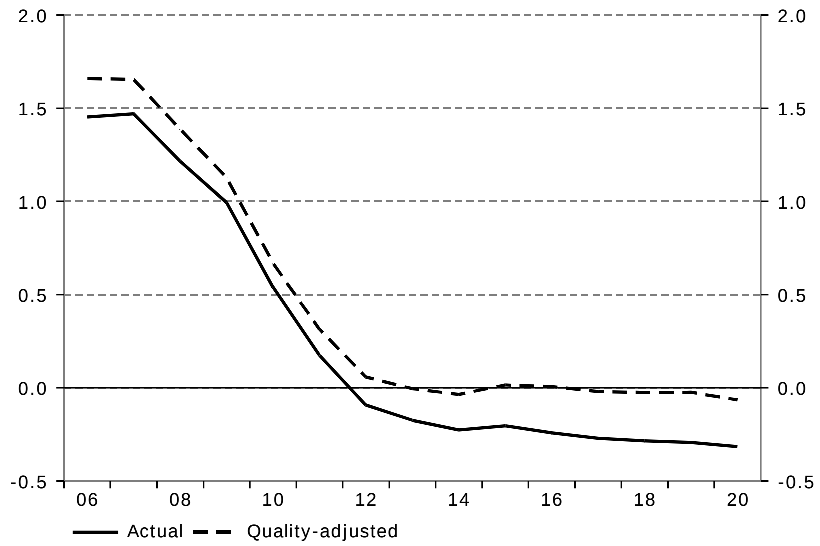
[54] Source: Statistics Sweden.

hours will increase considerably faster, by an annual average of 0.45 percent during the period. In total, quality-adjusted hours will thus increase 0.20 percentage point more rapidly per year, on average, than actual hours worked. The main reason for the faster increase in quality-adjusted hours will be the rapidly rising proportion of employees with higher education. However, quality-adjusted hours will be curbed somewhat by an increase during the period in the proportion of employed persons born outside the Nordic countries, whose average wages, and thus assumed productivity, are relatively low.

Diagram 3.9 Actual and Quality-Adjusted Hours in the Business Sector
Annual percentage change



Source: Statistics Sweden and NIER.

3.5 Projection of Productivity through 2020

3.5.1 ASSUMPTIONS IN THE MODEL

As when growth accounting is used on historical data, the projections are based on a neoclassical growth model with constant returns to scale (see Appendix C for a more detailed description of the model and the assumptions used for the projections). It is assumed in the projections that the production function is of the so-called Cobb-Douglas type. That means, for instance, that the cost of capital for firms is a constant share of value added, i. e. that the profit and labour-cost shares are constant over time. The labour market is assumed to be in cyclical balance, and changes in the supply of quality-adjusted hours will be met simultaneously by a corresponding change in demand. The method for quality adjustment of hours worked (see Section 2.2.2) implies that they are fully substitutable, and the projections are not dependent on which group within the labour force produces the hours.

The development of productivity in each industry is a function of the assumptions made about TFP, capital-cost shares, the development of prices for various investment goods and changes in the quality of the labour force. Different assumptions about TFP and the quality of the labour force affect the development of productivity both directly and indirectly through their impact on capital formation. For the development of productivity in the business sector as a whole, changes in the composition of industries also make a difference.

The projections are based on the assumption that capital-cost shares are in equilibrium. Adjustments in the capital stock are thus assumed to take place immediately. This assumption is not a realistic reflection of the way in which the adjustment actually occurs. Instead, the development shown should be taken as an equilibrium path. The labour force is assumed to be mobile between industries, and prices and labour costs adjust so that the economy is always in equilibrium.

To project productivity growth, various exogenous assumptions and forecasts must be made for a number of variables (see also Appendix C):

- changes in industry composition
- capital-cost shares
- development of the quality of the labour force
- net return required in the respective industries
- development of prices of investment in the different types of capital in each industry
- rate of depreciation for the respective types of capital in each industry
- development of TFP in each industry

In the projections as well, the business sector is divided into four industries (see the description in Appendix B).[55] The relative size of these industries influences the aggregate development of productivity in the business sector as a whole, since both the level of productivity and productivity growth differ from industry to industry. The relative sizes of the industries are shown in Diagrams 3.10 (share of total hours worked in the business sector) and 3.11 (share of value added in the business sector at current prices). Services excl. ICT constitute the largest industry, followed by manufacturing excl. ICT, then the other-goods industry and finally the ICT industry, the smallest of the industries studied; in this regard, it does not matter whether size is measured in terms of value added or hours worked. Between 1993 and 2005, the share of total hours worked increased gradually in the services industry excl. ICT. In the ICT industry the share of hours increased through 2001 and decreased thereafter. In manufacturing excl. ICT and in other goods, the share of hours declined for virtually all of the period 1993–2005.

In the projections through 2020, it is assumed that the present massive surplus in the current account will gradually diminish in the years ahead, primarily through lower saving in the household sector, but also through lower net lending in the general government sector. This change will affect the composition of output in several ways. Consumption includes a relatively larger share of services than do other areas of demand. When the share of consumption goes up, demand for services thus increases relatively more than demand for goods. Moreover, to judge by historical data, consumers are likely to demand relatively more services as their incomes increase. Increased demand for goods will then be met to a greater extent by more imports. Thus, the share of service industries will continue to grow in terms of hours worked as well

[55] Value added in the four industries is aggregated in the prices of the previous year and in current prices. Thereafter, the aggregate is calculated as a chain index with 2004 as the year of reference.

as value added, and it is assumed that by 2020 service industries excl. ICT will make up almost 60 percent of the business sector.

Diagram 3.10 Hours in the Industries of the Business Sector in Proportion to the Business Sector as a Whole

Percent

Sources: Statistics Sweden and NIER.

Diagram 3.11 Value Added in the Industries of the Business Sector in Proportion to the Business Sector as a Whole

Percent

Source: Statistics Sweden and NIER.

In the projections, the profit share, which corresponds to the total capital-cost share for the different types of capital in each industry, is held constant in the respective industry. For the business sector as a whole, the cyclically balanced profit share in 2007 is estimated at about 60 percent.[56] In comparison with the average for the period

[56] See NIER [2007b].

1997–2005, this profit share is somewhat lower. Since the profit share is held constant in each industry, the changed structure of the business sector will mean that the profit share of the sector as a whole will vary over time. The services industry accounts for a growing proportion of the value added in the business sector, and this industry has a higher profit share than the business sector as a whole, since the real-estate industry, which has a large capital stock and very little labour, is part of the services industry. The profit share in the business sector as a whole therefore shows a slight rising trend in the projections, although its average will still be less than the average for the period 1997–2005.

It is assumed in the projections that the composition of the labour force changes in the same way in all industries. Thus, a change in the quality of the labour force affects all industries to the same extent. This statement is obviously a simplification. During the period 1997–2005, the quality of the labour force developed differently in different industries. Part of the reason is probably that cyclical variations affected different industries in different ways during the period.

The three types of capital – i. e. machinery, buildings and ICT capital – differ in regard to productivity. The marginal productivity of a type of capital is assumed to equal its user cost. As described in Section 2.2.3 and Appendix A, user cost, expressed in percent, is determined by three factors: a required return (the interest obtainable on an alternative investment), the depreciation rate of capital and any capital gains/capital losses.

It is assumed in the projections that the required return and depreciation differ among industries in the same way as in 1997–2005. Depreciation is taken to be constant and equal to the historical depreciation for each type of capital and industry (see Section 2.2.3). Since the profit share for the business sector as a whole is assumed to be lower than in 1997–2005 (see above), a somewhat lower, but constant, required return is assumed for each industry.

The prices of investment goods are evolving differently for different types of capital. The price of buildings is increasing more than the price of machinery, which in turn is increasing faster than the price of ICT capital. These differences in the tendency of prices also reflect differences in the development of productivity for the various types of capital. The development of prices applies to a quality-neutral good. If the quality of a good rises over time, its price will go down, all else being equal. In the projections, the development of the prices of capital goods is assumed to be a function of the TFP tendency in the industry that produces the capital good in question. It is assumed in the projections that the benefits of any productivity improvement due to higher TFP will be passed on fully to consumers and investors in the form of lower prices of the goods and services produced by the industry.[57]

The development of prices of the different types of capital in the respective industries is assumed to be constant over time. The assumed development of prices for the various types of capital is shown in Appendix C.

ICT capital is produced in the ICT industries, machinery in the manufacturing industry excluding ICT and buildings in the other goods industries (including the building industry). This assumption is obviously a simplification, but it makes it possible to link the development of TFP to the development of prices of capital goods. If, for

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[57] According to estimates based on Swedish data for the period 1993–2003, an increase of 1 percent in TFP growth results in a price decrease of – 0.675 percent for a good produced in the industry; see Hagén & Skytesvall [2006]. According to estimates based on Canadian data for the period 1961–1995, the corresponding elasticity is – 0.8; see Baldwin, Durand & Hosein [2001]. In the projections in the present study, perfect competition is assumed; as a consequence, elasticity is – 1 for the relative price of the good produced in the industry. The profit share is thereby held unchanged.

example, TFP in the ICT industry increases 1 percent faster, it follows that the price of ICT capital will increase 1 percent more slowly (or decrease 1 percent faster), all else being equal. All industries are thus affected by the changed tendency of TFP in the ICT industry, as the attendant changes in the price of ICT capital will affect investment in all industries. This relationship is also used in the sensitivity calculation with higher TFP growth in the ICT industries, presented in Section 3.6.

As for the period 1997–2005, it is assumed that user cost is highest in percent for ICT capital, followed by machinery and then lowest for buildings; see Table 3.3. The user costs for the different industries are shown in greater detail in Appendix C.

Table 3.3 User Costs in the Business Sector

Percent

	2006–2020
Machinery	23.3
Buildings	10.1
ICT capital	42.0

Source: NIER.

3.5.2 PROJECTIONS OF TFP AT THE INDUSTRY LEVEL

As explained in Chapter 2, the largest contribution to productivity growth in 1997–2005 came from growth in TFP. Productivity increased by an annual average of 3.3 percent in that period, and the contribution of TFP growth averaged 2.0 percentage points per year. TFP growth in the ICT industry contributed more than half of total TFP growth in the business sector, i. e. slightly more than 1 percentage point per year, even though that industry accounted for only about 8 percent of the business sector. TFP growth has averaged a full 13.4 percent per year in the ICT industry, compared to an average of 1.0 percent for the other industries. Thus, the assumptions made about TFP growth in the ICT industry are of central importance to productivity growth in the entire business sector.

TFP growth reflects primarily the pace of technological development. Since technological progress is very difficult to predict, it is hard to know in advance how rapidly TFP will increase in the future. A reasonable starting point for the projections is the historical development in the various industries of one's own country. This is perhaps the most common method in economic literature.[58] If TFP has varied considerably over time, it is necessary to choose the period most relevant for the coming years. One way of illustrating uncertainty is to present different scenarios, based on different historical periods, for example. As international trade, the Internet and other factors are furthering the transfer of technology between countries, the development of TFP in different countries is interrelated. The European Commission (2005) therefore assumes that TFP growth in all EU countries will converge in the long run (by 2050).

In the projections in this study, it is taken as given that TFP in the ICT industry will advance more slowly in the period ahead than in 1997–2005. This assumption is based partly on the assessment by Jorgenson, Ho & Stiroh (2007) for the ICT industry in the US, where TFP is expected to increase by an annual average of 9.5 percent in 2005–2015. This forecast is more than one percentage point below the historical rate of increase in the US for 1995–2005. The method employed by Jorgenson, Ho &

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[58] See Section 3.1.

Stiroh to calculate TFP is relatively similar to the one used in the present study, with quality adjustments of both capital and labour. In the Swedish ICT industry, TFP increased by an annual average of 13.4 percent in 1997–2005. It is assumed in the projections that TFP in the ICT industry will grow by 9.5 percent per year, i. e. the same assumption that was made for the US by Jorgenson, Ho & Stiroh. This means that TFP growth in the Swedish ICT industry will be almost 30 percent lower in the projections.

The Swedish manufacturing industry excluding ICT is also considered to have had temporarily high productivity growth in 1997–2005. That period was characterized partly by the after-effects of the crisis in the early 1990's, when numerous firms were forced out of business and many employees lost their jobs. The period was also one of intensified internationalization as Sweden joined the EU. Trade with other countries expanded vigorously during these years. For this industry, too, it is assumed that the level of TFP growth will drop by nearly 30 percent, from an annual average of 2.8 percent in 1997–2005 to 2.0 percent per year in the projections.

In the other-goods industry and the services industry excluding ICT, TFP is assumed to increase at the same rate as in 1997–2005. TFP has grown much more modestly in these industries. Conceivably, of course, the indirect effects of increased ICT use have been very slow in coming, and in the years ahead organizational changes and other factors can boost TFP growth, particularly in the services industry excluding ICT. All aspects considered, TFP in the business sector as a whole is projected to increase by 1.6 percent per year; see Table 3.4.

Table 3.4 Assumptions about TFP

Average annual percentage change

	1997–2005	2006–2020
ICT industry	13.4	9.5
Manufacturing industry excl. ICT	2.8	2.0
Other-goods industry	0.5	0.5
Services industry excl. ICT	0.4	0.4
Business sector	2.0	1.6

Note: Development of TFP in the business sector is a consequence of assumptions about industries.

