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IT – an Engine for Growth

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IT – an Engine for Growth

REGERINGSKANSLIET

Ministry of Industry, Employment
and Communications

Preface

The Ministry of Industry, Employment and Communications is developing an industrial and the labour market policy to promote sustainable and strong growth. As part of this work, an internal study was commenced by the Analysis Unit of the Ministry, focusing on IT and growth. The study has looked at the importance of information technology for economic growth and employment.

There are indications that product innovations that give rise to new demand, or improved quality of existing products, are more important for the development of employment than the actual introduction of new technology in the production process. From this perspective, the challenge is to increase the capability of the economy to absorb the new technology by removing the obstacles to the development of IT.

The rapidly growing IT sector is important for the Swedish economy, both by creating employment and contributing to growth. The number employed in the IT sector totalled just over six percent in 1999. The rapid expansion of the IT sector in recent years has resulted in a strong growth in employment in this sector. In the period from 1997 to 1999, those employed in the IT sector rose by just over 26,000 persons, which corresponds to just over 40 percent of the increase in employment in the entire business sector.

In addition, the IT sector contributed one-fifth of Sweden's real growth between 1993 and 1999. Sweden holds a strong position internationally both as a producer and exporter of IT products (i.e. hardware). In 1997, Sweden was the fourth largest producer in OECD of IT products.

Not only will the IT sector will be vital to future Swedish growth, but the use of IT (i.e. IT as input goods) in businesses, public authorities and organisations, will probably have the greatest impact on growth. The decrease in productivity growth in the OECD countries in the 1970s and 1980s, took place at the same time as IT started to reach commercial success. This raised doubts about the potential of the new technology to generate growth. However, new technology often requires widespread and costly additional investments, and it takes time before these investments give return in the form of more efficient production. Studies show that additional investments in work organisation, human capital and IT infrastructure, strengthen the impact of IT on business productivity.

A series of empirical studies in recent years have also shown the positive impact of the use of IT in businesses on growth and labour productivity. This indicates that we have now come so far in adapting to the new technology that it has started to reach fruition by contributing to increased growth.

This report also focuses on the opportunities and obstacles for the potential of information technology to be optimally used in the economy. Sweden has good access to general IT proficiency, seen in an international perspective. However, there is a shortage of both specialist and strategic IT proficiency (i.e. business-specific proficiency in combination with an awareness of the opportunities that IT offers to the business in question). The shortage of workers trained in IT has been highlighted as one of the major obstacles to the expansion of both the IT sector and other business sectors, and therefore must be taken seriously.

Finally, the report draws attention to the fact that the proportion of female graduates from institutes of higher education, as well as the proportion of employed females with training in IT, is low in Sweden. One way of building up a workforce proficient in IT, is to increase the interest of females in educational programmes based on IT.

All available resources are needed in a growing Sweden. Therefore, it is important that central government, employers, trades unions, and individuals work together to enable the growth potential of IT to be effectively used. The Ministry of Industry, Employment and Communications hopes that this enquiry can serve as a basis for discussions on how the potential of IT can be optimally used within the framework of the initiatives that have resulted from the Government Bill 1999/2000:86 *An information society for all*.

The internal working party that has conducted the study consisted of Mats Granér (Project Manager), Karine Jabet, Frida Widmalm and Lena Skott.

Stockholm January 2001

Birgitta Heijer

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Summary

Today, Sweden is one of the world's leading information technology (IT) countries. Swedish companies are at the forefront in the use of information technology, and lead the way in certain technology sectors. In addition, Sweden has a relatively well-developed IT infrastructure, and there is a high level of proficiency in IT at user level, both in businesses and in households.

This study focuses on the relation between economic growth and information technology. The purpose is to map and describe the significance of information technology in economic growth and employment, by considering IT as both produced goods (i.e. the IT sector), and as input goods used in production (i.e. the use of IT in the "traditional" economy). Another purpose of the report is to identify the conditions and obstacles for making optimal use of information technology's potential in the economy.

The concept of the New Economy

The expression "the New Economy" has become both a name for the new IT sector, and a description of the type of macroeconomic development that is characterised by economic growth, increasing employment, and low inflation, and one that lasts longer than a "normal" boom period. This report uses the concept of the New Economy in the latter context.

The majority of observers regard the spread of information technology as a key factor in the development of the New Economy. Whether the New Economy and the way it functions is genuinely new, or whether this development simply represents a "normal" adjustment to yet another technological breakthrough, is still a subject of debate. Major technological breakthroughs that stimulate economic development are nothing new in themselves. Printing techniques and the steam engine are examples of

information and communication technologies that had widespread economic and social effects, leading to economic growth over many decades.

IT and growth

According to the endogenous theory of economic growth, human capital, research and innovations are important factors for creating long-term economic growth. According to the theory, investments in skills often have a greater social economic value than private economic value.

Information technology can impact economic growth in at least three different ways. Firstly, the actual production of IT can have a positive effect on growth. Secondly, the role of information technology as an input good in the production of goods and services has a potential to impact growth. Finally, the use of IT can generate positive externalities which contribute to productivity.

Innovations in the IT sector can lead to wide-reaching externalities. Production of information technology leads to new innovations in businesses that use IT. In turn, these innovations stimulate the further development of information technology. In addition, the use of information technology facilitates the transfer of technology and knowledge, and can lead to network effects. This line of reasoning can be used as an argument to justify an active IT policy that stimulates the IT sector and the use of IT in businesses, public authorities, organisations and individuals.

New technology and employment

The link between new technology and employment is an important element in the ongoing debate about the relatively high levels of unemployment in Sweden and Europe. A common view is that new technology and increased productivity lead to job losses.

However, it is neither surprising nor troubling in itself that new technology eliminated certain jobs and work tasks. Different types of rationalisations are often the primary purpose of introducing new technology. According to economic literature, there is a series of mechanisms in the economy that, in combination with a technology-based structural change, create new employment opportunities at the same rate as the old ones disappear.

However, empirical research cannot provide any clear answers regarding the relation between new technology and employment on a macro level. There is no evidence that IT in the long term will create either unemployment or new employment opportunities on a large scale.

The restructuring places demands on skills development in the IT sector, both for the people made redundant and those who are in employment. The development of skills is also important since a highly skilled workforce is in much greater demand today than previously.

There are indications that product innovations that give rise to new demands, or that continually improve the quality of existing products, are more important for positive trends in employment than the actual introduction of new technology in the production process. From this perspective, the challenge remains to increase the capability of the economy to absorb the new technology, by removing the obstacles that hinder the spread of IT, for example.

The IT sector and the Swedish economy

The rapidly growing IT sector is significant for the Swedish economy, both by creating employment opportunities and promoting growth. In 1999, just over six percent of the total Swedish workforce was employed in the IT sector, and the number employed in the IT sector increased by just over 30 percent between 1994 and 1999. In the period from 1997 to 1999, the number employed in the IT sector increased by just over 26,000, which can be compared with an increase of 64,000 employed in the Swedish business sector as a whole.

Growth in production has been even more remarkable. The average annual growth in real value added totalled just over 20 percent in the period from 1993 to 1999. The most rapid growth has been in the production of teleproducts (mainly telecommunications and radio communications equipment). The sector’s real value added has increased on average by 47 percent a year during the period. The service side has also witnessed widespread growth. The rapid growth of the IT sector means that it now makes a significant contribution to Sweden’s total growth. The IT sector contributed a quarter of Sweden’s real growth between 1993 and 1999.

The Swedish IT sector is dominated by the production of IT services, both in terms of total numbers employed and value added. These services make up around 70 percent of the IT sector, in terms of both the employees and the value added.

In addition, the growth in labour productivity has been considerably higher in the IT sector than in other business sectors. The average annual growth of productivity in the IT sector was 12 percent between 1993 and 1999. The growth of productivity was strongest in the production of teleproducts, with an annual average of an impressive 36 percent during the period. The high growth of productivity in the IT sector has had a significant effect on overall business productivity. Between 1993 and 1999, nearly one-third of labour productivity growth in the business sector was attributable to the strong growth of productivity in the IT sector.

Sweden holds a strong position internationally, both as a producer and exporter of IT products (i.e. hardware). However, closer inspection shows that this leading position is mainly due to the production of telecommunications and radiocommunications equipment. In addition, a single company, Ericsson, dominates the production of this equipment.

Compared to many other OECD countries, Sweden has relatively large exports of IT-related services, which also gives the country a strong competitive edge in this sector.

There are indications that the shortage of a skilled workforce is the largest obstacle to the continued growth of the IT sector. Therefore, an active education policy should help satisfy the employment needs of the IT sector. For this purpose, better knowledge is needed about what skills will be needed in the future.

IT and other parts of the business sector

The development of the IT sector in itself will probably not be most significant influence on growth in the future. The impact of information technology will first be fully realised when it is integrated with the “traditional” economy’s production of goods and services.

The downward trend in the growth of productivity in the 1970s and 1980s took place at the same time as IT started to reach commercial success. This promoted a debate about a productivity paradox – that new technology could be associated with decreases, rather than increases, in productivity. In recent years, economic theories have been put forward to support the idea that the introduction of new technology that impacts on the entire economy and has many areas of use, can initially reduce the rate of growth. One explanation is that the new technology requires widespread and costly additional investments. It takes time before these investments result in efficient production.

In recent years, empirical studies have proved that the use of IT in businesses has had positive impact on growth and labour productivity. One study shows that one-third of the growth of the Swedish business sector between 1991 and 1997 was attributable to investments in IT hardware and software. This can partly be explained by the fact that elected representatives, businesses, public authorities and organisations have learnt that additional investments are needed in order to take full advantage of IT. Several studies show that additional investments in new ways to organise work and human capital strengthen the impact of information technology on the productivity of companies. Investments in IT infrastructure can also have been important for a more efficient use of information technology.

IT skills

The ongoing restructuring process has consequences for business sector's need for skilled labour. This applies to general, specialised and strategic proficiency in IT.

There are several indications that Sweden has good access to general IT proficiency, seen in an international perspective. In 1999, 67 percent of the population between the ages of 15 and 84, had access to a computer in the home, and 77 percent of those employed in the same age group had access to a computer at work. However, this does not mean that the general level of proficiency in IT need not be improved. Various groups in society, such as the elderly, have less access to computers and the Internet than other groups. Only 17 percent of the population between the ages of 65 and 84 had access to a computer at home in 1999.

The educational system must be continually reviewed so that basic and vocational/professional educational programmes teach the skills required by information technology. Educational programmes must be adapted to the ongoing developments within society. The rapid restructuring process and development of the technology require continual development of skills and lifelong learning in the workforce, as knowledge and skills have a sell-by date.

Most people are aware of the current shortage of IT specialists in Sweden. Around 80 percent of computer consultants and computer service companies point out the shortage of personnel with sector-specific proficiency, according to the National Institute of Economic Research service barometer in October 2000. The shortage of workers trained in IT has been highlighted as one of the major obstacles to the expansion of both the IT sector and other business sectors, and therefore must be taken seriously.

A suitable measure would be to set up a commission consisting of representatives from the state, the business sector, different interest and sector organisations, as well as arrangers of educational programmes, to achieve an overall grasp of the problem.

It is hard to draw any general conclusions regarding the supply of, and demand for, strategic IT proficiency, i.e. business-specific proficiency in combination with an awareness of the opportunities that IT offers to the business in question. There are indications that this type of proficiency is also in short supply.

A key issue for the strategic use of IT is awareness within companies of the value of, and opportunities created by, IT. Therefore, it is important to work towards an enhanced understanding of the business opportunities created by an organisation adapted to IT. In countries such as Japan, support is given to companies who implement IT strategies, and invest in information systems. The need for similar types of support functions in Sweden has also been pointed out.

The proportion of female graduates from institutes of higher education, as well as the proportion of employed females with training in IT, is low in Sweden. The low proportion of females among IT specialists means that society is missing out on an important resource. One way of building up a workforce proficient in IT, is to increase the interest of females in educational programmes based on IT. However, a study carried out by Statistics Sweden shows that upper secondary school students have exhibited less interest in technology-oriented higher education in recent years, and most of that decrease applies to females. This can indicate a negative trend.

1 Introduction

We stand right in the middle of a change in society. The industrial society is gradually being replaced by a new, growing knowledge and service society. The technological development in the IT sector is one of several factors that have contributed toward society's development towards a knowledge-based service society in recent decades. Even if IT has not been the direct cause of the changes, the technology has often been the stimulus, and has reinforced ongoing processes, such as the globalisation of the economy and the growing importance of skills and technology.

In February 2000, the analysis company, IDC, ranked Sweden as the world's leading IT country, closely followed by the United States and the other Scandinavian countries.[1] The IDC analysis, which compared around 50 countries with regard to how far they had come in the use of information technology, showed that Sweden has a strong base in the New Economy (World Paper, 2000).[2] For many years, Swedish companies have been at the cutting edge in the use of information technology, and Sweden is a leading country in certain sectors of technology. In addition, Sweden has a relatively well-developed IT infrastructure. One of Sweden's biggest strengths is the high level of use of IT, by both businesses and households.

The purpose of this report is to map and describe the significance of information technology – partly as a production commodity (i.e. the IT sector[3]), and partly as input goods in production (i.e. the "traditional" economy's use of IT) – for economic growth and employment. Another purpose of the report is to highlight the opportunities and obstacles so that the potential of information technology can be optimally used in the economy.

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[1] Iceland was not included in the study.
[2] See Section 2.1 for a discussion of the concept of "the New Economy".
[3] See Section 4.1 for a definition of the IT sector.

In this report, we have chosen to look, in the first instance, at the connection between economic growth and information technology. We do this for several reasons. A high rate of economic growth generates a higher level of economic welfare, which forms the basis of a successful welfare policy. The line of reasoning regarding the significance of information technology on growth also stimulates a discussion of other aspects of information technology, such as the need for a workforce proficient in IT.

Growth means an increase in the total production by the country. If the increased growth is to be regarded as sustainable, it must be sustainable from economic, ecological and social perspectives. However, this report will focus only on economic growth. IT may have other aspects that can come into conflict with economic growth, but these are not discussed in this report.

IT also has a series of welfare aspects that cannot be measured in terms of economic growth, such as the impact of information technology on the work environment. These aspects are not covered in this report either.

What is IT?

Today, IT is an established expression in our language, but its scope is not obvious. The National Encyclopaedia describes the term information technology (IT) as a "technology for the collection, storage and processing of data, as well as communication and presentation of data in different forms." This is one of the many definitions of information technology. Often, the expression information and communication technology (ICT) is used, to make clearer that both information processing and communication are included in the definition. In this report, we use the concept of IT as defined by the National Encyclopaedia, and the definition also includes digital technology for communication.

Outline of the report

Chapter 2 starts with an account of the expression "the New Economy." This is followed by a discussion, based on economic growth theory, of how new technology and innovations can stimulate growth. Finally, we look at the role of information technology in stimulating growth by considering IT: (1) as a production commodity, (2) as a tool in the “traditional” economy, and (3) from the viewpoint that the use of IT in businesses can generate positive externalities.

In the general debate, worries are often expressed that the introduction of IT leads to rationalisations that can lead to long-term unemployment. Chapter 3 includes a discussion of the possible impact of new labour-saving technology on employment, in both short and long terms.

The clearest sign that information technology contributes to growth is the rapidly growing IT sector (i.e. the companies that produce IT products and IT services). Chapter 4 includes a review of the importance of the IT sector for Sweden’s growth. An international comparison of the scope of the sector, as well as the export of IT goods and IT services, is included to show the competitiveness of the Swedish IT sector.

The IT sector is already becoming more important for the economy, but the use of IT (i.e. IT as input goods) in industry, public authorities and organisations, will probably have its greatest impact on growth in the longer term. Chapter 5 looks at the reasons why empirical research has found it hard to prove the impact of the use of IT on productivity. In recent years, a number of studies have presented a more positive picture of the impact of information technology on growth and productivity, and these studies are also presented. Finally, we discuss how additional investments in new work organisations, human capital and IT infrastructure can improve the opportunities to make full use of the potential of information technology.