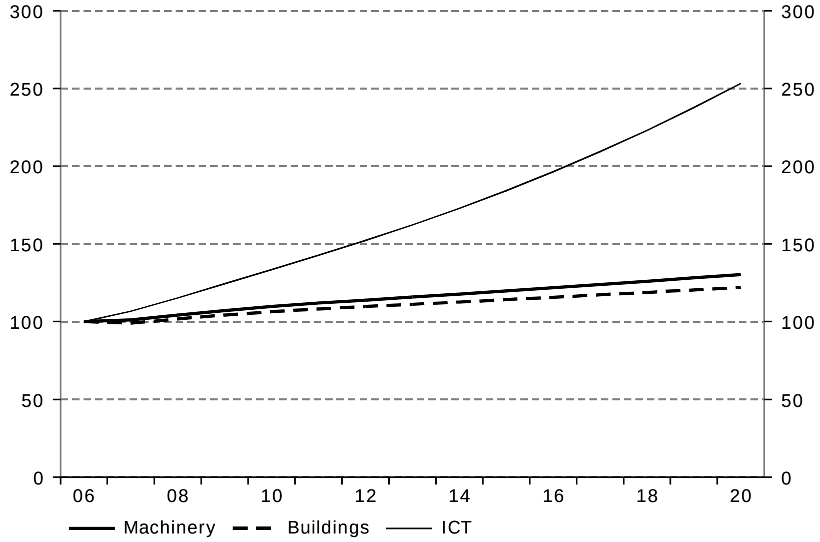
Source: NIER.

3.5.3 CAPITAL SERVICES

The assumptions about the development of TFP, capital-cost shares and the price tendency for the various investment goods determine how much capital of each type per quality-adjusted hour is optimal to use in production in the different industries. Differences in the marginal productivity of the various types of capital, as reflected in differences in user cost as a percentage, affect the composition of the different types of capital used in production. If price relationships among different types of capital change over time, i. e. if the rates of price increase differ, as they do in the projections, user cost will change in monetary terms (although it will be constant as a percentage). Assuming a constant capital share of value added in current prices, such a change in relative prices will affect the composition of the capital stock and thus productivity growth as well.

Since the prices of ICT capital are assumed to decrease, unlike prices of other investment items, the stock of ICT capital (by volume) will grow faster than the capital stock in buildings and machinery (see Diagram 3.12).

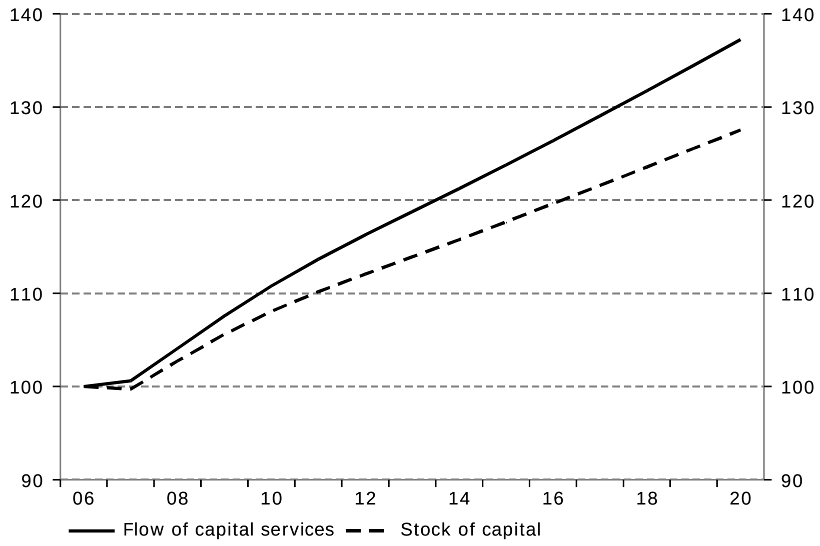
Diagram 3.12 Capital Stocks in the Business Sector
Index 2006 = 100



Source: NIER.

Since ICT capital has a higher user cost in percent than machinery and buildings, the flow of capital services for the business sector as a whole will grow faster than the capital stock (see Diagram 3.13). This will provide a positive contribution to productivity growth.

Diagram 3.13 Flow of Capital Services and Capital Stocks in the Business Sector
Index 2006 = 100

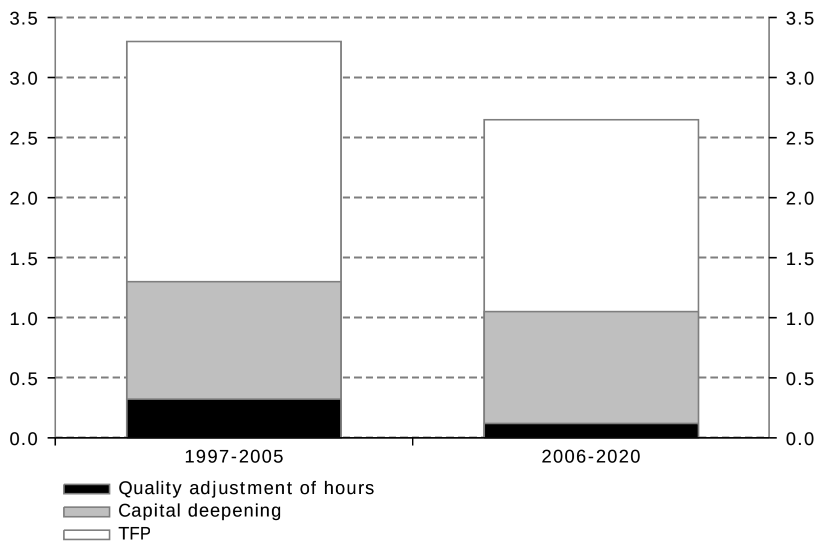


Source: NIER.

3.5.4 GROWTH IN PRODUCTIVITY AND VALUE ADDED

Productivity growth in the business sector as a whole is determined by the tendency in its constituent industries and by changes in the composition of industries. In comparisons between projections and the historical development, it is important to remember that the projections refer to cyclically balanced development, whereas in the period from 1997 through 2005, the actual development is concerned.

Diagram 3.14 Contribution to Productivity in the Business Sector
Percentage points



Source: Statistics Sweden and NIER.

With the assumptions described above and the development of quality-adjusted hours, business sector productivity will increase by an annual average of 2.7 percent in 2006–2020 (see Table 3.5 and Diagram 3.14). This more gradual growth compared to the period 1997–2005 is due primarily to the assumption of slower TFP growth, but in addition, the contribution from quality-adjusted hours is appreciably less in the projections. On the other hand, capital deepening contributes to roughly the same extent. The contribution of capital deepening can be divided into more capital (i. e. growth in the capital stock) and better capital (i. e. a change in the composition of the capital stock toward relatively more productive capital). In comparison to the period 1997–2005, even more capital, rather than improved capital (a change in composition), accounts for the capital deepening in the projections. One reason for the lesser contribution from improved quality of capital is that the user cost of ICT capital and machinery is lower in the projections. The reason is that the productivity of these types of capital does not increase as rapidly in the projections as it did during the period 1997–2005. As for the larger contribution from more capital, the explanation is that the projections for 2006–2020 apply to a cyclically balanced tendency, and that firms are assumed to optimize their capital stocks in each period. As a result, the capital stock will grow more rapidly than it did in 1997–2005.

Table 3.5 Value Added, Hours Worked and Labour Productivity in the Business Sector

Average annual percentage change and percentage points, respectively

	1997–2005	2006–2020
Value added	3.78	2.91
Hours worked	0.47	0.25
Labour productivity	3.32	2.66
Contribution from		
Quality adjustment of hours	0.32	0.12
Capital deepening	0.98	0.93
More capital	0.62	0.73
Better capital	0.36	0.19
TFP	2.00	1.60
ICT industry	1.04	0.86
Other industries	0.96	0.73

Sources: Statistics Sweden and NIER.

Table 3.6 and in Diagram 3.15 show the development in the various industries. Productivity increases fastest in the ICT industry because of the higher TFP growth in this industry. The contribution from improved quality of the labour force is about the same in all industries; the differences are due solely to the varied weights assigned to the labour force in the respective industries. The contribution of capital deepening is greatest in the ICT industry and least in the other-goods industry. For all industries, “more” capital provides a considerably larger contribution than “better” capital.

Table 3.6 Value Added, Hours Worked and Labour Productivity in the Industries of the Business Sector, 2006–2020

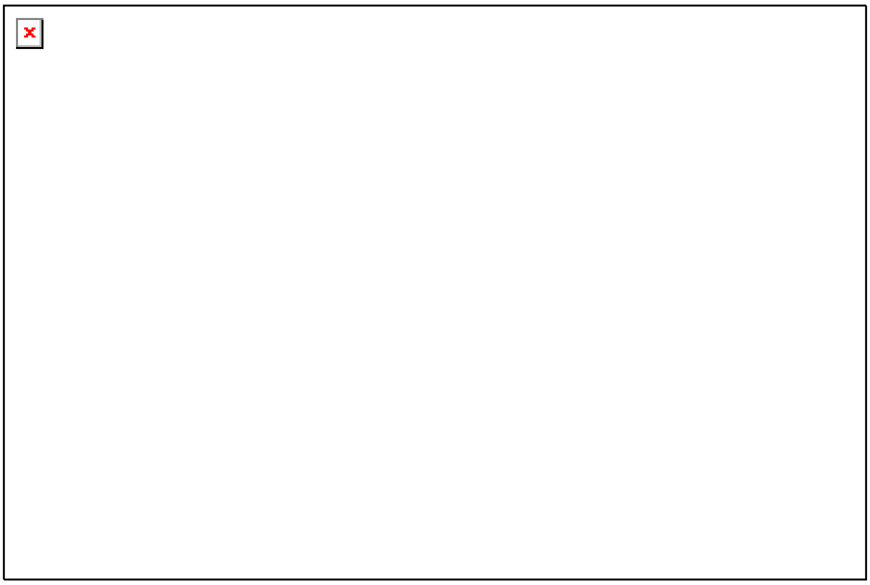
Average annual percentage change and percentage points, respectively

	ICT	Manufacturing excl. ICT	Other	Services excl. ICT	ICT
Value added	11.19	2.98	1.24	1.92	2.91
Hours worked	0.15	–0.05	–0.05	0.45	0.25
Labour productivity	11.05	3.04	1.29	1.47	2.66
Contribution from					
Quality adjustment of hours	0.13	0.13	0.11	0.11	0.12
Capital deepening	1.42	0.89	0.72	0.93	0.93
More capital	0.99	0.83	0.62	0.72	0.73
Better capital	0.43	0.06	0.10	0.21	0.19
TFP	9.5	2.0	0.5	0.4	1.6

Source: NIER.

Diagram 3.15 Contribution to Productivity Growth, 2006–2020

Percentage points



Note: Other goods = Other goods industries excl. ICT
Source: NIER.

As described above, it is assumed in the projections that the services industry excluding ICT will account for a growing share of the business sector, in respect to hours worked as well as value added; one reason will be a gradually decreasing surplus in the balance of trade. The lower productivity growth in this industry, compared with the average for other industries, means that productivity growth in the sector will be less than in a situation where the structure of the business sector remained unchanged. With no change in structure, total hours worked would have developed in the same way, but value added would have been higher. Such a scenario would be consistent, for example, with a persistently large surplus in the balance of trade, and thus with continued high net lending.

One reason for the higher productivity growth in the Swedish business sector compared, for example, to the assessment for the US, is that medical care, schools and nursing and other care – i. e. industries with low productivity growth – belong to the business sector to a greater extent in the US than in Sweden. Another explanation is that the ICT industry constitutes a larger part of the business sector in Sweden. In the projections by Jorgenson, Ho & Stiroh (2007), it is assumed that the ICT industry makes up about 5 percent of the business sector in the US. In the present study it is assumed that the ICT industry will account for roughly 9 percent of value added in the business sector during 2006–2020.[59]

3.6 Sensitivity Analysis – Alternative Paths of Development for TFP

As a sensitivity analysis, a calculation is presented here for an alternative development of TFP in the ICT industry. In the following, it is assumed that annual TFP growth in this industry will be 12.5 percent instead of 9.5 percent as in the Base Scenario. This means that the extremely high TFP growth in the period 1997–2005 continues virtually unabated. Since ICT capital is assumed to be produced in this industry, and since more rapid technological development is assumed to benefit consumers and investors through lower prices of ICT capital, other industries will also be affected.

In the sensitivity analysis, the relative price of ICT capital, i. e. the price of ICT capital in relation to the price of other types of capital, decreases 3 percentage points faster per year in all industries. The development of the relative price of ICT capital thus changes in the calculation to the same degree as TFP growth in the ICT industry. The faster decrease in the relative price of ICT capital means that firms in all industries will invest in more ICT capital.

Table 3.7 shows the development for the business sector as a whole. As expected, productivity growth will now be higher and more in line with the tendency in 1997–2005. The greatest change will be due to a higher contribution from capital deepening through both more and better capital. But as the change in TFP growth does not affect the composition of the labour force, the contribution from improved quality of the labour force is the same as in the Base Scenario.

Table 3.7 Value Added, Hours Worked and Labour Productivity in the Business Sector, 2006–2020

Average annual percentage change and percentage points, respectively

	Base Scenario	Higher TFP growth in ICT industry
Value added	2.91	3.60
Hours worked	0.25	0.25
Labour productivity	2.66	3.34
Contribution from		
Quality adjustment of hours	0.12	0.12
Capital deepening	0.93	1.34
More capital	0.73	1.02
Better capital	0.19	0.31
TFP	1.60	1.87
ICT industry	0.86	1.12
Other industries	0.73	0.73

Source: Statistics Sweden and NIER.

[59] In addition, the larger ICT share in Sweden is partly a consequence of differences in accounting for general government output.

Table 3.8 shows the differences between the Base Scenario and the sensitivity analysis at the industry level. The difference is greatest, of course, in the ICT industry, where TFP is growing faster and capital deepening is considerably greater. But productivity growth is going up in the other industries as well. Here, however, the only reason is that capital deepening increases with the more rapidly falling relative price of ICT capital.

Table 3.8 Industries in the Business Sector, 2006–2020, Difference between Base Scenario and the Alternative of Higher TFP Growth in the ICT Industry

Percentage points

	ICT	Manufac-turing excl. ICT	Other goods	Services excl. ICT
Labour productivity	3.81	0.38	0.30	0.40
Quality adjustment of hours	0.00	0.00	0.00	0.00
Capital deepening	0.81	0.38	0.30	0.41
More capital	0.57	0.28	0.28	0.29
Better capital	0.24	0.09	0.02	0.11
TFP	3.00	0.00	0.00	0.00

Source: NIER.

4 Alternative Scenarios

In the Base Scenario, which is described in Chapter 3, the trend rate of productivity growth in the business sector during 2006–2020 is an average of 2.7 percent per year. Hours worked in the business sector show a modest increase, and the trend rate of annual growth in value added in the business sector averages 2.9 percent per year. The principal explanation for this tendency is rapid growth in TFP, but there is also a contribution from quality adjustment of hours worked, though less of one than in 1997–2005. Thus, in the Base Scenario quality-adjusted hours increase somewhat faster than actual hours worked. This is primarily a consequence of the continued rise in the average level of education, even if the increase is slower than before. In the projections, the differences in employment rate among the various population groups are assumed to remain at their cyclically balanced level of 2006. It is also taken as given that the relative differences in wages among different groups in the labour force, and thus the assumed differences in their productivity, will persist.

The assumptions are of course uncertain. For example, demand for personnel with post-secondary education may grow more rapidly than supply in the Base Scenario, and more people may therefore continue their education. Moreover, the Base Scenario can be interpreted to mean that integration of the foreign-born on the labour market will not improve. That assumption may be overly pessimistic. It is conceivable, for example, that changed behaviour of employers, as well as political measures, can promote integration of the foreign-born on the labour market, partly through a rising employment rate, and partly through reduced differences in wages and thus in assumed differences in productivity, compared to natives of Sweden.

A first alternative scenario analyzes the consequences when more people receive post-secondary education. A second scenario analyzes the effects of gradually improved integration on the labour market of persons born outside the Nordic countries.

The scenarios do not show which factors may underlie the alternative development, for example in terms of political reforms or changed behaviour of the players in the economy. The scenarios are therefore best considered as describing the consequences for developments under alternative assumptions for certain variables. The analysis is limited to the effects on productivity, hours worked and value added in the business sector.

In the general government sector, the number of hours worked and quality-adjusted hours are assumed to be the same in the alternative scenarios as in the Base Scenario. This means that the change in number of hours worked in the alternative scenarios, and the quality adjustment of these hours, are fully reflected in the business sector. No analysis is made of the implications for public finances, such as those related to the costs of increasing enrolment capacity in education and of additional financial assistance to students in the Education Scenario, or those entailed by reducing transfer payments in the Integration Scenario, for example.

4.1 Education Scenario

The Base Scenario rests on the assumption that the number of persons who enter post-secondary education varies, depending on demography, around the cyclically balanced level for 2006 (see Section 3.3). The rising trend of recent decades in the number receiving post-secondary education thus comes to a halt. Nevertheless, the proportion of employees with post-secondary education is continuing to increase as the younger people joining the labour force have achieved this level of education to a considerably greater extent than the older people leaving the labour force.

In the Education Scenario it is assumed that a number of business-sector employees are enrolled for a time in post-secondary education instead of working, and thereafter return to employment in the business sector. With more people studying, the number of hours worked is less in the Education Scenario than in the Base Scenario. As shown in Chapter 2, a higher level of education goes hand in hand with higher wages, a statement interpreted to mean that productivity increases with a rising level of education. Thus, the contribution of quality adjustment to the number of quality-adjusted hours is higher in the Education Scenario than in the Base Scenario.

In the Education Scenario it is assumed that the number of persons receiving post-secondary education can be increased without impacting the productivity-enhancing effect of education. It is also assumed that the gradually growing supply of labour with post-secondary education in itself will generate a corresponding increase in demand, and that the changed composition of the labour force will not influence the development of TFP. In addition, it is implicitly assumed that equilibrium unemployment, or the unemployment prevailing when the economy is in cyclical balance, is not affected when more people are receiving post-secondary education. The scenario presented should be considered in light of these assumptions.

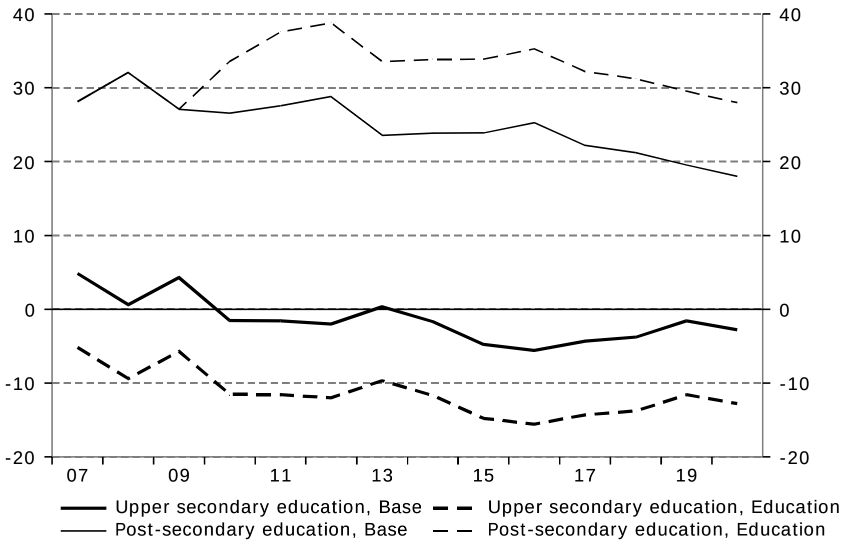
The starting point is that the number entering post-secondary education will be 10 000 larger each year than in the Base Scenario, beginning with 2007.[60] The additional students are assumed to belong to age group 19–27. All are assumed to enrol in education after employment in the business sector. In the Education Scenario, there is a decrease in the number of hours worked corresponding to the increase in number of students. The average duration of study is assumed to be 3.3 years, on par with the actual average time spent in post-secondary education by 30-year-olds in 2005; see Appendix B. After completing their studies, all are assumed to return to work in the business sector.

The proportion of employees with post-secondary education rises faster in the Education Scenario than in the Base Scenario, exceeding 38 percent by 2020, compared to 36 percent in the Base Scenario. This means in turn that the number of employed persons with no more than upper secondary education is correspondingly lower than in the Base Scenario.

Diagram 4.1 shows the net inflow of employees with upper secondary education and with post-secondary education, respectively, as their highest achieved level of education in the Base Scenario and in the Education Scenario.

[60] In the projections, the additional number enrolled in post-secondary education in the Education Scenario is not allowed to vary with demography.

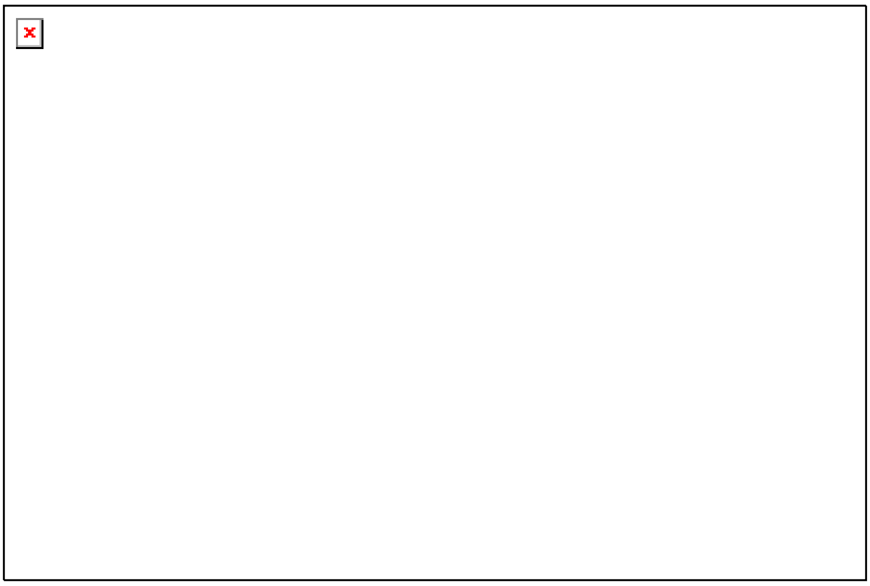
Diagram 4.1 Net Inflow of Employees with Upper Secondary and Post-Secondary Education, Respectively
Thousands of persons



Note: Base = Base Scenario, Education = Education Scenario
Source: Statistics Sweden and NIER.

In the Base Scenario the number of employees with post-secondary education as their highest level achieved increases by 20 000 persons to 30 000 per year during 2007–2020, as older, relatively less well-educated labour is replaced by younger, relatively better-educated labour. The number of employees with upper secondary education increases somewhat in the Base Scenario in 2007–2009, but declines thereafter. In the Education Scenario the number of employees with upper secondary education decreases faster. From 2007 on, the net inflow of employees with upper secondary education is 10 000 lower per year than in the Base Scenario, since more apply for admission to post-secondary education. With the average duration of studies assumed to be 3.3 years, the number with post-secondary education will not begin rising until 2010 in the Education Scenario. Beginning in 2011 the annual net inflow of employees with post-secondary education will be 10 000 higher than in the Base Scenario.

Diagram 4.2 Hours Worked and Quality-Adjusted Hours
Millions of hours



Note: Base = Base Scenario, Education = Education Scenario
Source: Statistics Sweden and NIER.

In the Education Scenario the number of hours worked shows a weaker tendency than in the Base Scenario (see Diagram 4.2). The difference is due to the increased inflow into post-secondary education. But beginning in 2010, the added inflow of persons with post-secondary education means that quality adjustment of hours worked will be greater than in the Base Scenario. The effect of quality adjustment will be gradual, and the decrease in number of hours worked will be the predominant tendency for the entire period up to 2020. This means that quality-adjusted hours in the Education Scenario do not reach the level of the Base Scenario until that year. Diagram 4.3 summarizes the effects of the Education Scenario on productivity and value added in the business sector. Labour productivity rises gradually, and in 2020 it is 0.6 percent higher in the Education Scenario than in the Base Scenario.[61] The higher productivity is partly a direct effect of a better-educated labour force, and partly due to the fact that the higher level of education contributes to greater capital deepening; i. e. the quantity of capital services per hour worked increases. Nevertheless, value added in the business sector is no higher in the Education Scenario than in the Base Scenario in 2020. The explanation is that the improving quality of the labour force is offset by the decrease in the number of hours worked.[62] If the time frame is extended beyond 2020, however, value added will be higher in the Education Scenario. This scenario indicates that it takes a fairly long time before the higher level of education becomes an advantage when considered strictly from the perspective of the economy, as value added in the business sector is no greater in the Education Scenario until after 2020. Also, increased investment in education will entail higher costs in the general government sector related to increasing enrolment capacity in education and student financial

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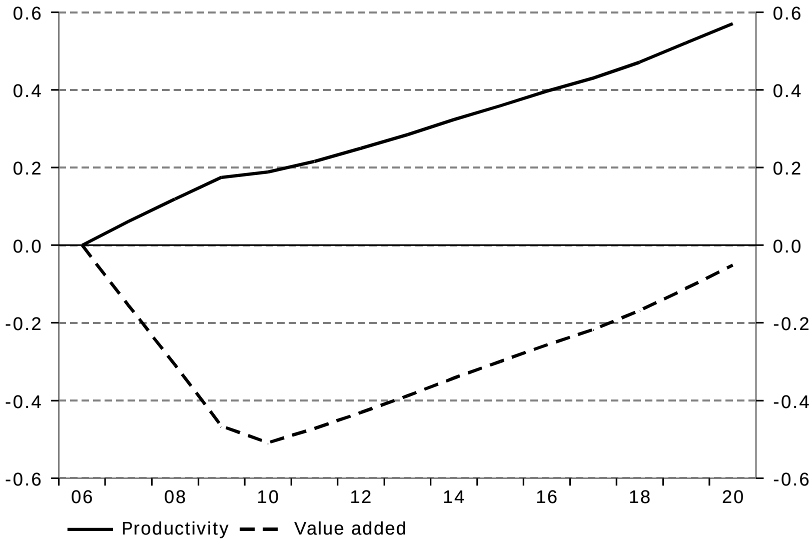
[61] The reason why labour productivity is higher in the Education Scenario as early as 2007 is that the composition of the group of employed persons changes when more young people with relatively low productivity seek enrolment in education instead of working.

[62] No consideration is given in the calculations to the additional hours worked in the education system resulting from the increase in education.

aid. But since the general government sector is not analyzed in this study, the public-finance aspects of the scenario are not treated either.

Diagram 4.3 Productivity and Value Added in the Education Scenario
Deviation from level of Base Scenario, in percent



Source: Statistics Sweden and NIER.