Perhaps the single most significant factor, both for the future of the IT sector and for an efficient use of information technology as an input good, is the access to a workforce proficient in IT. In Chapter 6, the concept of IT proficiency is discussed, and the chapter also looks at the supply of, and the demand for, this proficiency. In addition, the chapter includes a description of various measures aimed at solving the problem of the shortage of workers skilled in IT . Finally, we look at the situation in other countries regarding shortages in the surrounding environment and the measures being implemented to remedy them.

2 New technology and growth

The New Economy has become something of a fashionable term that often crops up in the media. The expression has become both a title for the IT sector, and an expression for the primarily American economy’s remarkable development in recent years. A number of observers suggest that the IT revolution has meant that old economic “laws” no longer apply, and that the business cycle has ceased to exist in principle. However, the change over time in the connection between different macroeconomic features is not a sufficient reason to change the very basics of economics. At least, not until there are plausible alternative theories.

In this report, our starting point is that the New Economy involves an increase in production growth over a period that is longer than a “normal” boom. Several observers state that the spread of information technology is a key factor in this development. Today, it is too early to say whether Europe will experience the favourable economic development we have seen in the United States. It is also too early to say with any certainty what impact IT will have on general economic development. We will not understand the total impact of information technology on the economy until the new technology is fully integrated with the “traditional” economy’s production and consumption of goods and services.

In this chapter, we discuss how IT and other technological innovations can contribute to economic growth and productivity. The introductory section attempts to ascertain what is really meant by the New Economy. This is followed by a brief summary of the “modern” economic theory of growth, in which the introduction of new technology and investments in human capital are seen as the primary factors for long-term growth. Finally, we have limited the discussion to how information technology can increase productivity and growth.

2.1 What is the New Economy?

The expression "the New Economy" is often used to refer to the IT sector and related activities. The New Economy is then associated with sectors that include a strong element of new technology. According to this interpretation, "the Old Economy" should then constitute the rest of the economy, i.e. the industries that produce "old" goods and services, the public sector that produces the same services as before, etc. Naturally, there is no watertight division between the Old and the New Economies. The New Economy interlocks with the traditional activities, and the "old" stimulates development in the "new" through the demand for its products and services.

Another phenomenon that has also been associated with the New Economy is an economic trend that is characterised by economic growth, increasing employment, and low inflation, and one that lasts longer than a "normal" boom. The clearest example of this is the United States, which has experienced this phenomenon throughout the 1990s. But this pattern is also evident in Sweden. In the last three years, open unemployment has been halved, from just over eight percent in 1997 to four percent in October 2000, and at the same time, inflation has been at a historically very low level. Economic growth has also been strong: 3.6 percent in 1998 and 4.1 percent in 1999.

Is there a connection between these two definitions of the New Economy? Does the new information technology promote the favourable macroeconomic development, and if so, is this a new connection? Can policy conclusions be drawn to promote continued growth, employment and stable prices?

The answer is probably yes to the first and the second questions. Many studies at micro level indicate the positive impact of investments in IT capital on productivity (see Chapter 5). At the same time, the increased use of IT also has positive effects on growth, but this is hard to measure. Examples of this are network effects, i.e. the use of IT by different players has a favourable impact on the productivity of other players.[4]

However, it is not only the spread of information technology that is thought to contribute to the increase in productivity

[4] The use of IT also has significant effects on welfare that are not included in the National Accounts. The opportunity to conduct bank business from a home computer, play computer games over the Internet, and participate in electronic discussion groups, are examples of how the use of IT can enhance individual welfare without directly contributing to GNP.

growth. Increased international integration and globalisation are also thought to play a role. But even if this partly results from political decisions to reduce trade barriers, the spread of information technology has stimulated globalisation. An example of this is the internationalisation of the financial markets, which is a result of efficient data communication in combination with deregulation of the currency markets.

Whether the New Economy, and the way it operates, is genuinely new, or whether the development is only a "normal" adaptation to yet another technological breakthrough, is still a subject of debate. Föreningssparbanken's economic secretariat questioned 100 economists in the EMU countries about this.[5] 42 of the respondents took the view that the New Economy is something genuinely new, and not merely a question of major technological innovations. However, the study did not report on the ways in which the respondents thought it was new.

Major technological breakthroughs that promote economic development are nothing new in themselves. The art of printing and the steam engine are examples of information and communication technologies that had widespread economic and social impact and which contributed to economic growth for several decades.

2.2 Theories of economic growth

Theories of economic growth can be divided into traditional and new theories. The main differences between them are the view of capital as a factor of production, and their conclusions about long-term growth.

According to traditional neoclassic economic theory, the total economic growth per capita can be divided up into the following components: increased input of work per capita (i.e. increased level of use and/or work time), increased input of capital per capita, and increased productivity. In the long term, the opportunities to increase the level of use or work time per capita are limited, which leaves investments in physical capital, such as machinery, and increased productivity, as the most significant factors stimulating long-term growth.

A common result in empirical studies of productivity is that production has increased, even when the increased input of the

[5] See "Onyanserad debatt om den nya ekonomin", Dagens Industri, 7-7-2000.

factors of production and/or their quality has been taken into account. The source of this residual item in growth statistics is usually called total factor productivity, and as a residual item, can be said to be a total measure of everything else that influences the conditions of production.

The neoclassical theory does not explain the reasons for long-term growth, and therefore gives no recommendations on how it can be stimulated. The long-term growth of the economy is mainly caused by technological development (which increases productivity), but whatever creates the technological development has to be sought outside the theory.

Dissatisfaction with a theory that is incapable of explaining the growth experienced by the western world in the last two hundred years other than by “technological development,” led to the development of the endogenous theories of growth. The expression "endogenous" emphasises that the growth of the economy is explained by factors and relations *within* these models, instead of assuming they are to be found *outside* the model.

According to the endogenous theory of growth, the primary factors in creating long-term economic growth are human capital, research and innovations. According to the theory, innovations and investments in skills often have a greater social economic than private economic value. Lööf (1999) exemplifies how long term economic growth is created according the endogenous theory of growth:

> “A profit-maximising company interprets the, as yet, weak and diffuse market signals earlier than its competitors. The company collaborates with a research company to produce the new product, which it plans to sell at a monopoly price for as long as the company maintains its lead over the competitors. Thereby, the costs of innovation are also met. The research company has two products. Firstly, the patent that it sells at the market price, and secondly, a contribution to society’s common bank of knowledge, for which it receives nothing. The increased bank of knowledge increases the productivity of all future innovators. This has an important impact on economic development, since growth is increased by the flow of innovations. The new product of the profit-maximising company leads to increased differentiation between products, and increased division of labour, and these

> results have a positive impact on the productivity of the workforce and the capital."

Innovations thus play a central role in the endogenous theory of growth. This implies that information technology can have significant potential in generating growth.

2.3 IT and growth

Information technology can contribute to economic growth in at least three different ways. Firstly, the actual production of IT can have a positive impact on growth. Secondly, the role of information technology as an input good in the production of goods and services has the potential to impact growth. Finally, the use of IT can generate positive externalities that contribute to total factor productivity.

IT can be of obvious economic importance through the production of IT products and IT services. Even if the IT sector is responsible for only a relatively small part of the economy, the contribution to growth can be significant if the IT sector grows faster than other sectors. In addition, the rapid technological development in the IT sector can lead to increased labour productivity in the sector. The contribution of the IT sector to growth in Sweden will be discussed in Chapter 4.

In its role as traditional input goods, IT differs very little from other capital goods used in production. The increased use of IT as a factor of production can be explained by a falling relative price, which means that IT is becoming cheaper in relation to workforce and other capital goods. If companies replace the workforce and other capital with IT capital, the investments in IT do not necessarily lead to an increase in production for the company making the investment. However, an increase in the use of IT should lead to increased labour productivity, since the amount of capital stock (IT capital and other capital) per employee is increased. This will lead to increased growth in the long run, according to historical experience and economic theory. At the same rate as jobs disappear, and productivity increases, new resources are freed that lead to increased demand, which in turn leads to increased production.

However, IT is best described, not as traditional input goods, but rather a technology that is embraced by the expression General

Purpose Technologies (GPTs).[6] A GPT has been defined as: (1) a technology with great potential for continued development; (2) a technology that can be used in a wide variety of areas of use; (3) a technology that can be applied throughout the economy; and (4) a technology that is a strong complement to other technologies (Lipsy, Bekar and Carlaw, 1998). The expression places information technology in the same category as earlier breakthroughs, such as the steam engine and the electric motor.

Many economists suggest that innovations with these characteristics play a significant role as driving forces for growth. A characteristic of GPTs is that they normally give rise to an economic return that is considerably higher than the normal return on investments. The big gain resulting from investments in this type of technology comes when they stimulate new technological innovations and changes in the organisation of companies. Company investments in GPTs not only give an extraordinary return for the company, but also give a social return that exceeds the return received by the company making the investment. Investments where the gains exceed the return that is received by the financiers of the investment, usually give rise to positive externalities effects. These positive external effects create growth through increased total factor productivity.

A striking example of the importance of information technology is biotechnology, whose rapid progress would not be possible without information technology. Today, it is almost impossible to find examples of innovations or technological development where IT is not important.

Technological development is not isolated processes conducted in individual companies, but sooner a development that often takes place as a collaboration between companies. Through cooperation, companies can benefit from the skills of other companies and organisations, and new ideas develop from the interface between different skills and experience. IT can be a tool that facilitates the transfer of knowledge and technology by opening up possibilities for closer cooperation, especially over larger geographical areas (see NUTEK, 2000c).

Another example of how the use of IT can lead to a social economic return that exceeds the return for the private company or the individual, is the occurrence of network externalities. A common example of a commodity whose consumption creates

[6] The expression was first used by Bresnahan and Trajtenberg (1995).

positive externalities is the telephone. For every new subscriber, the value increases for all other subscribers. An identical line of reasoning can be put forward regarding the computer in its role as an aid to communication. When more people are connected to a network, such as the Internet, the network itself becomes more useful. These effects can also occur when the network is not a physical network, but one that is held together in the form of a standardised platform. Anyone choosing a personal computer can choose to be part of the network that has most users. The more people that use personal computers, the more and better applications, such as software, that will probably develop on the market. This means that an increased use of personal computers, both in their role as a communication medium and as a tool for information processing, is expected to lead to an increase in the productivity gains generated by computer use.

In recent years, there has been a widespread development of theory, within the framework of the endogenous theory of growth, regarding the importance of technological breakthroughs for economic development. The theoretical models, supported by historical experience, indicate that it takes time before the opportunities afforded by a new GPT become reality. The transition can even cause productivity to fall and slow the rate of growth, before the new technology is sufficiently established to release new and more expansive forces. Another explanation for the introduction of a GPT lowering the rate of growth in the short term, is that the development of the new technology attracts research and development resources that, in an initial phase, could have been used more efficiently in the Old Economy. Another, and probably more significant, explanation is based on the fact that the new technology brings with it the need for widespread additional investments in human capital, physical capital, and a new way to organise work. These investments are costly, and it takes time before they bring a return in the form of more efficient production. In Chapter 5, we will discuss in more detail the importance of additional investments for an improved use of information technology.

2.4 Concluding remarks

According to the endogenous theory of growth, significant factors in explaining productivity growth are the externalities resulting from R&D, education and innovations. One conclusion that can be drawn from this theory is that there is a risk for permanent under-investment, and thereby a lower rate of growth, if the development in these areas is only guided by market requirements. This provides the state with an opportunity to hasten growth by stimulating the development of know-how, and by creating an institutional environment that stimulates innovative activities and entrepreneurial spirit. But the state can also inhibit growth by measures that reduce the entrepreneur’s incentive to earn money (Lööf, 1999).

IT is an innovation that can give rise to comprehensive externalities. The production of information technology leads to new innovations in the companies that use IT. In turn, these innovations create an incentive to develop information technology. In addition, the use of information technology facilitates the transfer of technology and knowledge, and can give rise to network externalities. These conditions can be used as arguments for an active IT policy that promotes the IT sector and the use of IT in companies, public authorities, organisations and by private individuals.

3 New technology and employment

The relationship between new technology and employment is an important aspect in the ongoing debate concerning the relatively high levels of unemployment in Sweden and the rest of Europe. A common notion is that new technology and increased productivity cause jobs to be lost. Advocates of this view do not accept that today's unemployment is a short-term deviation from full employment. Their argument is that a trend is starting in which the world's affluent countries will virtually not need any workforce. In the future, goods and services will be produced by intelligent machines using information technology, and not by humans (Rifkin, 1995).

However, it is neither surprising nor troubling in itself when new technology eliminates certain jobs and tasks. Often, the primary purpose of introducing new technology is to bring about different types of rationalisations. According to the Austrian economist, Schumpeter, technological changes can be seen as a process of *creative destruction*, i.e. a process by which old technology and obsolete production patterns are forced out, and replaced with more up-to-date and more efficient technologies.

The idea that the introduction of new technology generates high unemployment is not new. In the United Kingdom in the 1820s, a fear was expressed that the growing productivity that resulted from the introduction of machines would reduce employment and force down wages.[7] However, this hypothesis has proved to be wrong, so far. Instead, historical experience shows that increased productivity has contributed to increased demand for workers, as well as higher real wages (OECD, 1994). The question is whether this also applies to IT.

This chapter aims to briefly describe the relationship between IT and employment. The introduction discusses the relation between

[7] See Woirol (1996) for a more detailed discussion of the historical debate.

new technology and employment, seen from a theoretical national economic perspective. This is followed by a general survey of the empirical research on the subject.

3.1 Compensation mechanisms

According to the neoclassical school, the introduction of new technology will not lead to unemployment in the long term. The price of labour, i.e. wages, will fall if unemployment increases. The demand for labour will then rise, and the original level of employment will be reattained.

However, this view has been strongly criticised since the level of wages is often slow to fall. A wage cut can be difficult to implement for political, social, historical and/or institutional reasons. For example, lowering wages can be hard to implement in a country where the trades union movement is strong. In addition, the degree of that substitution is possible between the work and capital factors of production can be limited. In this type of situation, a reduction in wages will not have any great impact on the level of unemployment.

In addition to the wage mechanism, a number of other mechanisms exist in the economy that create new job opportunities at the same rate as the old ones disappear. However, unemployment can occur in the short term if the compensation mechanisms do not operate satisfactorily. In other words, the economy is not capable of creating new jobs at the same rate, or to the same extent, as others disappear.

What, then, are the compensation mechanisms that could recreate full employment after a technology-based restructuring (see OECD 1994, Lundgren and Wirberg, 1997, and Spizia and Vivarelli, 2000)?

Firstly, substitution effects can occur. These can be direct, i.e. certain jobs disappear at the same time as others appear at the individual workplace. One example is that a secretary may be made redundant, at the same time as a computer engineer is recruited at the same workplace. Even indirect substitutions can occur, where jobs that disappear in one industry are replaced by new jobs in another industry.

Secondly, a price effect can occur. A rationalisation generally implies reduced production costs, which in turn means that the price of the product can be reduced. This leads to increased sales, which, depending on the price sensitivity of the demand and the labour intensity of the production, can counteract the initial employment losses.

Thirdly, an income effect can occur. Rationalisations that result in increased productivity imply higher wages, profit, or some other kind of return. In turn, this can create increased demand elsewhere in the economy, which can promote a higher level of employment.

Fourthly, the new technology can give rise to completely new products. New technology not only has consequences for the production process, it can also create new products, markets or form the basis of completely new industrial activities. This, in turn, can have a positive impact on employment.

However, there are a number of objections to the efficiency of the compensation mechanisms.

One objection is that the increase in demand from certain consumers is counterbalanced by reduced demand from other consumers, namely the people who are made redundant as a result of rationalisations (Lundgren and Wirberg, 1997). In addition, the relation between an input-reducing new technology and increased productivity has been questioned. This is known as the productivity paradox.[8]

A number of other people, such as Ricardo (1951), claim that a reinvestment of the profits generated by rationalisation does not necessarily mean that new employment opportunities are created. To a large extent, this depends upon the character of the investment. If a large share of the investment is of a labour-saving character, this may lead to greater unemployment instead. In addition, there is often a significant time lag between the realisation of the gains of the rationalisation, and the implementation of new investments.