The result above reflects the return on increased education viewed strictly from a general economic perspective for the period 2007–2020. A single individual might adopt a longer-term perspective right from the start. For the individual, the return on education can be measured in various ways. As shown in Table 2.1 (see Section 2.2.2), the wage for someone with post-secondary education average between 25 and 40 percent higher than for someone else of the same age and origin but with only upper secondary education. The extent of the difference depends on a number of factors, one of which is the individual's origin. The difference is greatest for natives of Sweden and least for persons born outside Europe. A native of Sweden with post-secondary education and full-time employment can expect total career earnings some 30 percent higher, on average, than a person with only upper secondary education, on the assumptions that studies require 3.3 years between the ages of 20 and 24 and that the individual works until age 65.[63]

A more precise way to analyze the return on education is to calculate the discount rate that yields the same present value of future earnings in the two alternatives. For a native of Sweden who receives post-secondary education for 3.3 years between the ages of 20 and 24 and thereafter works full time until age 65, this discount rate is calculated to average 8.3 percent, according to the data used in the present study. This can be taken to mean that the return on education, in terms of higher future earnings, from foregoing earned income during the period of studies is equivalent to 8.3 percent interest in real terms. That rate may be compared with an expected real yield of about 3 percent on a bond, an approximate reflection of the return obtainable on saved earnings. The difference of some 5 percentage points can thus be regarded as the premium received for post-secondary study. For natives of Nordic countries other

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[63] Earnings at their level in 2005. In the calculations, consideration is not given to student revenue during the period of study, in the form of wages or student financial aid.

than Sweden, the estimated education premium is the same as for persons born in Sweden, whereas it is about 1.5 percentage points less for persons born in Europe excluding the Nordic countries, and almost 3 percentage points less for individuals born outside Europe. These findings are fairly consistent with those reported in other studies.[64] From the financial perspective of the individual, it would therefore appear advantageous to obtain post-secondary education.[65]

It is important to emphasize that the Education Scenario rests on several critical assumptions. In the Education Scenario it is assumed that the number receiving post-secondary education can be increased with no repercussions on the productivity-enhancing effect of education. This is not necessarily the case if the additional students are less well-prepared in a number of ways to complete their education successfully. Implicitly, it is also assumed that equilibrium unemployment, or the unemployment prevailing when the economy is in cyclical balance, is unaffected when more people receive post-secondary education. In reality, this may not be the case, and one cannot rule out the possibility that expansion of post-secondary education may be accompanied by somewhat lower equilibrium unemployment, particularly if the investment is education is focused on occupations where there are shortages of qualified personnel.

Moreover, it is assumed in the Education Scenario that the increased supply of labour with post-secondary education in itself will generate a corresponding increase in demand. If this does not happen, the change in the composition of the labour force may affect the complementarity of various groups of labour and thus the development of productivity (TFP). Consequently, it may be most appropriate to regard the dimensioning of the education system as a variable to be adjusted according to demand for labour with various kinds of education. Otherwise, shortages could be created or aggravated. There is also a risk of over-education, where a portion of the labour force may have the wrong skills or be overqualified for their work, thus affecting productivity. Furthermore, the development of TFP in the Education Scenario may be affected if higher demand for labour with post-secondary education is partly driven by increased efforts in research and development, to the extent that the latter give rise to so-called endogenous growth effects (see Box 1). However, it is assumed in the Education Scenario that TFP develops in the same way as in the Base Scenario.

The reported consequences when more persons receive post-secondary education should be interpreted with these aspects in mind. In qualitative terms, though, the findings are clear: with an increased proportion receiving higher education, productivity will be higher, whereas the number of hours worked will be lower. The quantitative implications for value added in the business sector are less certain. The results suggest that value added there will be slightly lower in the Base Scenario for the entire period through 2020, but that if the time frame were extended beyond that year, value added would be higher in the Education Scenario than in the Base Scenario.

4.2 Integration Scenario

The Base Scenario rests on the assumption that differences in the employment rate among various population groups remain at their cyclically balanced levels for 2006.

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[64] See, for example, Björklund, A. et al. [2006].

[65] Of course, there are a number of other aspects to consider in a thorough analysis of the financial return on education, such as the system of student financial aid and the design of the tax system, as well as the risk of unemployment.

This means, for example, that the employment rate for persons born abroad will continue to be relatively low in the projections. For persons born outside the Nordic countries, the employment rate is some 17 percent lower than for natives of Sweden.[66] Moreover, it is assumed in the Base Scenario that differences in wages between individuals of different origins with the same level of education and of the same age will persist in the years ahead. As shown in Section 2.2.2 and Appendix B, the foreign-born earn less on average than their Swedish-born contemporaries with the same level of education. This fact may be explainable by differences in productivity for various reasons, but also by wage discrimination (see Section 2.2.2 for a discussion). In this study, it is difficult to determine and analyze the extent to which differences in wages are due to discrimination or to actual differences in productivity. Here, differences in wages are assumed to reflect differences in productivity.

The Base Scenario can be interpreted to mean that integration of the foreign-born on the labour market will not improve in the years ahead. Such an assumption may be overly pessimistic. The Swedish labour market has been cyclically weak for most of the time since the severe financial crisis in the early 1990's. In the NIER's analysis, resource utilization on the labour market was below normal throughout 1993–2006 except around the outset of the new millennium and for about a year thereafter. A cyclically weak labour market affects all parts of the labour force, but as argued in Box 4, people born abroad are usually hit harder than those born in Sweden. In the Base Scenario it is assumed that there is cyclical balance on the labour market, and the cyclical effects of the slightly soft labour market in 2006 are considered in the projections. It is possible, however, that the protracted period of a cyclically weak labour market has also had lasting negative effects on employment for the foreign-born, particularly among the groups who find it most difficult to enter the labour market. Conceivably, therefore, the more favourable tendency of the labour market, by historical standards, in the projections would mean that more of the foreign-born gradually enter the labour market and that the employment rate would therefore rise for these groups. Such a development could be furthered by changes in employer attitudes, for example, and by political measures designed to improve integration.

The integration scenario analyzes the effects on productivity growth and growth in value added that result from gradually improved integration on the labour market of persons born outside the Nordic countries. This population group is the one with the lowest employment rate and the lowest wages, on average, even when differences in age and education level are taken into account. In the Integration Scenario it is assumed that the employment rate for persons born outside the Nordic countries successively rises so that the difference in relation to natives of Sweden with the same education and of the same age is cut in half by 2020. For persons born in Sweden, the employment rate was about 78 percent in 2006 (see Diagram 4.4). For persons born outside Europe, it was 57 percent in 2006, while the corresponding figure for persons born in Europe outside the Nordic countries was 66 percent. In the Base Scenario these employment rates are more or less constant. In the Integration Scenario the employment rates gradually rise for persons born outside the Nordic countries until 2020, to 69 percent for those born outside Europe and to 73 percent for those born in Europe outside the Nordic countries.

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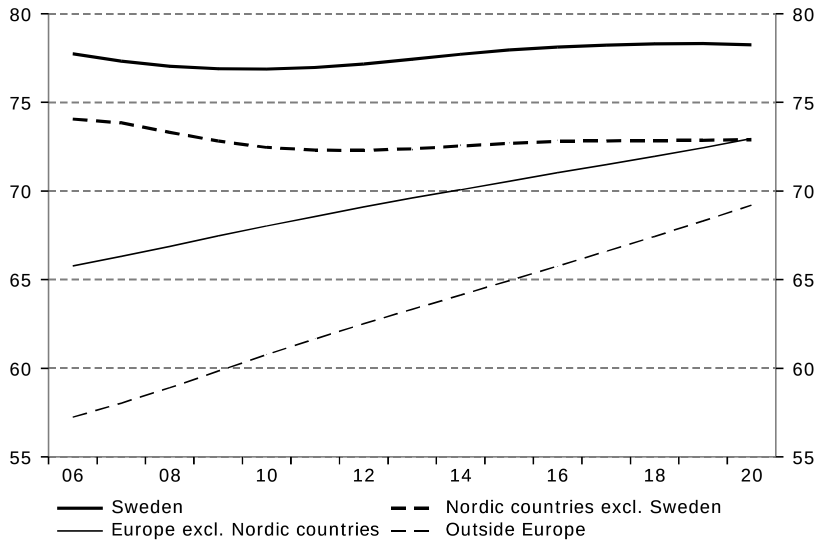
[66] Source: NIER.

Diagram 4.4 Employment Rates in the Integration Scenario
Percent of population aged 18–64 in the respective groups

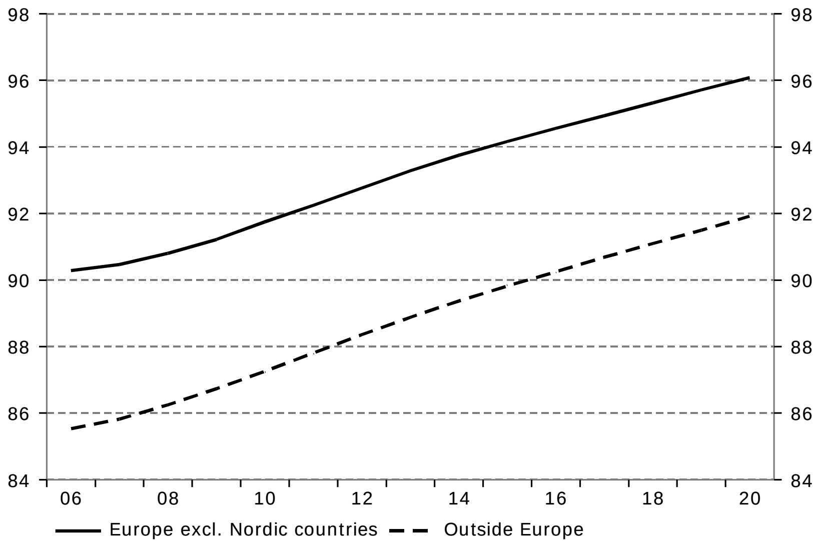


Source: Statistics Sweden and NIER.

In addition, it is assumed in the Integration Scenario that the wage gap between persons born outside the Nordic countries and those born in Sweden will be reduced by half for employees with the same level of education and of the same age. In addition, since it is assumed that differences in wages are not due to discrimination, the difference in productivity between persons born outside the Nordic countries and those born in Sweden, of equal education level and age, will be halved by 2020. The narrowing of this productivity gap may be due in part to improved integration and its contribution to a tendency where the foreign-born gradually acquire more relevant work experience and to a greater degree obtain work that matches their competence.

Diagram 4.5 shows how relative wages, and thus assumed relative productivity, develop for the various groups of origin until 2020.

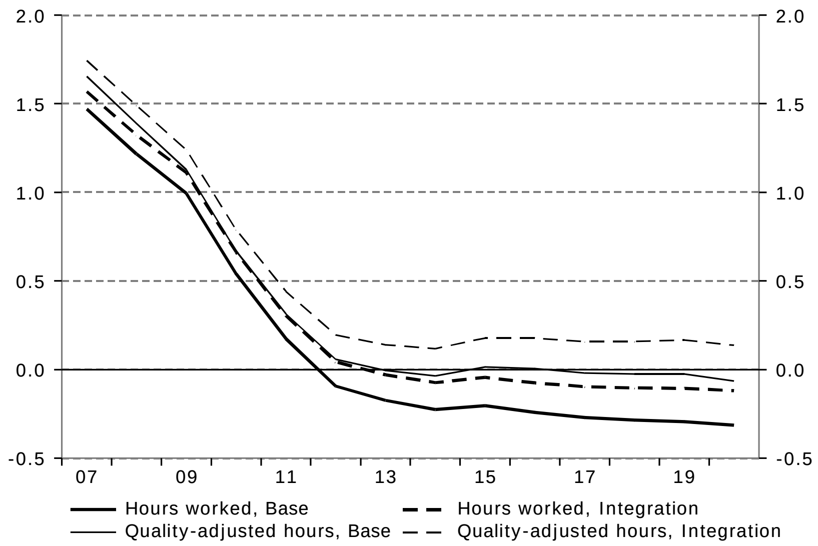
Diagram 4.5 Relative Wages in the Integration Scenario
Wages in relation to wages for natives of Sweden, percent



Source: Statistics Sweden and NIER.

The Integration Scenario is obviously a very favourable one for the development of the general economy.[67] As shown in Diagram 4.6, the tendency of hours worked is much stronger in the Integration Scenario, and by 2020 hours worked are 2.1 percent higher than in the Base Scenario.

Diagram 4.6 Hours Worked and Quality-Adjusted Hours
Annual percentage change



Note: Base = Base Scenario, Integration = Integration Scenario
Source: Statistics Sweden and NIER.

Partly because of the faster increase in hours worked, the growth of value added in the business sector is higher in the Integration Scenario. But growth is affected not only

[67] In addition to the effects shown on value added in the business sector, the finances of the general government sector are naturally influenced in the Integration Scenario, one reason being a reduction in transfer payments. However, the finances of the general government sector are not analyzed in this study.

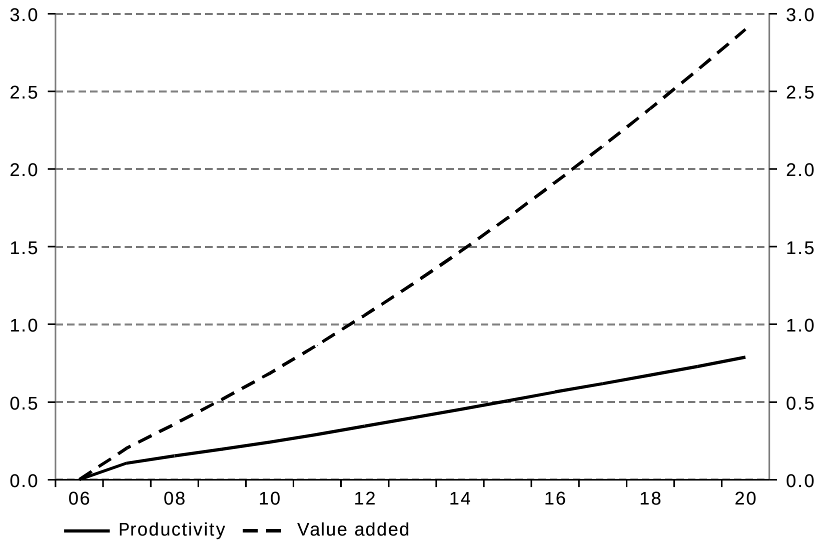
by more rapidly rising hours worked, but also by a different development of productivity.

In this regard there are two opposing forces: On the one hand, with a rising employment rate for persons born outside the Nordic countries, this group will account for a gradually increasing share of total hours worked. Since persons born outside the Nordic countries have lower wages, on average, and thus lower assumed productivity, than the average for all persons employed, this change in composition will tend to limit productivity growth. On the other hand, the wages of employees born outside the Nordic region, and thus their assumed productivity, will gradually approach the levels for employees born in Sweden. This will have a positive impact on productivity growth.

Improved integration will affect calculated productivity through two channels: Rising wages and a rising employment rate for persons born outside the Nordic countries will mean that the composition of the labour force changes, as do total wage income for the various groups of labour and thus their assigned weights in the quality adjustment of hours worked (see Chapter 2 and Appendix A). However, the quality adjustment of hours worked will be roughly the same as in the Base Scenario (see Table 4.1). But quality adjustment does not capture the direct effect on the level of productivity due to gradually rising wages, and thus rising productivity, for persons born outside the Nordic countries. The explanation is that improved integration, with attendant higher wages, is not a dimension of quality adjustment itself. Rather, this effect is reflected in the faster growth of TFP in the Integration Scenario than in the Base Scenario; see Table 4.1. All factors considered, productivity in 2020 is 0.8 percent higher in the Integration Scenario than in the Base Scenario.

Diagram 4.7 shows the aggregate effects on the development of productivity and value added in the business sector. With higher productivity and more hours worked, value added in 2020 is 2.9 percent greater in the Integration Scenario than in the Base Scenario. It is important to note that the Integration Scenario, too, rests on a number of critical assumptions. One of these is that differences in wages between the foreign-born and natives of Sweden of the same age and with the same level of education reflect differences in productivity. If the differences in wages were due to wage discrimination, the positive effects on productivity in the Integration Scenario would naturally be less. And if the entire difference in wages were attributable to wage discrimination, improved integration would have no direct effect at all on productivity. But productivity can be affected indirectly if the composition of the labour force in terms of age and education level changes because of improved integration. Such effects, however, are probably fairly minor in this context. As in the Education Scenario, it is also assumed that the changed composition of the labour force does not affect how well different groups of labour complement each other; thus, it has no impact on productivity (TFP), either.

Diagram 4.7 Productivity and Value Added in the Integration Scenario
Deviation from Base Scenario, percent



Source: Statistics Sweden and NIER.

Thus, improved integration of the foreign-born on the labour market may have potentially substantial effects on value added. In the Integration Scenario it is assumed that differences in employment rate and wages between natives of Sweden and persons born outside the Nordic countries, with the same education level and of the same age, will be halved by 2020. There is thus room for further improvement in integration, with attendant positive effects on productivity and value added.

4.3 Overall Analysis – Alternative Scenarios

Table 4.1 Value Added, Hours Worked and Labour Productivity in the Business Sector
Average annual percentage change and percentage points, respectively

	Outcome 1997–2005	Base Scenario 2006–2020	Education Scenario 2006–2020	Integration Scenario 2006–2020
Value added	3.78	2.91	2.91	3.10
Hours worked	0.47	0.25	0.21	0.39
Labour productivity	3.32	2.66	2.70	2.71
Contribution from				
Quality adjustment of hours	0.32	0.12	0.14	0.12
Capital deepening	0.98	0.93	0.94	0.95
TFP	2.00	1.60	1.60	1.63

Source: NIER.

Table 4.1 compares the development in the Base Scenario with the two alternative scenarios. For the period 2006–2020, the Integration Scenario shows the fastest increase in value added. The reason is primarily that with improved integration, hours worked go up more rapidly than in the other scenarios, particularly when compared to the Education Scenario. In general, the differences among the scenarios may appear rather minor if presented as comparative annual growth rates. But as noted above, the aggregate effect over the period is considerable. In 2020, for example, value added in the business sector was some 2.9 percent higher in the Integration Scenario than in either the Base Scenario or the Education Scenario. The corresponding figures for the number of hours worked are 2.1 and 2.7 percent, respectively.

Productivity in the Integration Scenario rises faster than in the Base Scenario, and marginally faster than in the Education Scenario. At first glance, this difference may seem surprising. Underlying the result, of course, is the assumption that improved labour market integration of persons born outside the Nordic countries will go hand in with a gradual increase in their wages, and thus their assumed productivity, toward the levels of wages and productivity of their Swedish-born contemporaries with the same level of educational attainment.

In summary, it may be stated that the development of productivity differs relatively little among the three scenarios. But the differences in hours worked are much more substantial. In the Integration Scenario, hours worked rise faster when improved labour market integration of persons born outside the Nordic countries boosts their employment rate, whereas hours worked show a weaker tendency in the Education Scenario as more people study while fewer work. The effects on total hours worked are thus the principal source of the differences between the scenarios in regard to the development of value added in the business sector.

5 Conclusions

After a lacklustre tendency in the 1980's, productivity growth in the Swedish business sector accelerated in the 1990's. The upswing is explainable partly by the development of the economy, but primarily by an upward shift in the trend rate of productivity growth. To some extent, the rising trend reflected the rapid elimination of low-productivity firms after the severe financial crisis of the early 1990's, though it was also due to deregulation of various domestic markets. However, the principal underlying cause of the high growth trend of the past 10 years has been extremely rapid technological development, particularly in the ICT industry. The fast pace of development has in itself increased productivity growth in the industry, but it has also contributed to a sharp drop in prices of ICT capital, helping to spur investment, not only in the ICT industry, but elsewhere in the business sector as well. The tendency has thereby boosted capital deepening and thus productivity growth in all areas of the business sector.

During the period 1997–2005, the growth rate of productivity in the business sector as a whole averaged 3.3 percent per year. Capital deepening contributed an annual average of 1.0 percentage point to productivity growth. Most of the contribution consisted of a larger quantity of capital, but over one third of it is explained by substitution in favour of more productive types of capital, such as ICT capital.

The weak labour market of the 1990's was accompanied by a rapid increase in the enrolment capacity of post-secondary education. As a consequence, a much larger proportion of the younger people now entering the labour market with jobs have post-secondary education than is the case with the older generation now leaving the labour force. The changed composition of the employed is helping to drive productivity growth, as individuals with higher education tend to have higher productivity. Although differences in country of birth and in age can also help explain why individuals do not have the same productivity, these factors have not affected the development of productivity to the same extent. During 1997–2005 changes in the composition of the employed provided an average total contribution of 0.3 percentage point per year to productivity growth in the business sector as a whole.

The part of productivity growth not explained by more and better capital or by higher quality of the labour force is the result of an increase in total factor productivity (TFP). Rising TFP entails no measurable costs of production and may be due, for example, to technological development and improved organization of work. In 1997–2005 TFP growth contributed an annual average of 2.0 percentage points to productivity growth. Roughly half of the contribution came from rising TFP in the ICT industry, even though this industry accounted for only about 8 percent of value added in the business sector.

For natural reasons, it is extremely hard to forecast the pace of technological development in the years to come. With growing globalization, technological development is strongly interlinked throughout the world. It is assumed in this study that technological development, and thus TFP growth, will remain high in the Sweden's ICT industry during 2006–2020, but that TFP growth will fall off by some 30 percent from its average rate in 1997–2005. The anticipated slowdown in TFP growth is consistent with the views of other analysts on the tendency in the US and other countries. Also in manufacturing excluding ICT, TFP growth is expected to be about 30 percent lower in 2006–2020 than its average rate in 1997–2005. As for the other-goods industry and the services industry excluding ICT, it is assumed that TFP will develop at the same rate in the years ahead as its average for 1997–2005. With the slower TFP growth in the ICT industry and in manufacturing excluding ICT, the price of ICT capital and machinery will show a stronger tendency in the future than in the period 1997–2005. This tendency will have a limiting effect on capital deepening in all industries of the business sector in the years ahead.

The projections of TFP are in many respects determinative for the future trend rate of productivity growth. For the business sector as a whole, this trend rate for 2006–2020 is estimated at 2.7 per year, with rising TFP accounting for 1.6 percentage point per year and capital deepening, i. e. more and better capital, for 0.9 percentage point per year. The projections by other analysts for the development of business sector productivity in other countries are generally a little lower than the rate for Sweden estimated here. One reason for the difference is that the ICT industry, which is characterized by extremely high productivity growth, accounts for a comparatively large share of the Swedish business sector. In Sweden, moreover, a comparatively large proportion of service industries, where productivity growth is relatively low, belong to the general government sector.

In the projections, TFP growth is taken as an exogenously determined process. It is thus assumed, for example, that changes in the proportion of employees with post-secondary education do not affect TFP growth. But they might affect it if, for example, a rising proportion of employees with post-secondary education is accompanied by increased investment in research and development, possibly speeding technological progress.

It is assumed in the projections that the number entering post-secondary education will more or less stagnate at its level in 2006. This means that the previous rising trend of enrolment in post-secondary education will come to a halt. But since older persons in the labour force have post-secondary education to a much lesser extent than the younger people entering the labour force, the proportion of employees with post-secondary education continues to increase in the projections. The rising level of education will entail gradual substitution of labour in favour of employees with higher productivity. On average, improved quality of the labour force will contribute just more than 0.1 percentage point per year to productivity growth in the business sector as a whole during 2006–2020. It is assumed in the projections that the changed composition of the labour force will not entail shortages of some types of labour and oversupply of others. It is thus taken as given that an increasing supply of highly educated labour will be met by a corresponding increase in demand. Accordingly, it is also assumed that the changed composition of the labour force will not influence how well the various parts of the labour force fit together. But in reality, such an effect could materialize, with consequences for the development of TFP.

The larger proportion receiving post-secondary education is thus assumed to have a positive impact on productivity growth. At the same time, however, employment is curtailed when more people are studying. In the Education Scenario, it is given that when the number of students increases, employment decreases to the corresponding extent. It is thus assumed implicitly in the scenario that equilibrium unemployment is not affected by an increase in enrolment capacity. As a practical matter, this assumption is not necessarily correct, and one cannot rule out the possibility of some decrease in equilibrium unemployment, particularly if the investment in education is focused on occupations where there is a labour shortage. But in all probability, growth in employment will be inhibited considerably if more people are studying, thus limiting the benefits of increased education for the general economy. Therefore, it may take quite a few years before the aggregate value added in the business sector increases because more people have higher education. The results in the Education Scenario suggest that value added in the business sector does not reach the same level as in the Base Scenario until 2020, but also that if the time frame were extended further, the value added in the business sector would be higher in the Education Scenario.

At the same time, it is important to underscore that the dimensioning of the education system cannot obviously be considered a policy variable for affecting growth in productivity and value added. The dimensioning of education might preferably be regarded as a variable to be adjusted according to the demand for labour with different kinds of education. Otherwise over-education might result in some categories of labour and shortages in others. Some employees might then have the wrong skills and/or be overqualified for their work, possibly limiting the development of productivity.

Employees productivity varies not only according to differences in education. Persons born abroad may be less productive than Sweden natives of the same age and with the same level of education if they do not fully master the Swedish language, if their work experience is not very relevant in a Swedish setting or if their education cannot be fully utilized in Sweden, for example. Moreover, discrimination may make it harder for the foreign-born to find jobs that match their qualifications. And the employment rate for the foreign-born is generally lower than for natives of Sweden. The potential gains to national economy from improving the integration of the foreign-born on the labour market are thus considerable.

In the alternative scenario presented in this study, with better integration of the foreign-born on the labour market, it is assumed that differences in wages between persons born in Sweden and those born outside the Nordic countries, with the same education and of the same age, will be reduced by half between 2006 and 2020. Differences in wages are used throughout as an approximation of differences in productivity, but it should be emphasized that in fact differences in wages may also be due to discrimination. The extent to which this is the case is not analyzed in the study, and the findings should be interpreted with that limitation in mind. Moreover, it is assumed that the difference in employment rate between Swedish natives and persons born outside the Nordic countries, with the same level of education and of the same age, will be halved between 2006 and 2020. In this scenario, the number of hours worked in the business sector is 2.1 percent higher in 2020, and productivity is 0.8 percent higher, than in the Base Scenario. All factors taken into account, value added in the business sector is 2.9 percent higher in 2020 in the Integration Scenario. Underlying the increase in productivity, of course, is the assumption that reduced differences in wages reflect reduced differences in productivity. If the differences in wages were instead assumed to be a result of wage discrimination, the smaller differences in wages would then have to be interpreted as showing that improved integration helps to reduce wage discrimination. In such circumstances, improved integration of the foreign-born on the labour market would not necessarily boost the development of productivity. But the overall impact on value added in the business sector would still be very favourable owing to the substantial effect on the number of hours worked.

Some interesting conclusions can be drawn from the findings. One conclusion, which is very much expected, is that technological development, and thus TFP, is the principal factor in productivity growth. A number of measures might conceivably affect the development of TFP, but probably only for a transitional period. For instance, continued expansion of post-secondary education could be accompanied by stepped-up efforts in research and development, helping to speed the pace of technological progress. But whether this element of so-called endogenous growth arising from increased investment in education would actually occur is highly uncertain.