According to OECD (1994 and 1996), the efficiency of the compensation mechanisms depends on a number of factors that are mainly macroeconomic and institutional. Rapid economic growth, for example, will strengthen the compensation mechanisms through increased demand and investments. In addition, institutional factors can impact the degree to which the job potential created by the technological development becomes actual job opportunities. The operation and flexibility of the employment and production markets, as well as the capability of the economy to adapt and learn to use the new technology, are important in this

[8] See Section 5.2 for a more detailed discussion of the productivity paradox.

context. In an economy with a specialised workforce, there is a risk of structural unemployment if the introduction of a new technology rapidly reduces the value of a certain skill. The situation can be exacerbated if, at the same time, there is a shortage of the proficiency demanded by the new technology. A discrepancy between the supply of, and demand for, labour can lead to inefficiency and disruptions to production, which in turn can make the unemployment more persistent. In terms of the product market, the degree of competition, as well as the opportunity for economies of scale, are the determining factors for price mobility.

3.2 Empirical results

Historical experience shows that unemployment often rises initially after the introduction of new technology, but that many new jobs are created later. These new jobs more than compensate for the number of jobs initially lost (OECD, 1994). The question is whether or not IT differs from previous technological innovations.

All sectors in the economy can benefit from IT. Earlier labour-saving technological innovations, such as electricity and the production line, initially impacted only manufacturing industry, and so only had consequences for a limited part of the workforce. The people that were then made redundant could quickly be reabsorbed by sectors growing elsewhere in the economy.

Another argument is that IT is spreading more rapidly than previous technological innovations. One consequence of this is that today's society has a shorter time in which to adapt, i.e. to retrain the people whose skills have become obsolete (Rifkin, 1995).

What, then, does the latest empirical research say about the relationship between new technology and employment?

Empirical studies show that there is probably a positive connection between the introduction of new technology and employment on a micro level (Van Reenen, 1997 and OECD, 1998).

However, it is difficult to draw any conclusions from studies conducted at micro level, about whether the introduction of new technology also has positive impact on employment at a sector/industry level. If an innovation leads to redundancies in a certain industry, and if the dissemination of technology is slow in the industry, the job losses can be temporarily counteracted when the first companies to implement the new technology (temporarily) increase their market share (Van Reenen, 1997). The relationship between new technology and employment at sector/industry level therefore depends upon the types of jobs created, the extent to which the new job opportunities replace others, and the impact of the introduction of new technology on competing companies in other industries or countries (OECD, 1998). The empirical research gives no clear answers to this.

It is also difficult to establish the effects, at macro level, of an introduction of new technology on employment.

Vivarelli (1995) studied the efficiency of the compensation mechanisms, using data from Italy and the United States. According to his study, the most efficient compensation mechanism was reduced prices. However, market forces compensated only a part of the initial savings caused by job losses. The profits that arose from the rationalisations were reinvested, but the investments were often allocated to the introduction of further labour saving technology. However, the negative impact on employment was counteracted in the United States by the positive impact of the product innovations on employment. In the case of Italy, another factor was important, namely the progressive and constant reduction in the total number of hours worked per capita per year.

Other studies also emphasise the importance of product innovations. Product innovations probably have a larger positive impact on employment than innovations that impact on the production process (OECD, 1994 and Van Reenen, 1997).

OECD (1994) has compiled a number of empirical studies conducted in the 1980s. The studies show that, generally speaking, there is no evidence to suggest that the introduction of new technology creates unemployment, but at the same time, there is no support for the view that information technology will create new job opportunities on a large scale. Compared to other factors, such as fluctuations in macroeconomic demand and growth, the impact of technological innovations on employment is limited. On the other hand, new technology gives rise to comprehensive “job switches” when technological innovations create jobs in certain sectors and rationalise jobs in others. Today, for example, a switching of jobs can be observed in OECD countries, from the manufacturing sector to the service sector.

Studies also show that IT has impacted the demand structure of the workforce with regard to skills. Mellander (1999) studied why the demand has fallen for poorly educated workers in the Swedish manufacturing sector. The study is based on data from 24 sectors within the manufacturing industries between 1985 and 1995. The study shows that technological development has not benefited poorly educated people, in this case defined as people with no more than the compulsory school education (see Section 5.3.2).

There are indications that the countries that rapidly implement new technology also show a greater increase in domestic employment compared to other countries. For example, OECD (1998) showed that the countries[9] that invested most in new technology (measured as the share of investments in IT in relation to total investments) between 1985 and 1995 also showed the greatest increase in employment. Although this applies to the economy as a whole, the relation between investments in IT and employment was also found in the service sector. In addition, the relationship applied, if less clearly, to different segments within the service sector, namely for the wholesale and retail trade, as well as for the financial and insurance sectors, in which labour-saving technologies have been introduced on a large scale.

3.3 Concluding remarks

The theoretical review shows that the introduction of new technology can have both positive and negative effects on employment. Therefore, the relation between new technology and employment is an empirical question.

However, the empirical research gives no clear answers to the question about the relation between IT and employment at a macro level. There is no evidence that IT will either create unemployment or new job opportunities on a large scale, in the long run.

It may be that the adjustment process regarding the skills of the workforce is more comprehensive than when earlier labour-saving technological innovations were introduced. This is because a greater number of people are affected, and because technological development today is so rapid. Restructuring places demands on the development of skills in the IT sector, both for the people

[9] The countries included in the review were France, Italy , Japan, Canada, UK, USA and West Germany .

affected by unemployment and those still employed. Skills development is also important in that today, a highly skilled workforce is in much greater demand than earlier.

There are indications that product innovations that give rise to new demand, or continually improved quality of existing products, are more important for the development of employment than the actual introduction of new technology in the production process. From this perspective, the challenge consists of increasing the capability of the economy to absorb the new technology, for example by removing the obstacles that hinder the development of IT.

4 The importance of the IT sector for the Swedish economy

There are clear indications that Sweden has comparative advantages regarding the production of IT, especially in the field of cellular communication. In Chapter 2, it was stated that IT can create growth through the production of IT goods and IT services. This can occur directly because the IT sector consists of industries with a more rapid rate of growth than the rest of the economy. Another contribution, which is harder to measure, is the transfer of knowledge and technology to other sectors in the economy.

Another argument as to why an expanding IT sector is significant for Sweden was presented in Chapter 3. The spread of information technology means that certain types of jobs are rationalised. The new job opportunities that are offered in the rapidly growing IT sector are important for avoiding high levels of unemployment during the current restructuring.

In this chapter, the importance of the IT sector for Sweden's growth and competitiveness is analysed. The chapter starts by attempting to define the IT sector. This is followed by a section that focuses on the importance of the IT sector for employment, GNP and real growth in Sweden. To illustrate the competitiveness of the Swedish IT sector, various countries are compared regarding the scope of the sector, and the export of IT goods and IT services. Finally, the conditions for continued growth of the IT sector are discussed.

4.1 What is the IT sector?

The IT sector includes the companies that produce IT goods and IT related services. However, the scope of the sector is not clear. In a development where goods increasingly include digital components, and more and more services are connected to IT, it becomes more difficult to define the sectors that produce IT goods and IT services. In this study we use the OECD definition of the IT sector.[10] The sectors included in this definition (see Table 4.1) can roughly be divided into two categories – the production of hardware, and the production of IT services. Partly for practical reasons, we have chosen to divide up the production of hardware into the following categories: office equipment and computers, teleproducts and other hardware. The service companies are divided into three subsectors: wholesaling and renting, telecommunications services, and information processing activities.

Defining the IT sector according to business sectors causes unavoidable measuring errors. Companies classified in an industry that is part of the IT sector can also produce goods and services that are not related to IT. This leads to an overestimation of the scope of the IT sector. On the other hand, there are companies that produce IT products and IT services, but not as their main activity. This leads to an underestimation of the size of the IT sector.

One way of avoiding at least some of these problems is to focus on goods defined as IT products. The sales of IT products can easily be calculated by using commodity statistics as a base. However, this type of definition based on goods does not give the opportunity of estimating either the value added or the numbers employed in the sector. In addition, it is not possible to measure the scope of IT related services based on commodity statistics. A definition using industrial sectors permits the presentation of a more complete picture of the IT sector. However, in the presentation of trade statistics, and in certain international comparisons, we have used the commodity statistics.

[10] The OECD definition was established in September 1998 at a meeting of the OECD Committee for Information, Computer and Communications Policy.

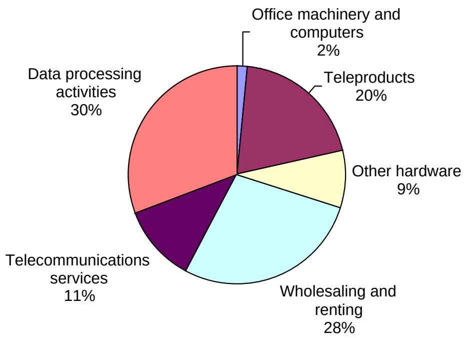
Table 4.1: Sectors included in the IT sector, according to the OECD definition

Sector code according to SNI92	Title
	HARDWARE
	Office machinery and computers
30.01	Manufacture of office machinery
30.02	Manufacture of computers and other equipment for information processing
	Teleproducts
32.10	Manufacture of electronic components
32.20	Manufacture of radio and TV transmitters, line telephony and line telegraphy
32.30	Manufacture of radio and TV receivers, apparatus for sound and video signals
	Other hardware
31.30	Manufacture of electrical wire and cable
33.20	Manufacture of instruments, apparatus for measuring, checking, testing, but not industrial process control
33.30	Manufacture of instruments for control of industrial processes
	IT SERVICES
	Wholesaling and renting
51.43	Wholesaling of household appliances, radio and TV commodities
51.64	Wholesaling of office machinery and office equipment
51.65	Wholesaling of other machinery for industry, trade and sea navigation
71.33	Renting of office machinery and office equipment, including computers
	Telecommunications services
64.20	Telecommunications
	Data processing activities
72.10	Consulting activities regarding hardware
72.20	Consulting activities regarding systems and software
72.30	Data processing
72.40	Database activities
72.50	Maintenance and repair of office and book-keeping machinery, and data processing equipment
72.60	Other activities related to computers

4.2 Employment in the IT sector

According to the central registry of companies and workplaces (*CFAR*), around 219,000 persons were employed in the IT sector in 1999. This corresponds to just over six percent of the total workforce. Of these, 66,000 persons were engaged in the production of hardware (office machinery and computers, teleproducts, and other hardware), and 65 percent of these were engaged in the production of teleproducts. Approximately 70 percent of those employed in the IT sector were employed in IT-related service companies, of which 43 percent were engaged in data processing activities, 41 percent in wholesaling, and 16 percent in telecommunications services (see Figure 4.1).

Figure 4.1: Persons employed in the IT sector in 1999, divided according to industry



Source: Statistics Sweden, CFAR

In 1998, just over 30 percent of those employed in the IT sector were female, according to the register-based labour market statistics (*RAMS*). The proportion of females in the IT sector is lower in the IT sector than in the private sector in total (37 percent in 1998).

The rapid expansion of the IT sector in recent years has resulted in a strong growth in employment in this sector. The numbers employed in the IT sector increased by nearly 30 percent between 1993 and 1999 (see Table 4.2). In the period 1997 to 1999, the numbers employed in the IT sector rose by just over 26,000 persons, which can be compared to an increase of around 64,000 employees in the entire business sector (NUTEK, 2000b).

The numbers employed in data processing activities more than doubled between 1993 and 1999. The numbers employed in hardware, teleproducts and wholesaling increased by between 20 and 50 percent over the same period. The numbers employed in telecommunications services decreased by 36 percent over the period, which can largely be explained by Telia's large personnel cutbacks.

Table 4.2: Growth of employment in the IT sector between 1993 and 1999 (figures in per cent)

Subsector	1994	1995	1996	1997	1998	1999	1993-99
Computers and office machinery	3.8	-31.6	-13.8	-3.4	-22.1	18.0	-45.7
Teleproducts	6.9	6.0	-1.7	23.1	6.7	0.8	47.5
Other hardware	3.0	16.7	0.0	9.5	4.8	3.4	42.6
Hardware Total	5.4	3.6	-2.3	16.9	4.2	2.4	33.1
Wholesaling and renting	-6.3	9.4	5.7	5.5	4.4	1.1	20.8
Telecom. services	-23.4	-11.5	-2.7	8.9	1.2	-12.1	-36.1
Data processing	3.4	9.9	16.6	9.0	20.7	21.1	111.2
IT services Total	-9.3	3.9	7.2	7.5	9.4	6.2	26.9
IT sector Total	-5.0	3.8	4.1	10.3	7.7	5.0	28.1

Source: Statistics Sweden, CFAR

Of all the employees in the IT sector in 1998, 60 percent were located in the larger metropolitan areas.[11] One-sixth were employed in university and university college regions, and the same proportion was found in regional centres. The other three region families – secondary centres, small regions with predominantly private employment, and small regions with

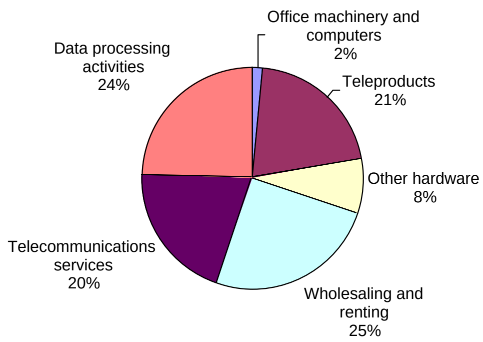
[11] In 1998, Sweden was divided into six region families, namely large metropolitan regions, university and university college regions, regional centres, secondary centres, small regions with private employment and small regions with public employment. A region family consists of several local labour market regions (LA). The region families are compiled from the production conditions of the different LA regions.

predominantly public employment, comprised only around seven percent of the total number employed in the IT sector. Therefore the IT sector is largely concentrated in the large metropolitan areas, and primarily in the Stockholm area. In 1998, nearly 45 percent of the employees in the IT sector were located in the County of Stockholm (NUTEK 2000a).

4.3 The value added by the IT sector and its share of GNP

Just over 70 percent of the value added by the Swedish IT sector stems from the IT-related service sector. In the service sector, wholesaling and renting, telecommunications services, and data processing activities have approximately equal shares of the value added. As Figure 4.2 shows, the production of hardware is dominated by teleproducts, making up two-thirds of the value added in 1998.

Figure 4.2 Values added in the IT sector 1998, divided according to subsector



Source: NUTEK (2000_a), Statistics Sweden, Company statistics

The IT sector's share of GNP provides an indication of the importance of the IT sector. The value added as a share of GNP has increased from 5.2 percent in 1993 to 7.3 percent in 1998 (see Table 4.3). With the exception of the production of computers and office machinery, all subsectors increased their shares of GNP between 1993 and 1998. The preliminary GNP shares of four subsectors can also be calculated for 1999. One interesting observation is that the teleproducts share of GNP has fallen each year since 1996. In contrast, the share of GNP attributable to data processing activities has increased strongly each year, which has resulted in more than a doubling of the share of GNP since 1993.

Table 4.3: The IT sector's value added as a share of GNP 1993 to 1999 (figures in per cent)

Subsector	1993	1994	1995	1996	1997	1998	1999
Computers and office machinery	0.15	0.14	0.12	0.11	0.11	0.14	0.12
Teleproducts	0.78	0.95	1.03	1.23	1.17	0.98	0.79
Telecom. services	1.42	1.44	1.47	1.61	1.73	1.80	1.88
Data processing	1.05	1.14	1.25	1.47	1.64	2.00	2.34
Total of above	3.40	3.67	3.87	4.42	4.65	4.92	5.13
Other hardware	0.44	0.53	0.56	0.56	0.58	0.61	--
Wholesaling and renting	1.41	1.56	1,.53	1.58	1.74	1.79	--
IT sector Total	5.25	5.76	5.96	6.56	6.97	7.32	--

Notes: The data for 1999 is preliminary. Source: Statistics Sweden Company Statistics (other hardware and wholesaling and renting) and the National Accounts (other subsectors).