If the proportion receiving post-secondary education continues to rise, the change in labour force composition toward labour with higher productivity will accelerate, raising the rate of productivity growth. But the proportion of the employed with post-secondary education is continuing to increase even with post-secondary education as presently dimensioned, the reason being the ongoing generation change on the labour market. Therefore, one cannot rule out the possibility that a further increase in the proportion receiving post-secondary education might contribute to an oversupply of people with that level of education. If so, the productivity gains from increased investment in education would be less certain. Furthermore, higher enrolment in post-secondary education would limit the number of persons employed. The findings thus imply that it is essential for additional endeavours in education to be governed by need and demand if they are to contribute within a reasonable time to higher value added in the business sector than otherwise.

Improved integration of the foreign-born on the labour market can have a more immediate favourable impact on the development of value added in the business sector. Here there is vast potential. In the Integration Scenario presented, there is gradual reduction by half of differences in employment rate and in wages, and thus in assumed productivity, between persons born outside the Nordic countries and natives of Sweden with the same education level and of the same age. Value added in the business sector is then 2.9 percent higher in 2020 than in the Base Scenario. In this study, no attempt is made to determine what measures and changes are required for the Integration Scenario to be realized, but improved integration of the foreign-born on the labour market promises considerable potential gains for the economy at large.

It should be emphasized that the two alternative scenarios are not to be considered mutually exclusive. Undeniably, better integration of the foreign-born on the labour market would be very beneficial for the development of the general economy, primarily through higher employment. In addition, expansion in post-secondary education would probably have positive effects on the development of the economy at large, at least in the long run. But for this outcome, it is important that further investment in education be guided by the needs of the labour market.

Appendix A: Calculating Productivity with Growth Accounting[68]

A.1 Fundamentals of Growth Accounting

The aggregate value added of each industry *(Y)* is produced with an input of the production factors of capital services *(K)* and quality-adjusted hours worked *(L)*. For the sake of simplicity, industry indexation has been omitted. The production function is assumed to have constant returns to scale and to be separable into the above arguments and the technology factor *(A)*, which is also referred to as total factor productivity, or TFP. The production function can thus be written as:

$$Y_t = A_t \cdot F(K_t, L_t) \qquad \text{(A1)}$$

where t indicates the point in time. To calculate the contribution of the production factors and TFP to the change in output over time, (A1) is totally differentiated:

$$\Delta Y_t = \Delta A_t \cdot F(K_t, L_t) + \frac{\partial Y}{\partial K} \cdot \Delta K_t + \frac{\partial Y}{\partial L} \cdot \Delta L_t \qquad \text{(A2)}$$

where the operator Δ indicates the change over time. Dividing the right and left parts of (A2) by Y yields the relative change, i. e.:

$$\frac{\Delta Y_t}{Y_t} = \frac{\Delta A_t}{Y_t} \cdot F(K_t, L_t) + \frac{\partial Y}{\partial K} \cdot \frac{\Delta K_t}{Y_t} \cdot \frac{K_t}{K_t} + \frac{\partial Y}{\partial L} \cdot \frac{\Delta L_t}{Y_t} \cdot \frac{L_t}{L_t}$$

which can be written as:

$$\frac{\Delta Y_t}{Y_t} = \frac{\Delta A_t}{A_t} + \frac{\partial Y}{\partial K} \cdot \frac{K_t}{Y_t} \cdot \frac{\Delta K_t}{K_t} + \frac{\partial Y}{\partial L} \cdot \frac{L_t}{Y_t} \cdot \frac{\Delta L_t}{L_t} \qquad \text{(A3)}$$

The growth in value added is thus the sum of the growth in TFP and the weighted sum of the growth in capital services and the growth in quality-adjusted hours worked. In order to calculate the respective

weights, i. e. $\left(\frac{\partial Y}{\partial K} \cdot \frac{K_t}{Y_t}\right)$ and $\left(\frac{\partial Y}{\partial L} \cdot \frac{L_t}{Y_t}\right)$, it is assumed that perfect competition prevails on goods and factor markets.

With perfect competition, a profit-maximizing firm invests as much of the production factors of quality-adjusted hours and capital services as required for the value of the

[68] See, for example, Timmer et al. [2007}

marginal productivity to be the same as the marginal cost of the respective production factor. Profit maximization can be described as:

$$\underset{K,L}{\text{Max}}\ \pi_t = P_t \cdot Y_t\left(A_t, K_t, L_t\right) - P_t^K \cdot K_t - P_t^L \cdot L_t \tag{A4}$$

where π_t represents profit, P_t is the price of the final good; Y_t is the production function (compare Equation A1); P_t^L is the wage per quality- adjusted hour and is taken as exogenously given by the firm; and P_t^K is the price per unit of capital services, i. e. the user cost in monetary terms, which is also taken as exogenously given by the firm. The first-order condition for profit maximization provides that:

$$\frac{\partial Y_t}{\partial K_t} = \frac{P_t^K}{P_t}$$

$$\frac{\partial Y_t}{\partial L_t} = \frac{P_t^L}{P_t} \tag{A5}$$

i. e. an extra unit of capital service generates as much value added as the cost of an extra unit of capital service, and an extra quality-adjusted hour of work generates as much value added as the cost of labour per quality-adjusted hour. Substituting (A5) into (A3), the growth in value added can be decomposed according to:

$$\frac{\Delta Y_t}{Y_t} = \frac{\Delta A_t}{A_t} + \frac{P_t^K \cdot K_t}{P_t \cdot Y_t} \cdot \frac{\Delta K_t}{K_t} + \frac{P_t^L \cdot L_t}{P_t \cdot Y_t} \cdot \frac{\Delta L_t}{L_t}$$

which can be expressed as:

$$\frac{\Delta Y_t}{Y_t} = \frac{\Delta A_t}{A_t} + v_{K,t} \cdot \frac{\Delta K_t}{K_t} + v_{L,t} \cdot \frac{\Delta L_t}{L_t} \tag{A6}$$

The weights preceding the growth in the production factors thus correspond to the compensation for the respective production factor as a share of value added. With the assumption of constant returns to scale, $v_{K,t} + v_{L,t} = 1$.

The relative change – or growth – is often approximated by the difference in logarithmized values, i.e.:

$$\frac{\Delta X_t}{X_t} \approx \Delta \ln X_t$$

With this approximation (manner of expression), (A6) can be written as:

$$\Delta \ln Y_t = \Delta \ln A_t + v_{K,t}\Delta \ln K_t + v_{L,t}\Delta \ln L_t \qquad \text{(A7)}$$

Capital can be divided into different types, and labour into different categories, but so far this aggregated form is retained for the sake of simplicity. Through subtracting both sides of (A7) by the change in actual hours worked, *(ΔH),* is obtained:

$$\Delta \ln Y_t - \Delta \ln H_t = v_{K,t} \cdot (\Delta \ln K_t - \Delta \ln H_t) + v_{L,t} \cdot (\Delta \ln L_t - \Delta \ln H_t) + \Delta \ln A_t$$

which can be expressed as:

$$\Delta \ln\left(\frac{Y_t}{H_t}\right) = v_{K,t} \cdot \Delta \ln\left(\frac{K_t}{H_t}\right) + v_{L,t} \cdot \Delta \ln\left(\frac{L_t}{H_t}\right) + \Delta \ln A_t \qquad \text{(A8)}$$

Equation (A8) divides the change in labour productivity into three components: (i) changed capital intensity; i. e. a change in the quantity of capital services per actual hour worked so that $\left(\frac{K_t}{H_t}\right)$ changes. An increase in $\left(\frac{K_t}{H_t}\right)$ is termed capital deepening; (ii) changed quality of the labour force, i. e. quality-adjusted hours worked increase faster or slower than actual hours so that $\left(\frac{L_t}{H_t}\right)$ changes; (iii) a change in total factor productivity, i. e. A_t .

An alternative way of expressing Equation (A8) is to divide the change in capital intensity into the change in physical capital per hour worked $\left(\frac{S_t}{H_t}\right)$ and improved quality of capital, i. e. capital service per physical unit of capital $\left(\frac{K_t}{S_t}\right)$. Equation (A8) can then be expressed as:

$$\Delta \ln\left(\frac{Y_t}{H_t}\right) = v_{K,t} \cdot \Delta \ln\left(\frac{S_t}{H_t}\right) + v_{K,t} \cdot \Delta \ln\left(\frac{K_t}{S_t}\right) + v_{L,t} \cdot \Delta \ln\left(\frac{L_t}{H_t}\right) + \Delta \ln A_t \qquad \text{(A9)}$$

The division according to Equation (A9) is used in the accounting for the results in Chapters 2 and 3.

Under certain assumptions, capital deepening and the improvement in the quality of the labour force can be calculated from actual data. TFP is not a measurable quantity, but is defined as the increase in value added that cannot be explained by an increase in the production factors of capital services and quality-adjusted hours worked. The change in TFP can thus be calculated as a residual, as can easily be seen if Equation (A9) is rearranged so that:

$$\Delta \ln A_t = \Delta \ln\left(\frac{Y_t}{H_t}\right) - \nu_{K,t} \cdot \Delta \ln\left(\frac{S_t}{H_t}\right) - \nu_{K,t} \cdot \Delta \ln\left(\frac{K_t}{H_t}\right) - \nu_{L,t} \cdot \Delta \ln\left(\frac{L_t}{H_t}\right) \quad \text{(A10)}$$

Rising TFP thus means that it is possible to increase value added without an added input of production factors. TFP thereby captures technological development, organizational changes etc. that are not ”embodied” in the production factors. But since TFP is calculated as a residual, the measure also captures measurement error in the data on productivity and the inputs of the production factors as well as cyclical variations in the intensity of their use.

A.2 Quality of the Labour Force

In this section, different categories of labour are introduced, j.
Different groups of labour may, on average, show differences in productivity, due to differences in education, for example. Therefore, if the composition of the labour force changes over time, productivity will change as well. The contribution of the labour force to the development of productivity
is captured in the term $\nu_{L,t} \cdot \Delta \ln\left(\frac{L_t}{H_t}\right)$ in Equation (A9). When quality-adjusted hours, *L*, grow faster than actual hours, *H*, this term increases and contributes positively to the development of productivity. The quality adjustment of hours follows the same principle as the quality adjustment of capital in the calculation of capital services (Section A3).

For each group of labour, the value of marginal productivity is approximated by the average wage of the group in accordance with the conditions for profit maximization in Equation (A5). For each group the number of actual hours is the same as the number of quality-adjusted hours, i. e.

$$L_{j,t} = H_{j,t} \quad \text{(A11)}$$

where j represents the various groups of labour. An index for aggregate quality-adjusted hours is calculated according to:

$$\Delta \ln L_t = \sum_j \left(\bar{\nu}_{j,t} \cdot \Delta \ln H_{j,t}\right) \quad \text{(A12)}$$

where $\Delta \ln L$ is the percentage rate of change in quality-adjusted hours and $\bar{\nu}_j$ is the weight for labour belonging to group *j*. Labour with relatively high wage per hour worked, w_j, , and thus with relatively high total wage, $w_j \cdot H_j$, is assigned a comparatively high weight in order to reflect its higher marginal productivity. The weights are calculated as:

$$\overline{v}_{j,t} = \frac{1}{2} \cdot \left(\frac{w_{j,t} \cdot H_{j,t}}{\sum_j \left(w_{j,t} \cdot H_{j,t} \right)} + \frac{w_{j,t-1} \cdot H_{j,t-1}}{\sum_j \left(w_{j,t-1} \cdot H_{j,t-1} \right)} \right) \qquad \text{(A13)}$$

Equations (A12) and (A13) mean that if firms substitute in favour of labour with higher marginal productivity, quality-adjusted hours will increase faster than actual hours. This explains, in turn, a portion of the growth in productivity, and TFP growth calculated as a residual is therefore lower than if the change in the quality of the labour force is not considered.

A.3 Capital Deepening and Quality of Capital

In this section different types of capital, *i*, are introduced.

Capital deepening measures the growth in capital services per actual hour worked. Different types of capital do not generate the same quantity of capital services per monetary unit invested for a given period of time. For example, it is obvious that one unit of currency invested in machinery normally contributes more to value added than one unit of currency invested in a building. On the other hand, a building usually has a much longer useful life than a machine. Therefore, to provide the same return, the marginal productivity required for an investment to be made must be higher for a machine than for a building. When an aggregate measure of capital services is calculated, the differences in marginal productivity must be considered.

In order to calculate the quantity of capital services generated by each type of capital, the capital stock and the user cost must be determined for each type of capital. Measures of capital stocks can be calculated according to:[69]

$$S_{i,t} = I_{i,t-1} + (1-\delta_i) \cdot S_{i,t-1} \qquad \text{(A14)}$$

The capital stock, $S_{i,t}$,of capital type *i* is determined at the start of period t as the sum of the investments in period t-1, i. e. $I_{i,t-1}$, and of what is left from the preceding period after depreciation has been deducted, i. e. $(1-\delta_i) \cdot S_{i,t-1}$.[70]

Here it should be emphasized that investments refer to units of capital of constant quality over time. In fact, of course, quality changes over time. A standard computer made in 2007, for example, is much higher-performing, and thus of much higher quality, than a standard computer made in 2000, even if there is little difference in price. When Statistics Sweden calculates capital stocks, this difference is taken into account

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[69] Stocks of capital are published by Statistics Sweden.

[70] In Statistics Sweden's calculations of capital stocks, it is assumed that both physical wear and tear (older machines are not as good as newer ones) and economic obsolescence (older machines make products that are less modern and therefore of less value) are exponential; thus, the rate of depreciation is constant. But in many cases, it is more realistic to increase the rate of depreciation over time. Often, therefore, a hyperbolic age-efficiency function with this feature is used for physical wear and tear; see Schreyer [2003].

through price deflators used to compensate for changes in quality over time. This means that the change in the volume of the capital stock consists of both more and better units.