4.4 The contribution of the IT sector to Sweden's growth

The development of the IT sector's share of GNP underestimates the significance of the IT sector. Great improvements in the quality of IT products, especially with regard to computers, cellular telephones and semi-conductors, have been achieved without a corresponding rise in the costs of production. This has led to a fall in the prices of these products. Consequently, the IT sector's share of the country's total production has actually increased more than is indicated by the development in shares of GNP.

Measurements of the IT sector's real growth are associated with uncertainty. Fixed price calculation of service production is a difficult area in the National Accounts and there are no indices that measure these types of service. Trends in the prices of consulting services are particularly difficult to measure, since the services sold are often unique. Therefore, other methods must be used in the National Accounts for fixed price calculation, and in

Sweden we mainly use wage indices. In the United States, an index for standard software has been developed using hedonic methods. This index deviates strongly from wage indices since it incorporates improvements of quality in the products. Consequently, the National Accounts real growth figures that are used here should be interpreted with a certain degree of caution.[12]

As can be seen in Table 4.4, there has been substantial growth in three of the four IT subsectors where the growth can be calculated.[13] The exception is the production of office machinery and computers, a subsector that shows a negative trend. Teleproducts deviate from other subsectors by showing a particularly strong growth. The average annual growth in value added between 1993 and 1999 was 47 percent. This has caused the real value added by the sector to increase ten-fold since 1993. But growth has also been strong in the data processing activities and telecommunications services, with an annual growth rate of around 11 and 12 percent respectively over the period. These are considerably higher figures than the average growth rate of industry.

Table 4.4: The real growth of the IT sector and other business sectors, 1993 to 1999[a] (figures in per cent)

Subsector	1994	1995	1996	1997	1998	1999	1993/99[b]
Computers and office machinery	-5.8	-11.6	-8.3	-3.8	30.8	-8.8	-2.2
Teleproducts	74.8	55.5	65.4	34.8	35.6	23.4	47.1
Telecom services	11.0	13.0	9.5	15.0	9.9	12.2	11.8
Data processing	12.6	9.2	3.0	12.4	12.9	17.0	11.1
IT sector Total	25.4	21.9	21.7	19.2	17.9	15.8	20.3
Manufacturing industry	15.0	9.6	2.1	5.3	6.9	4.1	7.1
Service sector	1.5	5.2	2.7	3.8	4.0	5.1	3.7
Business sector Total	4.5	6.2	1.8	3.6	4.5	4.6	4.2

Notes: [a]Exclusively wholesaling and renting, and other hardware. [b] Average annual growth.
Source: The National Accounts

[12] From 2001, Statistics Sweden will be receiving increased resources to produce economic statistics. Some of the funding will be used for work in improving fixed price calculations of the service production. In addition, the newly established study to look into economic statistics will take up these issues.
[13] It is not possible to deduce the real growth for wholesaling and renting, and other hardware, from the National Accounts.

The contribution of the IT sector to Sweden's economic growth can be calculated as the difference between the real growth in GNP, and the GNP growth excluding the contribution of the IT sector. The difference indicates how much the growth of GNP has increased as a result of the IT sector growing more rapidly than the rest of the economy.

The real growth in the economy was 4.13 percent in 1999. The growth in the economy excluding the four subsectors in the IT sector where data of real growth is available, was 3.53 percent. This means that the contribution of IT (excluding wholesaling and renting, and other hardware) to the economic growth in 1999 was 0.6 percentage points, or expressed another way, 15 percent of the growth (see Table 4.5 and Figure 4.3). This was in spite of the IT sector's share of GNP being only just over five percent. Of the GNP growth of around 20 percent between 1993 and 1999, the IT sector contributed with 5 percentage points, i.e. one-quarter of the growth.

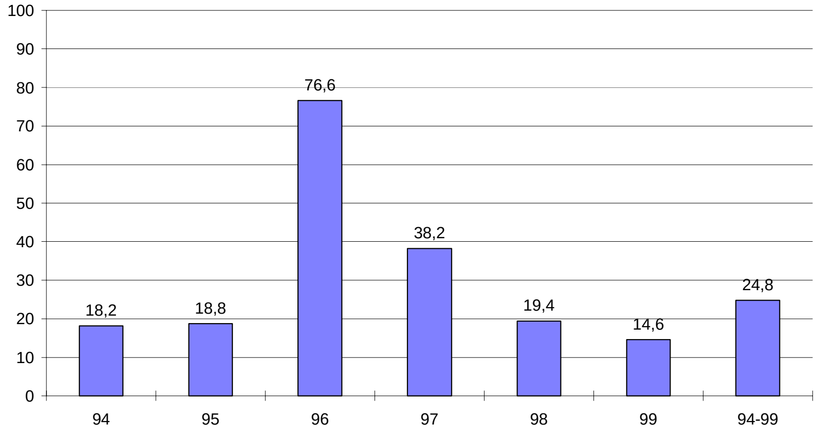
If we take a closer look at the individual subsectors in Table 4.6, it becomes clear that teleproducts are most important for growth. The strong growth in the subsector has contributed to the real growth of GNP by 3.1 percentage points in the period from 1993 to 1999.

Table 4.5: The contribution of the IT sector to real growth (figures in percentage points) [a]

	1994	1995	1996	1997	1998	1999	93-99
GNP growth	4.12	3.69	1.08	2.07	3.58	4.13	20.14
GNP growth excl. IT sector	3.37	3.00	0.25	1.28	2.89	3.53	15.15
Contribution by IT sector	0.75	0.69	0.83	0.79	0.69	0.60	4.99
Of which:							
Computers and office machinery	-0.01	-0.02	-0.01	-0.01	0.03	-0.02	-0.05
Teleproducts	0.56	0.49	0.67	0.41	0.37	0.19	3.11
Telecom. service	0.10	0.14	0.13	0.21	0.11	0.15	0.97
Data processing	0.09	0.06	0.03	0.15	0.15	0.26	0.87

Notes: [a] Excluding wholesaling and renting, and other hardware
Source: The National Accounts and our own calculations

Figure 4.3. The IT sector's share of real growth, 1994-99
(figures in per cent)



Source: The National Accounts and our own calculations

The labour productivity, measured as the ratio between real added value and number of hours worked, has also increased faster in the IT sector. Table 4.6 shows that the average annual productivity growth in the IT sector was just over 12 percent in the period 1993 to 1999. This can be compared with an average annual growth rate for the business sector as a whole of 2.5 percent over the same period. We find the highest growth in productivity in the teleproducts subsector, with an average annual figure of 35.6 percent between 1993 and 1999. According to National Accounts figures, the labour productivity of data processing activities has shown a negative trend over the period. As mentioned above, this can be explained by difficulties in fixed price calculations in the production of services. Other subsectors have clearly experienced a more favourable rate of productivity growth than has the business sector as a whole.

Table 4.6: Growth in labour productivity in the IT sector and in other industry, 1994 till 1999 (figures in percent) [a]

Subsector	1994	1995	1996	1997	1998	1999	1993/99[b]
Computers and office machinery	8.9	22.7	2.4	-1.3	33.8	-5.3	9.4
Teleproducts	58.2	30.7	50.0	28.1	31.6	18.7	35.6
Telecom. services and postal services	7.4	19.1	6.0	12.8	3.6	6.1	9.0
Data processing	3.5	-0.9	-10.9	1.7	-1.4	3.2	-0.9
IT sector Total	16.8	17.6	11.0	12.7	8.2	7.0	12.2
Manufacturing industry	11.4	2.1	2.1	6.3	5.4	2.9	5.0
Service sector	-2.1	3.3	1.4	3.7	1.8	1.1	1.5
Business sector Total	2.0	2.8	1.7	4.2	2.8	1.4	2.5

Notes: [a]Excluding wholesaling and renting, and other hardware. The IT sector includes postal services since it is not possible to separate in the National Accounts the number of hours worked within telecommunications services and postal services. [b]Average annual growth.
Source: The National Accounts

The high productivity growth in the IT sector has significantly impacted the development of productivity in industry. In 1999, labour productivity increased by 1.44 percent in the business sector in Sweden (see Table 4.7). If the IT sector is excluded from the calculations, the productivity growth in that year was only 0.89 percent. This can be interpreted that 40 percent of the productivity growth in 1999 stemmed from the IT sector. If the entire period of from 1993 to 1999 is considered, nearly one-third of the growth in the labour productivity of industry can be explained by the strong growth of productivity in the IT sector.

Table 4.7: The contribution of the IT sector to growth in labour productivity, 1994 to 1999, (figures in percentage points)[a]

	1994	1995	1996	1997	1998	1999	93-99
Productivity growth, industry	2.01	2.81	1.70	4.16	2.80	1.44	15.85
Productivity growth, industry, excl. IT sector	1.05	1.84	0.97	3.40	2.26	0.89	10.84
Contribution of IT sector	0.96	0.97	0.73	0.76	0.54	0.55	5.01
Of which:							
Computers and office machinery	0.03	0.,04	0.00	-0.01	0.04	-0.02	0.11
Teleproducts	0.69	0.47	0.78	0.46	0.49	0.24	3.,50
Telecom. Services	0.17	0.46	0.13	0.28	0.03	0.17	1.41
Data processing	0.04	-0.05	-0.22	-0.02	-0.06	0.12	-0.22

Notes: [a]Excluding wholesaling and renting, and other hardware. The IT sector includes postal services since it is not possible to separate in the National Accounts the number of hours worked within telecommunications services and postal services.
Source: The National Accounts and our own calculations.

The IT sector’s direct contribution to GNP growth and labour productivity probably underestimates its total contribution. In Chapter 2, it was pointed out that research and development (R&D) in a sector impacts the growth in the rest of the economy. According to Statistics Sweden and NUTEK, the Swedish National Board for Industrial and Technical Development, (2000), companies in the IT sector are more innovative than are Swedish industrial and service companies. in general. Between 1996 and 1998, over 90 percent of computer consultants and data service agencies were engaged in innovative activities.[14] This figure can be compared to 63 percent of service companies generally.

4.5 Sweden’s IT sector in an international perspective

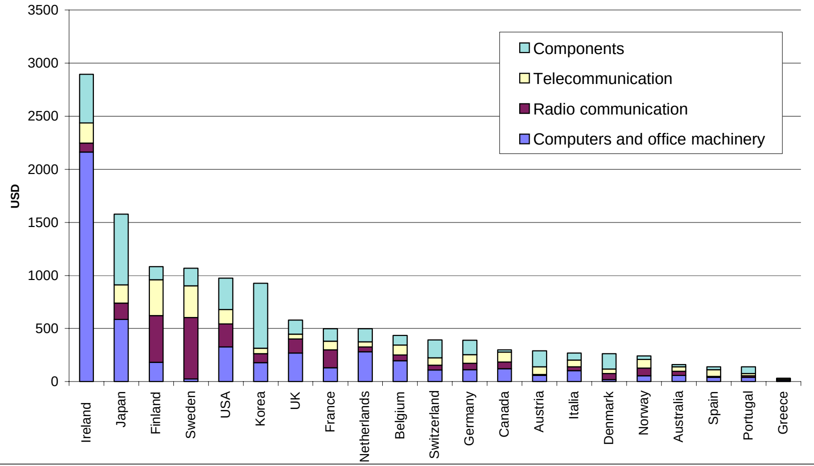
How strong is the competitiveness of the Swedish IT sector? Is Sweden a leading country in terms of consumption of IT products and IT services, as well as production? Sweden is known to be far

[14] Innovative activities refer to activities that lead to new, or considerably improved, goods/services, as well as new, or considerably improved, processes to produce/supply them. In addition, the new goods/services must have been introduced on the market.

behind the United States and several other countries in the production and development of computers. However, Sweden is a cutting edge country in the telecommunications field. Sweden is compared to other OECD countries in this chapter, to obtain a clearer picture of Sweden's position as a producer of IT products and IT services.

According to statistics from OECD (2000a), Sweden was the fourth biggest producer per capita of IT hardware in the OECD, after Ireland, Japan and Finland in 1997 (see Figure 4.4). Sweden's strong position is mainly due to our large production of communications equipment. In 1997, Sweden had the highest production of radiocommunications equipment (which includes cellular telephones), and the second largest production per inhabitant of telecommunications equipment after Finland. Sweden also had a strong position in the production of components. In contrast, Sweden's production per capita of computers and office equipment is one of the lowest in OECD.

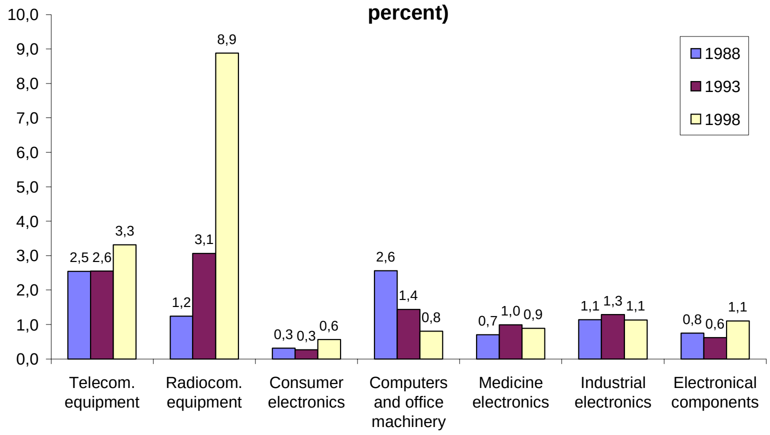
Figure 4.4: Production of IT products per capita, 1997, OECD-21



Source: OECD (2000a) and OECD in Figures 200

Exports and the balance of trade can give an indication of Sweden's international competitiveness in the IT field. Information on foreign trade is based on statistics of foreign trade of goods provided by NUTEK (2000a). In 1998, the export of IT goods made up 17 percent of Sweden's total exports. Between 1988 and 1998, the export of radiocommunications equipment, as a share of Sweden's total exports, increased eightfold, from one to nine percent (see Figure 4.5). In 1998, communications equipment (tele- and radiocommunications equipment) made up three-quarters of Sweden's exports of IT goods of just over 112 billion SEK. This illustrates the dominance of communications equipment, and Ericsson made up a large part of the exports. A single company, Ericsson Mobile Communication, an Ericsson subsidiary engaged in the production of cellular telephones, had exports of 27.7 billion SEK in 1998. In the same year, the exports of the entire Ericsson Group totalled 110.4 billion SEK, which was 16 percent of Sweden's total exports in that year.

Figure 4.5: Export of IT goods as a share of total exports in 1988, 1993 and 1998, divided according to commodity groups (figures in percent)

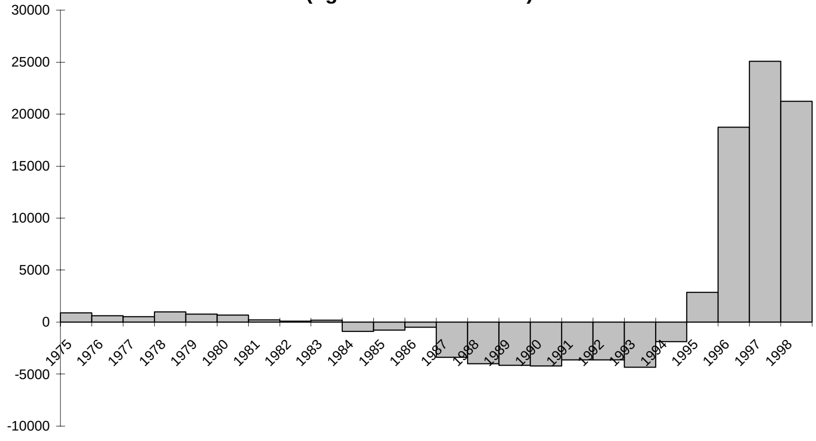


Source: NUTEK (2000a)/Foreign trade statistics of Statistics Sweden

In 1998, Sweden was one of the seven OECD countries[15] in which the exports of IT products and IT services were greater than imports (OECD, 2000b). In the period 1975 to 1998, the balance of trade for IT products has varied considerably (see Figure 4.6), but has shown a surplus since 1995. In 1998, the trade surplus amounted to 21 billion SEK. Figure 4.7 shows that the reason for the trade surplus is mainly the large surplus in trade involving radio and telecommunications equipment (43 and 12 billion SEK respectively in 1998). Medical electronics also shows a surplus in the trade balance, while the product groups of consumer electronics, computers and office machinery, industrial electronics, and electronic components show a deficit.

[15] The other countries were Japan, Korea, Ireland, Mexico, Finland and Hungary.

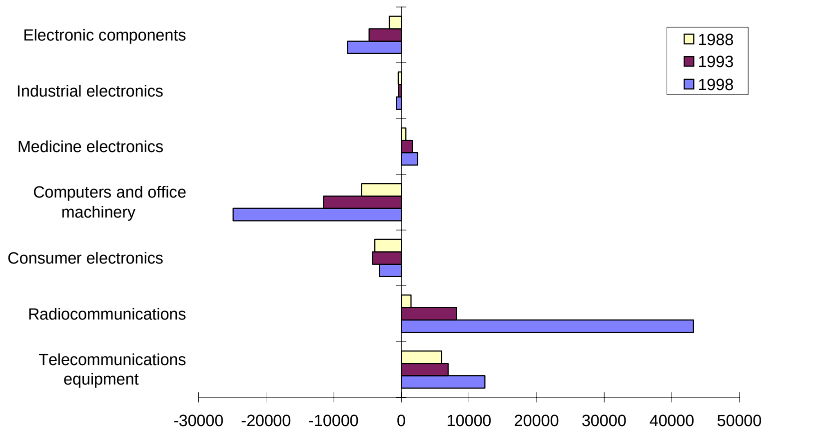
Figure 4.6: Balance of trade of IT goods, 1975 to 1998 (figures in SEK million)



Source: NUTEK (2000a)/Foreign trade statistics of Statistics Sweden

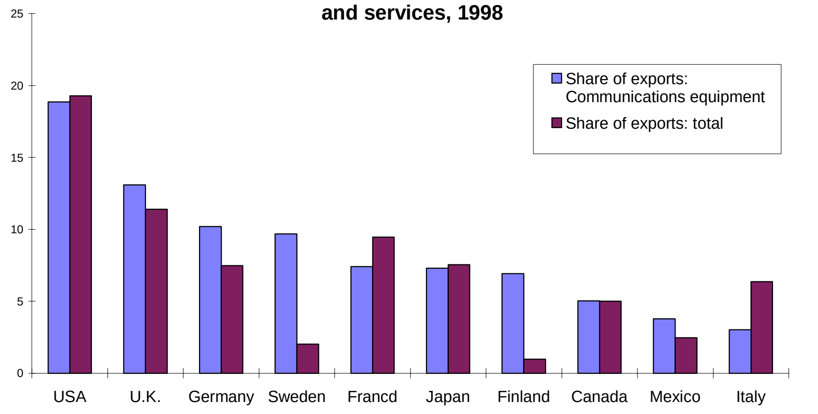
Source: NUTEK (2000a)/Foreign trade statistics of Statistics Sweden

Figure 4.7: Balance of trade of IT goods, 1988, 1993 and 1998, divided according to IT goods (SEK million)



According to OECD (2000a), Swedish exports of communications equipment amounted to 7.7 billion USD in 1998, which was 10 percent of the total exports of the OECD countries. As Figure 4.8 shows, Sweden in that year was the fourth largest exporter of communications equipment within OECD, after the United States, UK and Germany. Sweden's share of OECD's export of communications equipment is considerably higher than the share of the total export of goods and services, indicating that Sweden's is strongly competitive in this sector.

Figure 4.8: Communications equipment: leading exporting countries in OECD, exports as a percentage of the exports of the OECD countries, and the share of OECD's total exports of goods and services, 1998



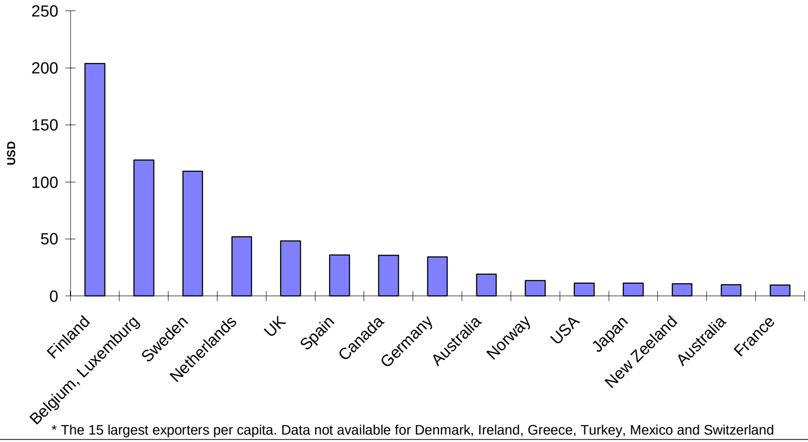
Source: OECD (2000a)

A comparison of exports of IT-related services per capita indicates that Sweden is also relatively competitive in this area. Information Technology Outlook (OECD, 2000a) includes information on the export of computer and information services, and communications services in the OECD countries in 1997/1998. Data is available for 24 countries, and Sweden is third after Finland and Belgium (including Luxembourg) in the export per capita of computer and information services. Sweden is fifth with regard to export per capita of communications services (see Figure 4.9 and 4.10). This indicates a relatively strong market presence in IT services.

Sweden has less of a leading position as an exporter of packaged software. In Information Technology Outlook (OECD 2000a), the ten largest exporters of packaged software in OECD are indicated, but Sweden is not among these ten. The OECD countries' exports of packaged software is dominated by the United States and Ireland, which together made up more than 60 percent of the exports in 1998.[16]

[16] In an unpublished draft to Information Technology Outlook 2000, figures showed the export of packaged software in 1997. Sweden was then in tenth position as an exporting country, making up just over one percent of the exports of the OECD countries. This figure is considerably less than Sweden's share of the total exports of the OECD countries, which was two percent in 1997.

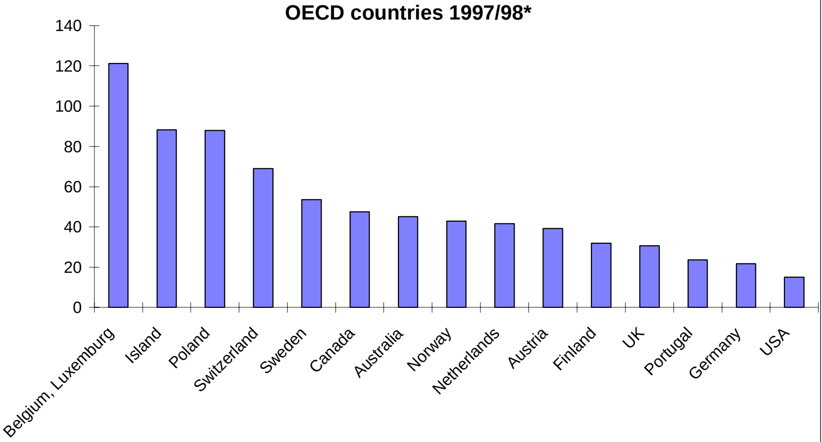
Figure 4.9: Export per capita of computer and information services, OECD countries 1997/98*



* The 15 largest exporters per capita. Data not available for Denmark, Ireland, Greece, Turkey, Mexico and Switzerland

Source: OECD (2000a)

Figure 4.10: Export per capita of communications services, OECD countries 1997/98*



* The 15 largest exporters per capita. Data not available for Denmark, Ireland, Greece, Turkey, and New Zealand

Source: OECD (2000a)

4.6 Conditions for the growth of the IT sector

A number of international reports show that Sweden is a world-leading country in IT. A large and growing demand attracts companies to set up and expand their operations in Sweden. This also makes Sweden an attractive test market for new IT products.

In addition, there are many indications that Sweden has good potential to develop an important industry for the production of IT products and IT services. However, this sector is developing rapidly. If Sweden is to retain its leading position, a favourable climate for business is needed, as is access to both basic and cutting edge skills in IT.

In 2000, NUTEK conducted interviews with just over 250 company executives from the 400 largest-selling private companies, to get a picture of their view of the Swedish business climate (NUTEK, 2000b). The study shows that the IT companies are part of the group that has most changed attitudes to the business climate compared to the previous study in 1997. Just over half of the IT companies take the view that the business climate has improved in the last three to four years. There are very few IT companies that feel that the business climate has deteriorated (7 percent). This is a noticeable improvement compared with 1997, when only every fourth IT company felt that the business climate had improved in the previous three to four years.

Company executives in all 29 interviewed IT companies believe that their head offices will be located in Sweden in the future. This is a big change compared to 1997, when almost half the IT companies thought that the head offices would be relocated abroad. Another positive change in attitude is shown by the fact that double so many IT companies compared to 1997, now feel that the best conditions for developing new products are found in Sweden.

In addition, the NUTEK study indicates that the largest potential obstacle to the expansion of IT companies is access to a *trained workforce* (see Table 4.8). Three out of four companies feel that the possibility for new recruitment is the most important condition for increasing the level of investments in Sweden in the future. Access to trained workers is not so significant for expansion for other companies, which indicates that it is the difficulties in recruiting workers skilled in IT that seems to most inhibit the investment plans of IT companies.

Table 4.8: Changes regarded to be of the greatest significance if a company is to increase investments in Sweden over a ten-year period

	Share of IT companies (%)		Share of all companies (%)	
	2000	1997	2000	1997
Increased supply of skilled labour	78	60	44	27
More stable industrial and tax policies	48	55	58	57
Swedish participation in EMU	45	--	31	--
Increased optimism in Sweden	41	--	45	--
Reduced wage costs	24	40	33	28

Note. -- = information not available in 1997
Source: NUTEK (2000b)

According to the NUTEK report, the most important factor for the growth of the IT sector seems to be access to skilled labour for industry, research and the education sector. Chapter 6 focuses more closely on the access to IT skills. However, there are several other factors, apart from those mentioned above, which are thought to be important for decisions concerning future investments.

For many young companies, an input of external *venture capital* is necessary to reach the desired growth. IT companies may have a greater need for external financing, for both the initial phases of development, and for commercialisation, compared to companies engaged in other sectors. The availability of venture capital is relatively good in Sweden, in a European perspective, but we are far behind the United States (EVCA Yearbook, 2000). IT companies seem, at least until recently, to have found it easy to attract venture capital. However, access to venture capital is not the only significant factor. The company providing the venture capital must also be proficient in the field. One study showed that the greatest problem experienced by entrepreneurs, in their contacts with companies providing venture capital, was their limited proficiency in IT (The Swedish IT/Internet Venture Capital Survey, 1998). The biggest problem is not getting hold of capital, but getting hold of competent capital, i.e. financiers who contribute proficiency in both IT and company management.

A fine-meshed *infrastructure* for traffic requiring digital broadband improves the competitiveness of companies that use broadband, and provides growth opportunities to companies that develop new products and services using the network as a platform. Broadband offers greater opportunity for the development of the IT sector. It gives Sweden a better chance of retaining the producers of IT products and IT services, and, at the same time, of attracting foreign IT companies to Sweden.

One characteristic feature of the development of knowledge-based products is that there are great opportunities to develop and commercialise products in collaboration with others, without needing to build up comprehensive development and production resources. In the IT sector, the successes in both Silicon Valley and Kista show the importance of a dynamic environment for the development of the sector. Development is favoured in environments that are close to knowledge, research, funding and market. The *transfer of knowledge and technology* is facilitated through contacts between the companies and the skills that are found in universities and university colleges (NUTEK, 1999b). The state can seldom point out clusters, but it can strengthen those that are being developed. One example of this is the Government decision to increase the resources allocated to one cluster, a group of institutions and companies engaged in silicon technology in Norrköping. The purpose is to strengthen the Swedish conditions for using future technology within silicon and circuit card design.

4.7 Concluding remarks

In this chapter, we have been able to confirm that the rapidly growing IT sector is important for the Swedish economy, both through creating jobs and through contributing to growth. We have also confirmed that Sweden holds a strong position internationally as a producer and exporter of IT products. However, Sweden's leading position on the hardware side is limited to the production of tele- and radiocommunications equipment. A single company, Ericsson, dominates the production of these products.

The Swedish IT sector is dominated by the production of IT services, in terms of the numbers employed and value added. IT services make up around 70 percent of the IT sector in terms of number of employees and as share of value added. Compared to many other OECD countries, Sweden has relatively large exports of IT-related services, indicating a strong market presence in this area too .

There are signs that a shortage of skilled labour constitutes the greatest obstacle for the continued growth of the IT sector. Research shows that the "technology" of different countries is guided by the input factors to which they have good access. One example is that countries with a large trained workforce tend to develop a technology that is specially adapted to a trained workforce. Since human capital seems to be a significant factor of production when new technology is introduced, an active education policy can promote a rapid development of the IT sector (Krusell, 2000). If the education policy is to be used as an instrument in encouraging the IT sector it is naturally important to know what types of qualifications are important.

5 Use of IT in industry

The debate about the New Economy largely concerns the importance of the growing IT sector for economic growth. The IT sector represents a new, dynamic and important economic activity, but the sector still constitutes a relatively small part of the Swedish economy. In terms of employment, the IT sector makes up around six percent of the total workforce. While this is not a negligible figure in itself, it means that 94 percent of workers are engaged in other activities that use IT in different ways and to a varying extent. The importance of information technology for growth is determined, firstly, by how IT is disseminated to, received by and developed by IT-using companies, public authorities and organisations.

Chapters 2 and 3 contains theoretical arguments that an increased use of IT in business can potentially promote not only increased productivity, but can promote the development of new products and services, thus positively contributing to economic growth, employment and welfare.

The purpose of this chapter is to identify and assess the obstacles and opportunities that information technology presents for increasing business productivity. The chapter begins with a description of the extent and purposes, for which information technology is used by Swedish companies. Through a review of empirical research, we try to determine whether the comprehensive investments in IT in the last two decades have impacted growth and productivity. Finally, a number of factors are discussed that are thought to contribute to a more efficient use of information technology.

5.1 The use of IT in Swedish companies

The lack of knowledge about how, and to what extent, Swedish companies use IT raises difficulties in estimating how the use of IT impacts the economy. Today, there are no compiled statistics available for IT.[17]

NUTEK has conducted a survey to examine the use of IT by companies.[18] A questionnaire was sent to 5,700 workplaces, and the frequency of response was just over 50 percent. “Workplace” refers to an activity at a specific address, as opposed to a "company" that can consist of several workplaces.

The NUTEK study shows that 66 percent of workplaces with more than five employees used computers and datacommunication for information processing in 1997 (see Table 5.1). The use of IT increases with the size of the workplace. The corresponding proportion for workplaces with more than 20 employees was 80 percent. Virtually all companies with more than 250 employees used computers and datacommunication for information processing, compared with just over half the workplaces with 5-9 employees.

Table 5.1. Proportion of workplaces in each size class using computers and datacommunication for information processing, 1997

Size class, total number of employees	Percent
5-9	57
10-19	63
20-49	76
50-249	90
Over 250	96
Total	66

Source: NUTEK, Flex2-database

The use of IT varies among different sectors. In the business services sector, 90 percent of the workplaces used computers and

[17] The Swedish Institute for Transport and Communications Analysis (*SIKA*) has been commissioned by the Government to look into the establishment of a system for statistics on IT.
[18] NUTEK project on Flexible work organisation (Flex2).

datacommunication for information processing in 1997, while the corresponding share in the building sector was only 42 percent. In manufacturing, trade, communication and services (excluding business services), between 60 and 70 percent of the workplaces used IT (see Table 5.2).