To calculate the aggregate measure of capital services, it is first necessary to calculate capital services for each type of capital. The flow of capital services is assumed to be proportional to the capital stock. The change in capital services for the respective type of capital ($\Delta \ln K_{i,t}$) is thus taken to be the same as the change in the corresponding physical stock of capital ($\Delta \ln S_{i,t}$).[71]

$$\Delta \ln K_{i,t} = \Delta \ln S_{i,t} \quad \text{(A15)}$$

The aggregate measure of the flow of capital services can then be calculated as:

$$\Delta \ln K_t = \sum_i \left(v_{i,t} \cdot \Delta \ln S_{i,t} \right) \quad \text{(A16)}$$

where $v_{i,t}$ is the weight assigned to capital type *i*. Types of capital with a relatively high user cost, and thus high assumed marginal productivity, are assigned comparatively high weights; these are calculated as:

$$\bar{v}_{i,t} = \frac{1}{2} \cdot \left(\frac{\mu_{i,t} \cdot P_{i,t}^S \cdot S_{i,t}}{\sum_i \left(\mu_{i,t} \cdot P_{i,t}^S \cdot S_{i,t} \right)} + \frac{\mu_{i,t-1} \cdot P_{i,t-1}^S \cdot S_{i,t-1}}{\sum_i \left(\mu_{i,t-1} \cdot P_{i,t-1}^S \cdot S_{i,t-1} \right)} \right) \quad \text{(A17)}$$

where μ_i is the user cost in percent and P_i^S , is the price of investment in capital type *i*. The weight for each type of capital is thus calculated as the mean value for the current and preceding periods of the aggregate user cost of the capital type, as a proportion of the total user cost of all capital.

Equations (A16) and (A17) mean that if firms substitute in favour of capital with higher marginal productivity, capital services will increase faster than the capital stock. In this case, that would explain a portion of productivity growth, and TFP growth calculated as a residual would be lower than if quality adjustment of capital were not considered.

For a firm to invest money in productive capital, the expected (risk-adjusted) return on the investment must be (at least) equal to the return on alternative (for example, financial) investments, i. e.

$$(1 + r_t) \cdot P_{i,t-1}^S = P_{i,t}^K + (1 - \delta_i) \cdot P_{i,t}^S \quad \text{(A18)}$$

[71] Since the capital stock in fact refers to the situation at the start of the year, an average of the capital stocks for years t and t+1 is used.

where r_t is the nominal rate of return on an alternative investment; $P_{i,t-1}^{S}$ is the price of one unit of capital of capital type *i*; δ_i is the rate of depreciation for capital type *i*; and $P_{i,t}^{K}$ is the user cost of one unit of capital type *i*. As shown above, the value of the marginal productivity in monetary units under conditions of profit maximization is the same as the user cost in monetary terms. Solving Equation (A18) yields the user cost expressed in units of currency for one unit of capital:

$$P_{i,t}^{K} = P_{i,t-1}^{S} \cdot r_t + \delta_i \cdot P_{i,t}^{S} - [P_{i,t}^{S} - P_{i,t-1}^{S}] \qquad \text{(A19)}$$

Intuitively, it is rather easy to understand the components of user cost as expressed in Equation (A19). The user cost increases when the rate of return on an alternative investment increases. Similarly, the user cost is higher if the rate of depreciation is higher, as the capital depreciates. Moreover, the user cost is affected by the price tendency of a unit of capital. If the price is decreasing over time, as it has been for ICT equipment, this factor in itself is an argument for postponing an investment. The weaker the price tendency for an investment good, the higher its user cost.

The rate of deprecation and the price tendency of investment goods can be found in the National Accounts. On the other hand, it is not clear what rate of return should be used. In principle, any market rate of return, plus possibly a risk premium, could be chosen. This procedure is termed the "external rate of return" method. The problem with it is that the return on the capital, or the income from the capital, will not be consistent with the operating surplus according to the National Accounts. The operating surplus is calculated as value added less labour costs, and it is intended as compensation for the use of capital. Another way to calculate the nominal rate of return is to assume that the operating surplus is equal to the user cost. This is known as the "internal rate of return" method. Since data on depreciation and changes in prices of investment goods are available in the National Accounts, the nominal rate of return can then be calculated as a residual in the following manner:

$$r_t = \frac{P_t^{K} \cdot K_t + \sum_i \left([P_{i,t}^{S} - P_{i,t-1}^{S}] \cdot S_{i,t}\right) - \sum_i \left(P_{i,t}^{S} \cdot \delta_i \cdot S_{i,t}\right)}{\sum_i \left(P_{i,t-1}^{S} \cdot S_{i,t}\right)} \qquad \text{(A20)}$$

The term $P_t^{K} \cdot K_t$ consists of income from capital, which with constant returns to scale is the same as value added less labour costs, i. e. the operating surplus. In this report we have chosen to calculate the nominal rate of return according to Equation (A20). This method, which appears to be the most common one, is used, for example, in the EU KLEMS project.[72] The method normally results in a higher nominal rate of return than if a market rate had been used.

[72] See, for example, Timmer et al. [2007].

Appendix B: Wage Structure Statistics for the Private Sector[73]

B.1 Productivity Approximated by Wages

In the report, the productivity of individuals is approximated by the wage that they receive; thus, relative productivity can be measured by relative wages. The labour force is divided into annual cohorts for ages 18 to 64, four geographic areas of origin and four maximum levels of education, for a total of 752 groups. To calculate the relative wages of these groups, the Wage Structure Statistics published by Statistics Sweden are used. The Wage Structure Statistics are intended to show levels of wages, wage structure and the development of wages in the private sector and elsewhere. For years prior to 1996, however, the education level is not provided for hourly employees. This report is therefore limited to the period 1996–2005.

B.2 Sample

The Wage Structure Statistics are based on a sample survey. The samples are selected by so-called simple random sampling, stratified according to firm size and industry. The size of the samples varies over the years; for the private sector the sample consists of approximately 8 000 to 12 000 firms / organizations / foundations per year. A total study is conducted on the strata with firms having at least 500 employees, according to the firm data base of Statistics Sweden (FDB), and on the Church of Sweden, which is part of the private sector as from 2000. Of the smallest firms (1–9 employees), less than three percent are investigated. In the study of some five percent of all firms / organizations / foundations within the sampling framework, data are collected on about one million individuals, or roughly 50 percent of employees in the private sector. That sector is defined as consisting of private and public corporations, incorporated associations/foundations, trading companies, limited partnership companies, trade associations and financial corporations as well as institutions. The private sector also includes the non-profit organizations of the household sector. Employees are defined as personnel aged 18–64 with market-level wages who have worked at least one hour during the period of measurement. Participants in labour market programmes, crews of vessels and aircraft, contract jobbers, temporary employees and project employees as well as owners/partners with no contractually specified compensation and/or time are not included in the target population. The latter consists of two parts: hourly employees and salaried employees. Hourly employees are defined as employees within the LO (Swedish Trade Union Confederation) sphere of collective bargaining. Salaried employees are defined as employees within the SACO/TCO (Swedish Confederation of Professional Associations /Confederation of Professional Employees) sphere, as well as personnel with individual employment contracts.

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[73] A description of the Wage Structure Statistics can be found at www.scb.se

B.3 The NIER's Classification by Industry

For purposes of the present study, the business sector is analyzed both as a whole and divided into four different industries, which for the sake of simplification are referred to as four industries in the report. The ICT industry comprises the following industries according to the Swedish Standard Industrial Classification (SNI) 30–33, 64.2 and 72. The ICT industry is thus defined largely in the same way as in a number of other studies where growth accounting is used and the ICT industry is analyzed separately; see, for example, Forsling, G. & T. Lindström (2004) and Van Ark, B. et al. The services industry except ICT comprises SNI 50–95 except 64.2 and 72. The manufacturing industry excluding ICT consists of SNI 15–29 and 34–37. The other-goods industry is made up of SNI 01–14, 40–41 and 45.

Table B.1 Classification of Industries

Division		Principal group (SNI)	NIER
Manufacturing sector [A-C]	Agriculture, hunting, forestry. Fishing. Mining and quarrying	0–14	Other-goods industry excl. ICT
[D, part of]	Manufacturing	15–29	Manufacturing excl. ICT
[D, part of]	Manufacturing: Office equipment; Telecommunication products, Manufacture of precision, medical and optical instruments, watches and clocks	30–33	ICT
[D, part of]	Manufacturing	34–37	Manufacturing excl. ICT
[E,F]	Electricity, gas, heat and water supply; Construction	40–45	Other-goods industry excl. ICT
Service sector [G-H]	Wholesale and retail trade; Repair of motor vehicles, household goods and personal goods. Hotels and restaurants	50–55	Services industry excl. ICT
[I, part of]	Transport, storage and communication	60–64.1	Services industry excl. ICT
[I, part of]	Transport, storage and communication: Telecommunications	64.2	ICT
[J-K, part of]	Financial intermediation. Real estate, renting and other business activities	65–71	Services industry excl. ICT
[K, part of]	Real estate, renting and business activities. Data processing etc.	72	ICT
[M-O]	Education. Health. Social work; veterinary activities. Other community, social and personal service activities	80–93	Services industry excl. ICT

Source: Statistics Sweden and NIER.

B.4 The NIER's Classification by Educational Level

In this study, business sector employees are classified into four categories according to highest level of education attained: (primary and lower secondary, upper secondary, post-secondary and postgraduate). This classification follows the Swedish Educational Terminology (SUN 2000), which is also used in the Wage Structure Statistics. The classification has been chosen to reflect differences in wages, and thus in assumed productivity, among different groups of employees with different education. The classification is also consistent with other studies that apply growth accounting to Swedish data; see, for example, Forsling & Lindström (2004). Table B.2 shows the distribution of business sector employees by level of education in 2005, as a mean value for all employees ages 18–64 and also for 30-year-olds separately.

For 30-year-olds with post-secondary education, the average time required to complete the course of study was 3.3 years, given the following assumptions: those with at least one term but less that two years of (post-secondary) education have an average of 1.25 years of such education; those with at least two but less than three years have 2.5 years on average of post-secondary education; those with at least three but not four years have an average of 3.5 years; those with at least four but not five years have an average of 4.5 years; and that those with at least five years of post-secondary education have an average of 5.5 years of such education.

Table B.2 Educational Level, Proportion of Business Sector Employees Aged 18–64, 2005

Percent

	SUN code	All ages	30-year-olds
Primary and lower secondary education, total		17.9	5.0
less than 9 years	100–106	6.0	0.6
9 (10) years	200–206	11.9	4.5
Upper secondary education, total		55.0	54.6
less than 2 years (at least 1 term)	310–317	2.9	2.4
2 years (at least 2 but not 3 years)	320–327	24.3	13.8
3 years	330–337	27.9	38.4
Post-secondary education, total		26.4	40.0
of which university/college		*20.3*	*34.7*
of which occupationally oriented, not postgraduate		*1.9*	*2.8*
less than 2 years (at least 1 term)	410–417	7.2	5.8
2 years (at least 2 but not 3 years)	520–527	5.7	7.3
3 years (at least 3 but not 4 years)	530–537	7.8	15.3
4 years (at least 4 but not 5 years)	540–547	5.2	10.7
5 years or more	550–557	0.5	0.9
Postgraduate education, total		0.6	0.4
other/unspecified	600	0.0	0.1
licentiate studies	620	0.1	0.1
doctoral studies	640	0.4	0.2

Note: SUN is an abbreviation of Swedish Educational Terminology. SUN codes refer to SUN 2000.

Source: Wage Structure Statistics, Statistics Sweden and NIER.

B.5 Variables Used in the Study

Total wage is used to approximate the productivity of individuals. Total wage includes the wage/salary received for time worked as well as benefits, on-duty and on-call compensation, compensation for waiting time and for travel outside ordinary work hours. For hourly employees, weekend pay (i. e. compensation for earnings lost on weekends) is included. In the calculation of time worked, hours worked are not used, as the hours reported are not comparable over time and among different groups. Instead, degree of service is used as a variable. The degree of service indicates how much an individual works in proportion to full time and varies from 0 to 100 percent. The degree of service is multiplied by the normal number of hours worked per month to obtain a measure of hours worked. For the years prior to 1999, data on degree of service are missing for a large number of individuals. These individuals are given imputed values for this variable equal to the average degree of service for their respective age, native country and education groups.

Table B.3 Monthly Wage and Wage in Proportion to Wage of 18–24-Year-Olds, Primary and Lower Secondary Education

SEK and percent, respectively

	Sweden		Nordic countries excl. Sweden		Europe excl. Nordic countries		Outside Europe	
Age	SEK	Percent	SEK	Percent	SEK	Percent	SEK	Percent
18–24	15 692	100.0	15 444	100.0	15 624	100.0	15 510	100.0
25–39	18 043	115.0	17 552	113.7	16 680	106.8	16 127	104.0
40–54	19 040	121.3	18 715	121.2	17 511	112.1	16 375	105.6
55–64	19 065	121.5	18 989	123.0	18 484	118.3	16 195	104.4

Note: Data refer to mean values for the business sector 1996–2005.

Source: Wage Structure Statistics, Statistics Sweden and NIER.

Table B.4 Monthly Wage and Wage in Proportion to Wage of 18–24-Year-Olds, Upper Secondary Education

SEK and percent, respectively

	Sweden		Nordic countries excl. Sweden		Europe excl. Nordic countries		Outside Europe	
Age	SEK	Percent	SEK	Percent	SEK	Percent	SEK	Percent
18–24	15 803	100.0	15 346	100.0	15 785	100.0	15 598	100.0
25–39	19 493	123.3	18 950	123.5	17 859	113.1	17 747	113.8
40–54	21 461	135.8	20 351	132.6	19 063	120.8	18 546	118.9
55–64	22 707	143.7	21 214	138.2	21 015	133.1	18 895	121.1

Note: Data refer to mean values for the business sector 1996–2005.