Table 5.2. Proportion of workplaces in each sector using computers and datacommunication for information processing, 1997

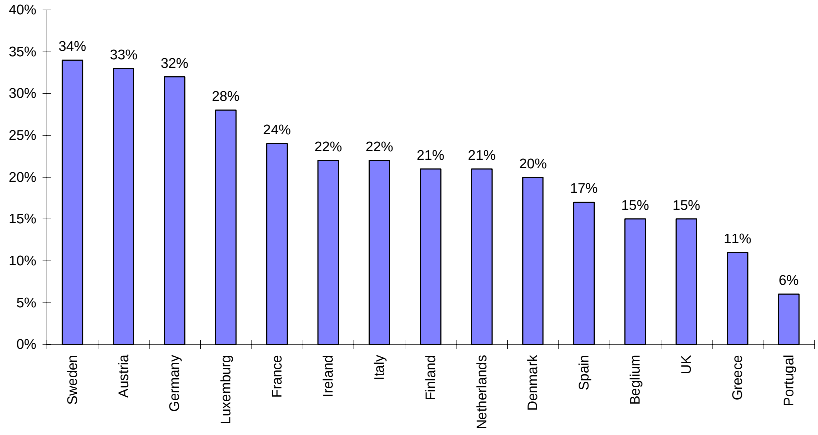
Sector	Percent
Manufacturing	65
Building	42
Trade	62
Communication	67
Business services	90
Other service companies	65
Total	66

Source: NUTEK, Flex2-database

According to ENSR[19] Enterprise Survey (European Commission, 2000), small and medium-sized Swedish companies made more use of the Internet for marketing, purchases, sales and payments, compared to other EU countries in 1998 (see Figure 5.1). According to the same survey, the most common commercial use of the Internet was for marketing. In 1998, only 10 percent of the small and medium-sized companies in the EU received orders via the Internet, and only three to four percent used the Internet for processing or receiving payments from customers. In the same year in Sweden, ordering and payments via the Internet were much more common than in other EU countries. According to the survey, approximately one-quarter of the companies received orders, and eight percent received payments, via the Internet.

[19] European Network for SME Research

Figure 5.1: Proportion of small and medium-sized companies using the Internet for commercial purposes, EU countries 1998



Source: European Commission (2000).

The use of IT in businesses is not evenly distributed throughout the country. The most striking difference between different region families is that businesses in sparsely populated areas make much less use of computers and datacommunication for information processing. This is a definite problem if companies in sparsely populated areas do not use the technology that would present an opportunity to overcome the many disadvantages caused by distance (SOU 2000:87).

5.2 Connection between productivity and IT maturity in companies

In recent years, the connection between IT and productivity has been the subject of lively discussion. In 1987, the American economist and Nobel Prize winner, Robert Solow, formulated a concept that became later known as the *productivity paradox*: You can see the computer age everywhere but in the productivity statistics. The statement is based on the fact that empirical research in the 1980s generally could not prove the existence of productivity gains associated with investments in IT, which partly lowered the expectations of the growth potential in the new IT society.

The pessimistic picture shown by the empirical research of the impact of information technology on growth has been widely criticised. Critics have questioned whether it is really possible that a new technology, through rationalising many work tasks and job opportunities, really would not lead to a significant increase in productivity.

Three aspects may explain why IT has not left a mark on the productivity statistics. The first is the fact that investments in IT have, to date, been relatively small in relation to the total capital investments. One study showed that computer equipment constituted only 4.5 percent of the American stock of capital goods in 1996 (Schreyer, 2000). In spite of the rapid growth of IT capital, the contribution to growth has been relatively modest, as the proportion of IT capital in relation to the total stock of capital is small.

The second explanation to the productivity paradox is based upon the difficulties of measuring production and investments. Much of the investment in IT and other technologies is used to differentiate products, improve the quality of products and services and introduce products/services onto the market more quickly, as well as just-in-time deliveries. The official statistics make certain adjustments for quality, but the general opinion of researchers seems to be that these adjustments are often quite arbitrary and insufficient. Another problem is erroneous measurements of the production in the service sector. At the same time, the service sector is where investments in IT have increased most dramatically. One example is the banking sector in the United States, where the calculation of the production of the banks is based on the number of employees. The banks have replaced a great number of workers with IT. The measuring method used has often shown that the measured production seems to have decreased, while the use of the factors of production is unchanged or has increased. Therefore, the official productivity measurement shows incorrect decreases in productivity (Krusell, 2000).

The third, and perhaps the most interesting, explanation of the productivity paradox, is based on earlier experiences of investments in new technology. Both economic theory (see Section 2.3) and research into economic history, indicate that it often takes a considerable time before technological breakthroughs generate productivity gains.

The American economic historian, Paul David (1990), has made an interesting travesty of Solow's productivity paradox. He suggested that if an observer, one hundred years ago, had noticed the dynamo, the beginning of its use in industry and its impact on the economy, he might have said that "we can see the dynamo everywhere, except in the productivity statistics." It was not until the end of the 1920s that society's adoption of electricity was reflected in productivity increases and the creation of new products. Electricity gave rise to a development that created opportunities for new jobs, new businesses, and in fact a whole new society. But to make this development possible, the state, companies and individuals were forced to implement a whole series of additional investments. Electricity needed to be transported to factories and residential areas, and from the factory door to the individual machines, all of which demanded investments in new *infrastructures*. An important, but often neglected, example of the many additional innovations that were needed, before the technology could be fully exploited, was the apparently simple invention of the electricity meter. The electricity meter can be seen as a parallel of today's problems of payments via the Internet, or of electronic signatures. To take advantage of the potential of electricity, *institutions* also needed to change, i.e. the formal and informal rules of the game that impact our behaviour patterns. In addition, people in different positions needed to learn to handle, not only the new technology, but also the new organisational forms and additional technologies that arose in the wake of electricity.

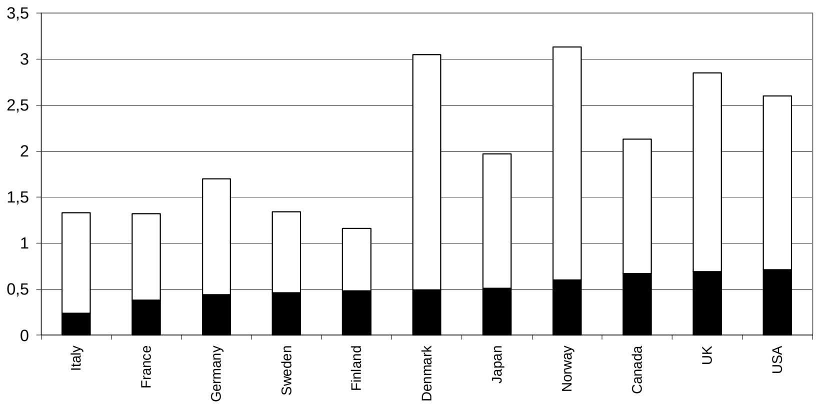
Naturally, IT and electricity are not identical. One difference is that information technology interacts with humans on a deeper and more varied level than does electricity. Nevertheless, it is perhaps the best parallel we can find. In fact, the most salient difference between IT and electricity, perhaps, is that IT demands even more institutional adaptations and increased proficiency than electricity.

Solow made his statement more than ten years ago, and IT development has been remarkably rapid since then. Consequently, there is every justification for a new evaluation of the connection between IT and productivity. Today, there are many indications that companies have come so far in adapting to the new technology that the potential of IT is starting to take effect, in the form of increased productivity and a higher rate of growth. In recent years, several studies have been published that indicate positive impact. Some of the results are so positive that some people are now talking about the *reversed* productivity paradox. Critics are now questioning the possibility that investments in IT can have had the big positive impact that has been actually measured.

One example is an OECD study (Schreyer, 2000), which shows that, on average, 17 percent of the G7 countries'[20] growth between 1990 and 1996 can be explained by investments in IT capital in the form of hardware. The impact of IT capital on growth has increased strongly. Between 1985 and 1990, only 8 percent of the growth could be explained by investments in IT.

The contribution of IT capital to growth has also been studied by Daveri (2000). His study covered more countries, including Sweden, and the definition of IT capital was broadened to also include software. This resulted in the IT capital assuming an even greater importance for growth. Figure 5.2 shows that the IT capital in the period 1991 to 1997 has had the greatest absolute importance for growth in the United States out of the selected countries (the G7 countries and the Scandinavian countries excluding Iceland), contributing with 0.73 percentage points. In Sweden, the IT capital contributed annually 0.47 percentage points, which means that one-third of the growth of the business sector over the period is explained by investments in IT capital. Only in Finland was the contribution of IT capital, calculated as a share of the growth of the business sector, greater than in Sweden.

Figure 5.2: Contribution of IT capital to the annual growth of the business sector, 1991-97*



* The height of the column indicates the total growth of the business sector, and the shaded section indicates the contribution of the IT capital

Source: Daveri (2000).

The two studies described above are examples of recent research, which almost unanimously shows that the use of information technology has made a significant contribution to the western

[20] USA, Japan, UK, Germany, Italy, France and Canada.

world's growth in recent years. However, opinions are still divided regarding the impact of IT on total factor productivity (TFP), and especially the impact on TFP outside the IT-producing sector. In recent years, new and sophisticated methods of measuring TFP have been developed, especially in the United States. These new methods have supported the view that IT has played in important role in explaining the increase in TFP in the United States in the second half of the 1990s. Using American sector data up to 1998, Jorgenson and Stiroh (2000) found that the IT sector had an increasing impact on TFP. This impact was sufficiently important to make a significant contribution to the total productivity growth in the United States. Like Gordon (2000), the authors did not find any significant TFP growth outside the IT sector.

In contrast to these studies, Ohliner and Sichel (2000), and the Council of Economic Advisors (2000) found that the data from recent years (the periods 1996-1999 and 1995-1999) show that sectors that do not produce IT also made a clear contribution to TFP growth. Both the studies estimate that more than half of the TFP growth has its origin outside the IT sector. However, the extent to which this is explained by the increasing use of IT is left unanswered.

Therefore, the extent to which the use of IT as a factor of production contributes to TFP growth at a macro level is still unclear. However, its contribution to labour productivity in the United States could be established with greater certainty. Three different studies, using refined methods of measuring IT capital, estimate that around two-thirds of the increase in USA's labour productivity, in the second half of the 1990s, could be explained by the combined effects of productivity growth in the IT sector, and the accumulation of IT capital (Council of Economic Advisors, 2000; Ohliner and Sichel, 2000, and Whelan, 2000). According to Ohliner and Sichel (2000), hardware, software and telecommunications equipment contributed nearly one percentage point to the annual increase in labour productivity of 2.6 percent in the United States in 1996-1999.

In recent years, a large number of studies using data at the company level have been published. These studies have looked at the connection between the use of IT and productivity. The results are not completely unequivocal, but most of the studies show a positive connection. One interesting study based on American company data, estimates that the annual gross return on computer investments is over 50 percent, which can be compared with a return of 15 to 20 percent on other investments. The study concludes that the productivity paradox at company level disappeared as early as 1991 (Brynjolfsson and Hitt, 1996). A number of other studies based on American company data indicate positive impact of IT investments and IT use on productivity.[21]

5.3 Conditions for an efficient usage of IT

Conclusions concerning IT investments have become more positive. This can partly be explained by the fact that elected representatives, companies, public authorities and organisations have learned that additional investments are needed in order to take full advantage of the benefits of information technology. Several studies show that additional investments in new ways to *organise work* and *human capital* strengthen the impact of information technology on the productivity of companies. In addition, investments in *IT infrastructure* for datacommunication with high transfer capacity can also have been important for a more efficient use of information technology. In this section, we discuss how these factors can impact the opportunities of information technology to promote productivity and growth.

5.3.1 Adapted work organisation

In the transition from the industrial society to the information society, many large companies have changed their internal organisational structure, from a hierarchical structure to a more decentralised decision-making process. Information technology and globalisation have placed new demands on companies, public authorities and other organisations. One example is that customers, on short notice, demand delivery of goods and services that are customised to their needs. This trend can largely be explained by the technological development, which enables the competitors to satisfy these demands. Quite simply, the costs of “flexibility” and “rapid interaction” have been reduced, and hence the demand for new organisational forms and skills that exploit these opportunities.

A striking aspect shown by the recent research into productivity, is that productivity at company level positively

[21] See OECD (2000c) for a review of selected studied based on company data.

correlates with factors such as new work organisation, new forms of wages, and increased participation for employees in the decision-making process.

A report from NUTEK (1999a) shows that this also applies to Swedish companies. The report shows that companies with flexible organisations have higher productivity, measured as value added per employee, than companies with a more hierarchical structure. In addition, companies with flexible organisations had a higher growth of productivity in the period from 1993 to 1995.

The NUTEK study shows that Swedish companies with flexible organisations invest more in information technology than companies with more traditional organisational forms. This indicates a complementary relationship between IT and investments in new work organisation. A report by the National Bureau of Economic Research looks at the importance of IT, work organisation and human capital on the productivity of companies (Bresnahan *et al.*, 1999). The results of the study indicate that IT and work organisation are complements, i.e. that return, in the form of increased production after an investment in IT, is increased if the work organisation is flexible. According to the report, the companies with the highest productivity combine a high proportion of IT capital with a flexible work organisation. Companies with a lot of IT capital, but with a relatively rigid work organisation, are no more productive than companies that combine relatively little IT capital with a centralised work organisation. This indicates that the return from IT investments is strengthened when investments are also made in a new work organisation. Other studies offer a certain amount of empirical support for this.[22] The report also shows that human capital is a complement to both work organisation and information technology, and we will discuss this in more detail in Section 5.3.2.

Why is it then that the return from the IT investments is higher for companies with a flexible organisation than for companies with more rigid organisational forms? One explanation is that the new technology reduces costs of communication, and this impacts the degree of centralisation in the company. If communication is costly, decision-making may be centralised to reduce the costs of

[22] A Canadian research review indicates that the positive effects on productivity caused by new technology are greatest when they are combined with organisational changes. Similar results are shown by an American study, which shows that high technological investments in the motor industry, without complementary changes of personnel policy and work organisation, lead to neither productivity increases nor improvements in quality (see Lundgren, 1997).

communication. The relevant information is collated centrally rather than disseminating it to many people in the organisation. If the costs of disseminating information are reduced, for example by an increased use of IT, the optimal solution may be to decentralise the decision-making. In addition, the increased flow of information, in itself, can stimulate a less hierarchical decision-making process. An individual can only handle a limited amount of information, so the marginal costs of central decision-making are increased as the flow of information increases. This increases the need for decentralisation (Hitt and Brynjolfsson, 1997).[23]

5.3.2 Additional investments in human capital

Additional investment in education is a prerequisite if IT is to contribute to increased productivity in industry and the public sector. One explanation for the impact of information technology on productivity becoming more apparent recently, is that there is now greater access to a workforce skilled in IT. The arrival of computers in schools, homes and working life means that an increasing number of people have at least elementary computer proficiency. One condition for the use of IT in encouraging growth is that the employees have a mastery of the technology.

It is not surprising that information technology is used best in companies where there is good access to a workforce skilled in IT. Personnel who can use IT, and integrate it into the organisation, are also needed for optimal use of the technology. It is less clear whether skills that are not directly IT-related lead to a better use of information technology, or whether IT increases the return on human capital.

However, there are many indications of a connection between the increased use of IT and a greater demand for a more educated workforce. Several empirical studies support the supposition that we are currently undergoing a structural change that is characterised by a skills-based technological development, i.e. a technological development that leads to an increased demand for a

[23] In principle, computerisation can also lead to increased centralisation. If computers can be used to analyse information, this can facilitate centralised decision-making. At times, and in certain areas, there has been great interest in, and expectations of, artificial intelligence, expert systems etc. However, with today's technology, the opportunities of completely replacing human qualitative analysis with computers are very limited. On the other hand, systems such as these can contribute to more efficient and faster analyses.

skilled workforce.[24] This trend indicates that physical capital and new technology are complements to a highly educated workforce. Data from the United States confirms this: the employees' use of computers, IT capital per employee, and the extent of IT investments are greater in industries with faster upgrading of the human capital (Autor, Katz and Krueger, 1998). The results of the study of the National Bureau of Economic Research, described in the previous section, indicate a complementary relationship between IT and human capital. The report shows that a large amount of IT capital in a company is associated with high productivity, but only if the company is human capital intensive as well. This result indicates that the potential of information technology to increase productivity in companies is most effective if IT investments are combined with investments in skills development and the recruitment of an educated workforce (Bresnahan *et.al*, 1999).

One explanation why the spread of information technology not only increased the demand for a workforce proficient in IT but also increased the demands on the level of education generally, can be the connection between IT and work organisational changes, which were discussed in the previous section. Information technology has speeded up technological development, thereby encouraging flexible organisations. This, in turn, has brought with it an increased demand for a highly educated workforce. Therefore, computerisation can be an important factor in explaining the increased demands on education that we have experienced in the last decades.[25]

5.3.3 A functioning IT infrastructure

The improved infrastructure for datacommunication is another explanation why the return on company investments in IT can be expected to increase over time. In the second half of the 1990s, we have experienced a dramatic increase in the use of the Internet. This provides companies with increased opportunities to use IT as

[24] See e.g. Bartel and Lichtenberg (1987); Levy and Murnane, (1997); Doms, Dunne and Troske (1997).

[25] This argument is based on the supposition that the use of IT is a factor that stimulates the trend towards flexible organisations. As far as we know, there is no empirical evidence that causality goes from IT to organisational changes. It is fully possible that it is the trend towards flexible organisations that is causing an increased demand for IT. The causality probably works in both directions.

a communications medium, and as an instrument for commerce with other companies and consumers.

The ongoing expansion of the broadband network, which allows rapid transfer of digital information at a lower cost, favours industry in several ways. Access to rapid transfer means not only lower transaction costs in the form of saving time, but also new areas of use for information technology. This leads to better return on IT investments.

Access to a good IT infrastructure can be a way for a company located in a sparsely populated area, with long distances to major markets, to compete on national and international markets. The technology can reduce the disadvantages of distance and make possible different forms of distance work.

A characteristic feature of services that are provided via a network is a feature known as network externalities. It is important to the individual consumer to know how many, and which others, are connected to the same network. Access to broadband at a lower cost means that more companies and households can be connected to the Internet. Therefore, information technology can be better utilised as a tool for communication and financial transactions.

5.4 Concluding remarks

The consequences of information technology are not limited to certain sectors. Through its all-embracing character, information technology is similar to previous technological breakthroughs, such as the steam engine and electricity. The impact of information technology will not be fully realised until it is fully integrated with the production of goods and services in the “traditional economy.”

The latest development of the endogenous theory of growth proposes that innovations that affect the conditions for production in all sectors, cause significant positive externalities. This means that use of IT in industry can generate productivity growth, and that a policy that stimulates an increased use of IT can be socially and economically profitable.

The historically low increase in productivity in the OECD countries since the mid-1970s, occurred at the same time as IT started to reach commercial success. This led to a debate about a productivity paradox – that new technology could be associated with decreases in productivity rather than increases. The recent positive macroeconomic trends in, primarily, the United States, has led to the pessimism being replaced by a more optimistic view (possibly overexaggerated) of the impact of the new technology on the economy. In contrast to previous research, empirical studies in recent years have indicated that the use of IT in companies has had a more positive impact on growth and labour productivity. However, the empirical research can still not identify the impact of information technology on total factor productivity.

In recent years, economic theories have been presented that support the idea that the introduction of a new technology that runs through the whole economy, and has many areas of use, can mean that the rate of growth can initially be pulled down. One explanation for this is that the new technology requires costly additional investments. It takes time before these investments give return in the form of more efficient production (see also section 2.3).

This chapter has pointed out the importance of additional investments in new work organisation, human capital and IT infrastructure for best use of the potential of information technology to create growth. What can the state do to promote and hasten these types of investments?

Investments in new work organisations can be promoted. Naturally, the state has a responsibility to ensure that the public sector adopts a more flexible organisation in the activities where IT investments and IT operations are important. However, the responsibility of the state for changes in the work organisation of private industry is less obvious. The central measures being implemented today to promote the development of flexible organisations, apply mainly to the dissemination of organisational innovations. Examples of initiatives that can promote this are the earlier Objective 4 work and the new Objective 3 programme (Ds 2000:49).

The state and the municipalities are primarily responsible for satisfying the business sector’s need for skilled workers. But the business sector also has a responsibility to ensure that the proficiency of the workforce is adapted to changed needs. Since workers can move between companies, there is a clear risk that the employers’ initiatives on skills development may be less than what is optimal from a social economic viewpoint (see also Section 6.5).

The third additional investment highlighted in this report is the IT infrastructure. In its Bill *An information society for all* (prop. 1999/2000:86), the Government has decided that, within a few years, all households and companies in the entire country should have access to an IT infrastructure with high transfer capacity. This is to occur via market channels in the first instance. However, the state has an overall responsibility to ensure that the IT infrastructure is available in the whole country. Therefore, the Government has adopted a number of measures to hasten the development. One example is the commission given to the Swedish National Grid to build a backbone network with high transfer capacity to the country's municipalities. The IT Bill also announced tax concessions to stimulate connection to the broadband network. A government bill on this has been submitted to Parliament (prop. 2000/2001:24). The Government has also set up a commission concerning municipal support to local IT infrastructure in small urban areas and in rural areas. The commission submitted its final report in November 2000.

6 Proficiency in IT

The changes taking place in the economy have consequences for the business sector's need for IT proficiency, in terms of both general and more specialised skills. Also important is the proficiency in company management that is needed to adapt production processes and work organisations to ensure optimal use of IT.

A number of observers have pointed out that the lack of a workforce skilled in IT is one of the biggest obstacles to growth, both in the IT and other business sectors. According to a NUTEK report, three out of four IT companies feel that an increased supply of a trained workforce is the most important prerequisite for future investments in Sweden.

The purpose of this chapter is to clarify the extent of the current shortage of workers with IT proficiency, and how the situation is expected to develop in the future. We also discuss measures and proposals aimed at remedying any shortages. The chapter includes a review of the situation in other countries regarding any shortages in the surrounding environment and the measures being taken, and that have been taken, to provide a solution to these problems.

6.1 What is IT proficiency?

Three broad types of proficiency in IT can be identified: general proficiency, specialist proficiency, and strategic proficiency.

All individuals need a general or basic proficiency in IT in order to take advantage of the opportunities provided by IT. This type of proficiency in the general public is also necessary in order for the technology to have its full impact. Examples include searching for information, and conducting bank business via the Internet, or being able to use the most common applications in a computer without any complicated introduction. In addition, general proficiency concerns the ability to use the new technology in order to obtain information, to communicate and to express oneself. A general level of proficiency in IT does not only involve basic IT skills, but also sufficient proficiency in subjects such as Swedish, English and Mathematics.

IT specialists is a title often used without a more precise definition of either work tasks or educational background. The persons working with IT can have a university education within IT or some other field, be self-taught, trained within a company, or they have developed proficiency in IT in some other way.

NUTEK (1998) defines IT specialists as persons with professional competence in the IT field, who understand and can develop the technology and its functions. NUTEK defines IT education as courses or programmes containing a core of IT subjects, such as computer science, computer technology, electrotechnology and information/systems science.

However, this technology-oriented definition of IT education is not obvious. The National Agency for Higher Education states that IT education does not only contain educational programmes in technology. The programmes may also be cross-disciplinary courses with elements of IT, and traditional programmes with IT-related course elements. Today, students are often able to put together their own IT educational programme by choosing individual courses.

In addition, there are other IT educational programmes, such as labour market schemes, as well as advanced vocational courses specialising in IT. The purpose of these programmes is to improve the IT proficiency of the workforce at both professional user and specialist levels.

In this chapter, we mainly use the term IT specialist to refer to individuals with a higher education degree qualification within the core subjects of IT, in accordance with the NUTEK definition. We do so because the statistics of Statistics Sweden (Statistics Sweden) are designed in the same way.

In Chapter 5, we discussed the importance of adapting the work organisation to the changed conditions that information technology has brought to the production process. To succeed with this, *strategic IT proficiency* is needed. One example of this is knowing how the specialist proficiency that already exists in the company can be utilised in the best way. Issues such as what type of system is needed in that company, how these systems will affect the organisation of the company, or how the personnel can be encouraged to use the new systems, must be answered before IT can be used optimally in a company. Company-specific proficiency, in combination with awareness of the opportunities opened up by IT, is vital for a strategic use of IT. Both a general technological knowledge, and skills in, for example, organisational studies, are required for this.

6.2 Access to a workforce proficient in IT

There are several indications that Sweden is well forward regarding access to *general IT proficiency*. A measure of this is the number of people that have access to computers and the Internet. Compared to other EU countries, Sweden has the greatest access to both computers and the Internet in the home (European Commission, 1999). Sweden is also one of the leading EU countries regarding company access to the Internet and e-mail (SIKA, 2000). Finally, there is good availability of computers for schoolchildren in Swedish schools compared to other countries (Ds 2000:23).

However, general IT proficiency also requires a general knowledge base, in addition to basic skills in IT. The International Adult Literacy Survey (IALS), an international comparison of the reading, writing and mathematical proficiency of the adult population (16 to 65 years), showed that Sweden had the highest base proficiency in the participating countries (OECD, 1995 and 1997, and OECD and Statistics Canada, 2000).

The high level of basic proficiency of the workforce, combined with the widespread use of computers and the Internet, indicates that Sweden has good potential to absorb new technology. A conservative conclusion is that Sweden has a relatively good access to workforce with general IT proficiency.

One reason for the widespread access to computers in the home is the possibility to buy computers via employers. According to the Agency for Administrative Development, in 1998, 27 percent of employees in private companies had taken advantage of this opportunity. The corresponding proportion among state and municipally employees was 17 and 9 percent respectively. In May 1998, more than 20 percent of computers in households were bought through economic support from, or were owned by, the employer.

However, different groups in society have differing levels of access to computers and the Internet. According to SIKA, the Swedish Institute for Transport and Communications Analysis (2000), in 1999, 67 percent of the population between the ages of 15 and 84 had access to a computer in the home, and 77 percent of those employed in the same age group had access to a computer in their places of work. In 1999, 49 percent of the population between the ages of 16 to 74 had access to the Internet in the home, and 58 percent of the workforce had access to the Internet at work in the same year.

In 1999, there was no obvious difference between the sexes regarding access to a computer in the home. In the ages 15 to 84, 69 percent of the men and 65 percent of the women had access to a computer at home. However, accessibility to computers varied according to age. Younger people were the age category with greatest accessibility to computers in the home. The accessibility decreased somewhat with increasing age, and then dramatically decreased for persons of 65 of older. Only 17 percent of the population between the ages of 65 and 84 had access to a computer at home in 1999. There is also a connection between access to a computer in the home and the level of income. Persons with lower incomes had less accessibility to computers than persons with higher incomes. In addition, persons with higher education had greater access to computers in the home than less-educated persons. Access to a computer at home also varied according to the type of place of residence (see Table 6.1). Access to computers was greatest in the larger metropolitan areas, i.e. Stockholm, Göteborg and Malmö (SIKA, 2000).

Table 6.1: Access to computers in the household according to type of place of residence, proportion of the population in the 15-84 age group (figures in percent)

Place of residence	Proportion
Stockholm	71
Göteborg and Malmö	72
Larger urban centres	68
Southern mixed areas	60
Northern densely populated areas	60
Northern sparsely populated areas	56
The whole country	**67**

Source: SIKA (2000)

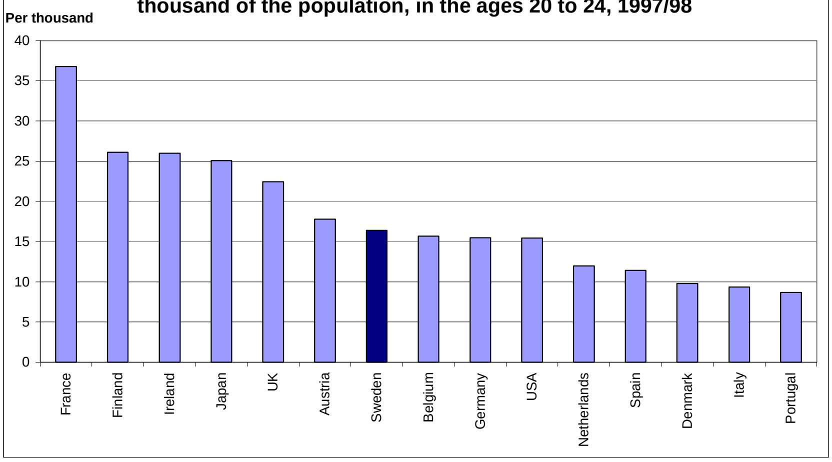
Access to the Internet in the home largely follows the same pattern as access to computers.

Sweden has good access to general IT proficiency, but this does not necessarily mean that the same applies to specialist proficiency.

Sweden has a lower proportion of graduates from at least three-year science and technology programmes at institutes of higher education, in relation to the working population, compared to many other OECD countries. The number of graduates from these programmes per 100,000 people in the working population, 25 to 34 age group, totalled just over 780 in 1998. This can be compared with figures of around 1,370 in Ireland, and around 1,270 and 850 in Finland and the United States respectively (OECD Education Database).

Figure 6.1 shows that the graduation of students from science and technology programmes per thousand of the population in the ages 20 to 24 was lower in Sweden compared to countries such as Ireland and Finland. However, Sweden had more graduates from science and technology programmes than the United States.

Figure 6.1: New graduates in science and engineering shown per thousand of the population, in the ages 20 to 24, 1997/98

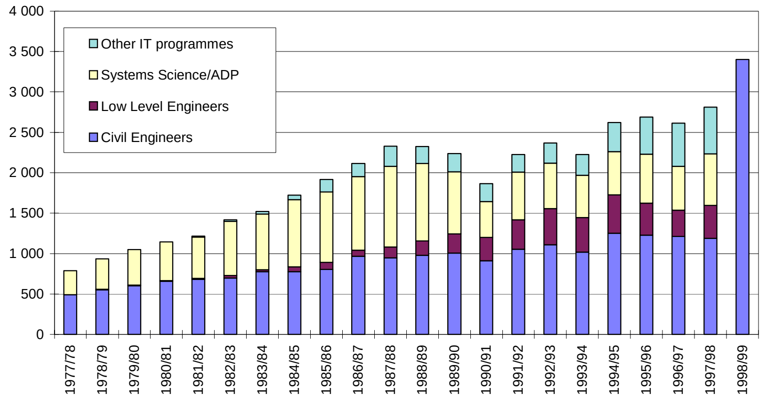


Source: Eurostat/UOE/US Bureau of Census

Figure 6.2 shows the number of graduates from IT programmes in higher education in the period 1977 to 1998/99. This gives an indication of the change in the availability of the workforce proficient in IT with a higher education qualification.[26]

The range of direct IT educational programmes increased during the 1980s in terms of the number of places, programmes and institutes of higher education. However, when the short ADP programme was removed, the number of graduates in the field of systems science/ADP fell drastically between the 1988/99 to 1990/91 academic years. In the 1990s, the number of graduates has risen from nearly 1,900 persons in the 1990/91 academic year to just over 3,400 in the 1998/99 academic year. The largest group of graduates with a higher education qualification within the IT sector is made up of Master of Science Degrees followed by systems science/ADP.

Figure 6.2: Number of new graduates higher IT education, 1977/78–1998/99*



* The number of graduates is not subdivided for the 1998/99

Source: Statistics Sweden

In the period 1977/78 to 1998/99, a total of 43,500 persons graduated from IT educational programmes at higher education level (excluding postgraduates). 22 percent of these were females.

Seven percent of all graduates from higher education programmes in IT in the period 1977/78 to 1996/97 had a postgraduate qualification (NUTEK, 2000d).

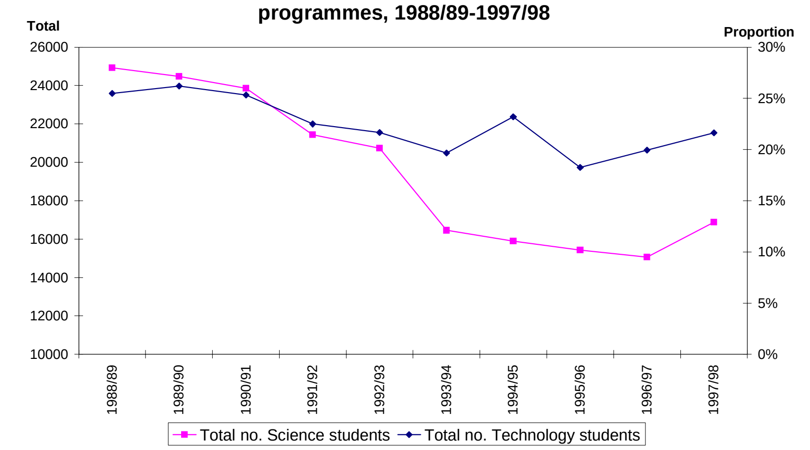
[26] In October 1999, the Ministry of Industry and Trade commissioned Statistics Sweden to compile and present statistics of persons educated in IT, for the academic years 1977/78-1997/98, ref. N1999/10526/AE. The source of the statistical data was the register of higher education. "IT education" was defined in line with the definition previously used by NUTEK.