Source: Wage Structure Statistics, Statistics Sweden and NIER.

Table B.5 Monthly Wage and Wage in Proportion to Wage of 25–39-Year-Olds, Post-Graduate Education

SEK and percent, respectively

	Sweden		Nordic countries excl. Sweden		Europe excl. Nordic countries		Outside Europe	
Age	SEK	Percent	SEK	Percent	SEK	Percent	SEK	Percent
25–39	29 839	100.0	30 648	100.0	30 293	100.0	25 725	100.0
40–54	43 843	146.9	40 468	132.0	37 826	124.9	34 395	133.7
55–64	45 408	152.2	42 079	137.3	44 664	147.4	38 952	151.4

Note: Data refer to mean values for the business sector 1996–2005.

Source: Wage Structure Statistics, Statistics Sweden and NIER.

Appendix C: Method and Assumptions for Projections of Productivity

As with growth accounting for historical data, the projections are based on a neoclassical growth model with constant returns to scale. It is assumed in the projections that the production function is of a so-called Cobb-Douglas type. This means that the elasticity of substitution between production factors is one; i. e. if the relative price of production factors changes by one percent, the relative use of those production factors will also change by one percent. In the projections the cost of capital for firms is constant in proportion to value added; i. e. the profit and labour-cost shares are constant over time. The demand for quality-adjusted hours is assumed to be the same as the supply of quality-adjusted hours, whereas the demand for capital is determined by the profit maximization of firms. The method for quality adjustment of hours worked (see Chapter 3) implies that quality-adjusted hours are fully substitutable between the different categories of labour that produce them.

In the projections a number of important factors are exogenously determined:

- TFP in each industry
- the required net rate of return in each industry
- the development of the price of investment for the different types of capital in each industry
- the rate of depreciation for each type of capital in each industry
- changes in the composition of industries
- the development of the labour force
- the capital-cost share and labour-cost share in each industry.

In the projections the following conditions are satisfied in each time period:

- The capital-cost share, which is equal to the gross surplus as a share of value added, is constant in each industry (follows from the assumption of Cobb-Douglas technology).
- The user cost of capital services, i. e. the cost of capital for each type of capital, is constant in proportion to value added in the respective industries – the size and composition of the capital stock are adjusted so as to fulfil this condition.
- The required net rate of return, the development of the price of investment and the rate of depreciation are assumed to be constant over time.
- Growth in wages is the same in all industries – the value-added price in each industry adjusts so that gross surplus accounts for a constant share over time of value added in all industries.
- The value-added price for the business sector as a whole, like the price of investment, is consistent with the Riksbank's inflation target, the nominal anchor of the economy.
- Demand for labour is equal to supply of labour; i. e. firms fully use the labour available, and unemployment is equal to equilibrium unemployment.

C.1 Method

As with growth accounting for historical data, the business sector is divided into four industries in the projections. Value added in the four industries is aggregated at the price levels of the previous year and at current price levels. Then the aggregate is calculated as a chain index with 2004 as the year of reference.

The productivity growth in each industry, i. e. the change in *(Y/H)*, can be divided into a contribution from capital deepening *(K/H)*, one from the quality of labour *(L/H)* and one from TFP *(A)*.[74]

$$\Delta \ln\left(\frac{Y_t}{H_t}\right) = \Delta \ln A_t + v_K \cdot \Delta \ln\left(\frac{K_t}{H_t}\right) + v_L \cdot \Delta \ln\left(\frac{L_t}{H_t}\right) \qquad \text{(C1)}$$

In turn, the contribution from capital deepening can be divided up into a contribution from a changed composition of the capital stock, i. e. changed quality, and one from pure capital deepening, or more capital per hour worked. Equation (C1) can then be written as

$$\Delta \ln\left(\frac{Y_t}{H_t}\right) = \Delta \ln A_t + v_K \cdot \Delta \ln\left(\frac{S_t}{H_t}\right) + v_K \cdot \Delta \ln\left(\frac{K_t}{S_t}\right) + v_L \cdot \Delta \ln\left(\frac{L_t}{H_t}\right) \text{(C2)}$$

where *(S/H)* is pure capital deepening, i. e. more capital *(S)* per hour worked, and *(K/S)* is changed quality/composition of the capital stock. If there is gradual substitution in favour of more highly productive capital, the flow of capital services will increase faster than the physical stock of capital, so that *(K/S)* provides a positive contribution to productivity growth.

The capital cost share, v_K, in Equations (C1) and (C2) constitutes the capital-cost share of value added, and v_L constitutes the labour-cost share of value added:

$$v_K = \frac{P_t^K \cdot K_t}{P_t \cdot Y_t}$$

$$\text{(C3)}$$

$$v_L = \frac{P_t^L \cdot L_t}{P_t \cdot Y_t}$$

The assumption that the production function is of a Cobb-Douglas type with constant returns to scale means that $v_K + v_L = 1$ and that v_K and v_L are constant over time.

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[74] For a detailed review of growth accounting, see Appendix A.

The flow of capital services is calculated as follows:

$$\Delta \ln K_t = \sum_i \left(v_{K,i} \cdot \Delta \ln S_{i,t} \right) \tag{C4}$$

where $v_{K,i}$ is the cost of capital for the portion of the total cost of capital accounted for by each type of capital. Firms choose $S_{i,t}$ so that the share of value added, in current prices, $v_{K,i}$, accounted for by each type of capital is constant over time (follows from the Cobb-Douglas assumption):

$$v_{K,i} = \frac{\mu_i \cdot S_{t,i} \cdot P_{t,i}}{P_t \cdot Y_t} \tag{C5}$$

where $\mu_i \cdot S_{t,i} \cdot P_{t,i}$ is the user cost for type of capital *i*, and $P_t \cdot Y_t$ is the value added, in current prices, in each industry.

Thus, there is an additional condition that v_K, i. e. the aggregate cost of capital for all types of capital, is constant:

$$v_K = \sum_i v_{K,i} = \frac{\sum_i \left(\mu_i \cdot S_{t,i} \cdot P_{t,i} \right)}{P_t \cdot Y_t} \tag{C6}$$

In the projections, TFP, that is, *A*, is exogenously determined. Quality-adjusted hours are calculated outside of the model described above.

C.1.1 Quality-Adjusted Hours and Labour Costs (L, P^L)

Hours worked by different groups of the labour force are projected with the use of KAMEL, the NIER's demographic model. The projections are based partly on Statistics Sweden's population forecast. Together, and with the NIER's forecasts for education and relative productivity (approximated by relative wages) for different groups of the labour force, these data are used to generate projections of quality-adjusted hours worked.

The principle followed in quality adjustment of hours worked is described in Appendix A. In the projection of quality-adjusted hours, it is assumed that the structure of relative productivity for the different groups of labour is consistent with the average for the period 1997–2005. It is also assumed that the employment rate and average hours worked are constant for the various groups of labour at the cyclically balanced levels of 2006. This implies, for example, that demographically determined changes in the composition of the labour force affect all industries to the same degree. Thus, a change in the quality of the labour force has an equal impact on all industries.

The labour force is assumed to be mobile between industries. Consequently, labour costs (wages) will develop in the same way in all industries. On the other hand, the level of labour costs (level of wages) need not be the same in all industries. In the projections, value-added prices are modelled so that the cost of labour (wages) develops equally in all industries. The real cost of labour, i. e. the cost of labour deflated by the value-added price, will thus develop differently in different industries.

C.1.2 TFP (*A*)

The projected development of TFP is based largely on the historical growth trend for TFP in the respective industries, but the views of other international analysts on developments have also been considered; for further discussion, see Chapter 3.

C.1.3 User Cost (μ_i)

The capital used by firms is divided into three types: machinery, buildings and ICT capital. These types of capital differ in productivity. The productivity of the types of capital is assumed to be equal to their user cost; see Appendix A. Differences among the types of capital in regard to user cost and productivity affect the quantity of each type of capital used in production.

The user cost for the different types of capital is calculated in the projections by the same principle as their historical development. The user cost is determined by the required rate of return (i. e. the return obtainable on an alternative investment), by the portion of the capital stock that depreciate each year (i. e. the rate of depreciation) and by any capital gains/losses, i. e. whether the price of new investment goods rises or falls. The first two factors provide positive contributions (marked with plus signs) to the user cost, whereas the contribution of changes in the price of investment goods is marked by the inverse sign.

- **Rate of return (*r*)**

  As with the period 1997–2005, it is assumed that the nominal rate of return required differs from industry to industry because of differences in risk premiums; see Chapter 2.

- **Depreciation (δ_i)**

  The rate of depreciation is assumed to be generally the same in the projections as the historical average for the respective type of capital and industry. Thus, depreciation on the same type of capital will differ among industries. This difference is reasonable, as the composition, or mix, of types of capital varies from industry to industry. In each industry, machinery, for example, consists of a diverse set of machines with differing rates of depreciation. The method of using different depreciation rates in different industries, with the rates remaining constant over time, is followed, for instance, in the EU

KLEMS project.[75] In the present study, this assumption applies to the projections as well.

TFP in the ICT industry and in manufacturing develops more slowly in the projections compared to the historical tendency. This could imply that ICT capital (which is assumed to be produced in the ICT industry) and machinery (assumed to be produced in the manufacturing industry excluding ICT) will depreciate more slowly in the years ahead, but it is assumed in the projections that this is not the case.

- **Development of the price of investment goods (ΔP_i)**

  In the projections, the development of the price of investment goods is a function of the TFP tendency in the industry producing the good. An improvement in productivity due to higher TFP is assumed in the projections to benefit consumers and investors fully through a lower price tendency for the goods and services produced by the industry.[76] It is assumed that ICT capital is produced in the ICT industry, machinery is produced in the manufacturing industry excluding ICT and buildings in the other-goods industry (which includes the construction industry, among others). These assumptions of course entail considerable simplification, but they make it possible to link the development of TFP with the price tendency for investment goods in the projections. If for example TFP in the ICT industry increases 1 percent faster, it follows that the relative price of ICT capital will fall by 1 percent, all else being equal. ICT capital is then assumed to be more productive as well. Investment, and thus capital services, is thereby affected in all industries by the change in the development of TFP in the ICT industry.

Table C.1 shows the user cost employed in the projections for each industry. The user cost is highest for ICT capital, next highest for machinery, and least for buildings. The differences in user cost are attributable primarily to differences in depreciation rates.

[75] See the European Commission [2007].

[76] According to estimates of Swedish data for the period 1993–2003, 1 percent higher TFP growth results in a price decrease of – 0.675 percent; see Hagén & Skyttesvall [2006]. According to estimates based on Canadian data for the period 1961–1995, the corresponding elasticity is – 0.8; see Balwin, Durand & Husein [2001]. In the projections, perfect competition is assumed; consequently, elasticity is – 1; i. e. 1 percent higher TFP results in a 1 percent decrease in price. The profit share is thereby kept constant.

Table C.1 User Cost

Percent

Type of capital	ICT industry	Manufacturing industry excl. ICT	Other-goods industry	Services industry excl. ICT
Required rate of return	15.0	13.9	10.9	10.9
Machinery				
User Cost	28.7	25.8	20.7	23.6
Depreciation	18.6	14.5	12.6	15.2
Price tendency	4.4	2.4	2.7	2.3
Buildings				
User Cost	13.7	14.9	9.7	9.4
Depreciation	2.5	3.1	2.4	1.7
Price tendency	3.4	1.9	3.3	3.0
ICT				
User Cost	41.2	43.7	35.7	44.2
Depreciation	21.4	29.2	22.1	31.0
Price tendency	-4.0	-0.5	-2.4	-2.0

Note. Price tendency refers to the price tendency for investment goods of each type of capital.

Source: NIER.

C.1.4 Capital Share (V_K and $V_{K,i}$):

For the business sector as a whole, the cyclically balanced labour cost share is estimated at 60 percent. The capital share is thus 40 percent.[77] This is somewhat less than the actual capital share during the period 1997–2005. The capital share varies among the different industries, but in the projections it is assumed that the capital shares for the different types of capital in the various industries are constant.

[77] See NIER [2007].

Table C.2 Capital Share 2006–2020

Percent

Capital share	ICT industry	Manufacturing industry excl. ICT	Other-goods industry	Services industry excl. ICT
Total	0.35 (0.39)	0.32 (0.32)	0.46 (0.47)	0.42 (0.38)
Machinery	0.07 (0.08)	0.17 (0.17)	0.19 (0.17)	0.11 (0.07)
Buildings	0.15 (0.16)	0.10 (0.10)	0.25 (0.29)	0.27 (0.26)
ICT	0.13 (0.15)	0.06 (0.06)	0.01 (0.01)	0.05 (0.04)

Note: Capital share refers to the cost of capital in proportion to value added. The total capital share is equivalent to the profit share in the industry. Average values for 1994–2005 in parentheses.

Source: NIER.

C.1.5 Capital Deepening, Change in (*K/H*)

The contribution from capital deepening in each industry is determined exactly by the assumptions about the development of TFP, about capital cost shares and about the development of the relative prices of different investment goods. When the relative prices of different investment goods change over time (i. e. if the rates of price increase differ), the composition of the capital stock, and thus productivity growth as well, will be affected.

C.1.6 Productivity (*Y/H*)

In the projections, the development of productivity in each industry is determined by assumptions about the development of TFP, capital cost shares, the price tendency for different investment goods and changes in the quality of the labour force.

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