Today however, there are good opportunities of finding work without graduating from programmes, since there is a widespread demand for well-trained personnel. A follow up of the three-year engineer programmes offered at various places in the country shows that only one student in four on the courses actually completes the degree course (Dagens Nyheter, 2000). Therefore, the supply of IT specialists should be increasing at a faster rate than that shown by the figures above.

One of the prerequisites for increasing the flow of graduates with higher education in IT is that there are sufficient students with the qualifications to apply for these programmes. The majority of higher education programmes in IT field require an upper secondary school qualification in science/technology (the *NT* programme). Between the 1988/89 and 1997/98 academic years, the number of students leaving from the science/technology programmes at upper secondary level has fallen from around 25,000 to less than 17,000 (see Figure 6.3). Over the period, the proportion of all students leaving upper secondary schools with a science/technology qualification has fallen from 25 to 22 percent.

The proportion of females in the total number of students leaving the science/technology programmes at upper secondary schools was 40 percent during the 1997/98 academic year. The proportion of females completing the science programme was 54 percent, while the proportion of females completing the technology specialisation was 14 percent (Statistics Sweden, 1999b). Only nine percent of the applicants to the new technology programme in 2000 were female. In total, just over seven percent of the applicants to upper secondary schools chose the new technology programme (National Agency for Education, 2000).

Figure 6.3: Students completing science/technology programmes at upper secondary schools – total and proportion of all programmes, 1988/89-1997/98



Source: Statistics Sweden, Yearbook of Education Statistics 1999, tables.

Since 1993, Statistics Sweden has conducted annual surveys of the interest of upper secondary students for higher education. The latest survey was in 1999 (Statistics Sweden, 1999c). The study shows that the interest for higher education increased each year in the period 1994/95 to 1997/98. In the 1997/98 academic year, nearly 58 percent of the students in the final year of upper secondary schools planned to study at a university or university college within the next three years. The following year, the interest fell by four percentage points, for both females and males. The interest was virtually unchanged in the last year (53 procent). The subject that upper secondary students planned to study has changed over the period. Since the 1994/95 academic year, the interest for technology has decreased amongst the students on the Science/Technology programme. In the 1994/95 academic year, half the students in the final year of the Science/Technology programme wanted to study technology. The corresponding figure for the spring of 2000 was one-third. The decreasing interest for technology mainly applies to the females. In the 1994/95 academic year, one-third of the females on the Science/Technology Programme wanted to study technology at a university or university college, compared with one-tenth in the 1999/00 academic year. An increasing number of students in the final year of the Science/Technology programmes are interested in studying medicine and information/communication.

Other routes into IT educational programmes at higher education level are through the municipal adult education programme and the Adult Education Initiative. For example, earlier upper secondary studies can be supplemented with a science/technology foundation year and, in this way, students acquire the qualifications necessary to apply to science and technological programmes at universities and university colleges. The foundation year is under the auspices of the adult education programme and institutes of higher education. In the Adult Education Initiative, computer science is easily the biggest subject, both in terms of credits and as proportion of students. Just over 17 percent of the students on the Adult Education Initiative studied computer science in the spring of 1998.

Since 1996, trial projects with advanced vocational education (AVE) have been implemented. AVE offers over 200 different courses in 14 sector areas. In 1999, 46 different programmes were related to IT. AVE is partly aimed at professional positions with specialist proficiency in IT. The Government has allocated resources to AVE, corresponding to over 12 000 places from 1999.

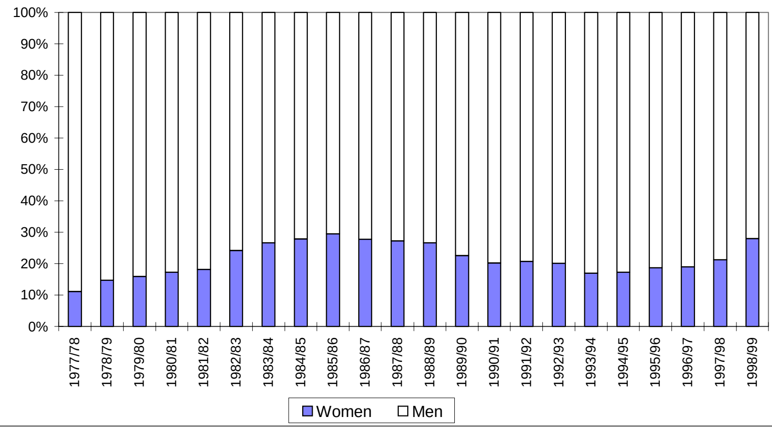
It is difficult to comment on the access to *strategic IT proficiency* since persons with this proficiency do not have a specific educational background.

6.2.1 Low proportion of women graduates with higher education qualifications in IT

The bases of IT knowledge, and a conception of the use of IT, are laid at preschool level, and are then built upon in the compulsory schools and at upper secondary level. The differences in attitutes to IT between boys and girls probably also originate at these levels, and these differences can lead to different choices regarding educational programmes and professions. In the longer term, this impacts the degree of gender equality on the labour market and in society generally, in terms of the access to, and the use of, IT.

The IT educational programmes are predominantly male dominated. The proportion of females graduating with a degree in the IT sector from a university or university college was only 28 percent in the 1998/99 academic year (see Figure 6.4). The proportion has increased in recent years, but the proportion of female graduates is still somewhat smaller than in the middle of the 1980s, when the proportion was over 30 percent. One explanation can be that the short ADP educational programmes were ended in the 1980s.

Figure 6.4: Proportions of females and males graduating with higher education degrees in the IT field, 1977/78-1998/99



Source: Statistics Sweden

The lowest proportion of female graduates was in the technological IT educational programmes. In the more social studies-based educational programmes, such as programming/systems scientists, the proportion of females is higher. But even this programme is male-dominated, where the proportion of male graduates amounted to over two-thirds in 1997/98.

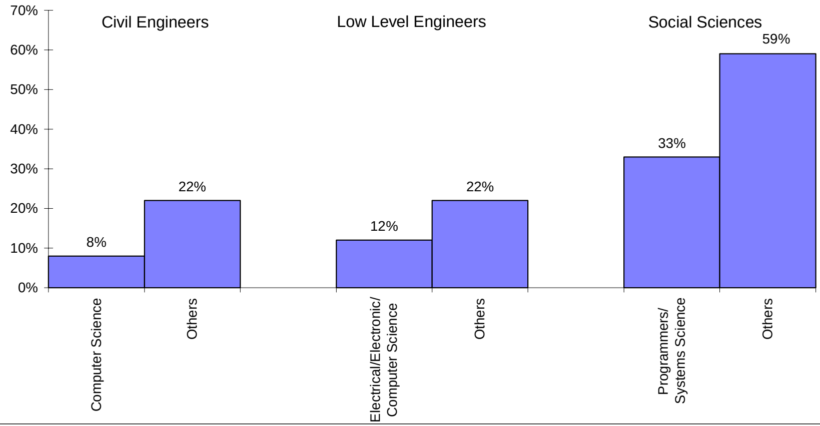
The low proportion of female students is not unique to IT educational programmes. Engineer degree courses are generally male-dominated. But when the proportion of female graduates from the IT educational programmes is studied, the figure for females graduating with degrees in computer science is especially low.

As can be seen in Figure 6.5, only 22 percent of Civil Engineer Degrees[27] (excluding computer science) were awarded to females in 1997/98, but only eight percent of the degrees taken by females were in computer technology. No other civil engineer programmes had such a small proportion of females. Figures for diplomas in lower level engineering that specialised in

[27] Other Civil Engineers programmes were electrotechnology, industrial econonics, chemistry/biotechnology, surveying, mechanical/marine technology, materials/geotechnology, technological physics, and civil engineering.

electrical/electronic/computer science, show that the proportion of graduates that were female was 12 percent, compared with 22 percent in other lower level engineer programmes.[28] Considerably more females chose to become programmers/systems scientists.[29] One-third of the graduates from these programmes in 1997/98 were female.

Figure 6.5 Proportion of female new graduates from IT programmes and comparable programmes, 1997/98



Source: Statistics Sweden (2000)

In autumn 1998, the proportion of female postgraduate students was 41 percent. In 1998, 26 percent of the new intake to postgraduate programmes in technology were females, while the proportion of the new intake to postgraduate programmes in the IT sector was just over 17 percent (SOU 2000:31).

The gender distribution for persons in employment with IT education is shown in the *Workforce Barometer '99* (Statistics Sweden, 2000). This shows that the proportion of females in employment, with a Civil Engineer degree in computer science, is at the same level as the proportion of graduates in the 1997/98 academic year, i.e. eight percent (see Figure 6.6). The proportion of females in employment, compared to other Civil Engineer

[28] Other Lower Level Engineer programmes were chemical engineering and mechanical engineering. Mechanicial engineerig has a somewhat lower proportion of females than electrical/electronic/computer engineering (11 percent). The relatively high proportion shown in the "other" group in Figure 6.4, is explained by a large proportion of female graduates in chemical engineering (55 percent).

[29] Other social science programmes were economics, law, human resources and behaviour science, psychology, social studies, sociology, library studies, and religious studies/theology.

graduates, is significantly lower than the proportion of recent graduates.

The proportion of females graduating from lower level engineering programmes, and the proportion of female lower level engineering graduates in employment, is at approximately the same level, while the proportion of female graduates in programming/systems science is lower than the proportion of those employed. This indicates that the proportion of females among IT specialists in employment will remain at the same low level, or even decrease, in the next few years.

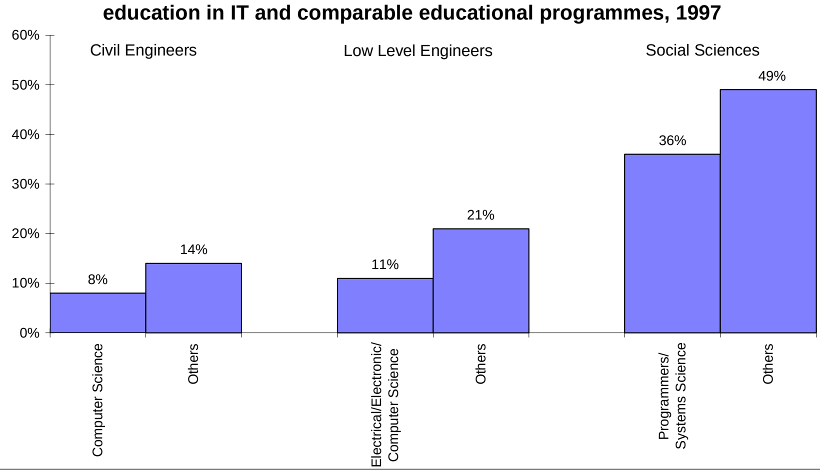


Figure 6.6: Proportion of females in employment who have higher education in IT and comparable educational programmes, 1997

Source: Statistics Sweden (2000)

The low proportion of females educated in IT, who are in employment, is not unique to Sweden. Females are underrepresented in the IT sectors of all EU countries. The proportion of females in the IT workforce increased until the mid-1980s, and then fell thereafter. In no EU country does the proportion of females in the IT workforce exceed 30 percent, and the proportion is closer to 20 percent in most countries (Panteli *et al.*, 1999).

The low proportion of female IT specialists means that females are not given the opportunity to use their skills to the same extent as males, and society is missing out on an important resource at the same time. All resources and talents in the economy must be used, if growth is to increase. Companies must have the best choice of workers, and the best proficiency, to raise productivity. If values and tradition determine women's choices of educational programmes and professions, there are social economic benefits to be gained if this trend can be broken.

6.3 Shortage of IT proficiency

The demand for persons with proficiency and skills in IT increased dramatically in the latter half of the 1990s, and many new companies have been started in the IT sector. The demand for workers proficient and skilled in IT has also increased in industry and the public sector. This trend has proved difficult to trace in prognoses. The prognoses or predictions that focus on the future demand for workers educated in IT, are often presented with reservations. However, most observers agree that there is currently a shortage of a workforce trained in IT in Sweden.

A workforce lacking a given proficiency is an example of a market imperfection. Shortages occur when the demand for a certain proficiency is greater than the supply at a given wage level. On a "perfect" market, a shortage would mean that the price, i.e. the wage, of persons with a certain proficiency would rise, which in turn would mean that the employers would no longer choose to employ so many persons with the specific proficiency. Therefore, demand would decrease, at the same time as more people would choose to follow educational programmes in the specific field (the supply would go up), so the shortage would cease. However, the labour market is not a "perfect"market, which means that shortages can occur, for example, as a result of employers building cartels for the purpose of holding down wages. In addition, the adjustment of supply and demand takes time, and shortages occur during the period of adjustment. In addition, the demand for a certain proficiency may increase more rapidly than the supply. This is called a "dynamic" shortage. (For a more detailed discussion on shortages, see Veneri, 1999.) Bottlenecks, on the other hand, mean that the shortage is so widespread that companies are prevented from expanding their activities/production.

In the National Institute of Economic Research (KI) service barometer for October 2000, approximately 80 percent of computer consultancies and computer service companies pointed out a shortage of personnel with sector-specific proficiency. Nearly 60 percent, mainly the computer consultancy companies, stated that access to a workforce constitutes the largest obstacle to expansion.

A report by the National Labour Market Board (2000a), based on 60 extensive interviews with representatives from the IT sector (companies, sector organisations, and university/university colleges) states that the IT sector will continue to find it difficult to find a sufficient number of trained workers. The shortage of workers proficient in IT affects the whole country, but the shortage is especially felt in the large metropolitan areas. Professions that require long higher education courses are particularly short of workers. Graduates with Master of Science and Bachelor of Science degrees in electronics, electrotechnology, computer science and telecom, are in particular short supply today, and this situation will continue in the future. But the demand is increasing for personnel with other areas of proficiency, such as web designers, IT economists, information specialists, project managers, or other social scientists with adequate IT proficiency. This is because company activities are expanding towards neighbouring sectors. According to the National Labour Market Board (2000b), a relatively large number of workers have been trained on shorter IT educational programmes, such as within the framework of the national IT programme (SwIT) (see section 6.4). This is reflected in the more rapid rise in employment within IT professions for workers with short educational programmes, than within professions that require longer educational programmes. Many companies are now forced to recruit personnel with upper secondary school qualifications, and then train them internally, due to the shortage of personnel with higher education qualifications.

The most common consequences of recruitment difficulties for companies are increased recruitment and wage costs. Representatives of the IT sector point out that recruitment difficulties will also have other consequences. These include postponed expansion, production being relocated to other companies, companies being forced to turn down orders, increased overtime for personnel, and that companies start to run their own training courses (National Labour Market Board, 2000a).

The results from the *Workforce Barometer '99* (Statistics Sweden, 2000) show that graduates with Master or Bachelor of Science degrees, in a number of subject areas, are in great demand on the labour market. There is a great shortage of experienced graduates in all specialist fields. Particularly acute is the shortage of experienced graduates with a specialisation in computers.

Experienced programmers/systems scientists are also in short supply. In addition, recently-graduated specialists in computer science are in short supply, but the balance between supply of, and demand for, recent graduates in programming/systems science, and Bachelor of Science graduates, is thought to be in balance. Most employers questioned in the study estimate that the number of graduates in employment will increase up until 2002, especially those with qualifications in computing. The demand for programmers/ systems scientists is also thought to be increasing.

Statistics Sweden (1999a) also focuses on the long term trends in the labour market. Statistics Sweden assesses that the current shortage of Master of Science graduates will have disappeared by 2010. The continual increasing demand for labour in this sector has led to an expansion of the number of higher education places on these programmes, and in addition, the group is comparatively young, and relatively few will retire in the next few years. Therefore, the net growth to the labour market will be relatively good, assuming that all higher education places are filled, and that the current level of graduation is maintained. The supply of, and demand for, graduates from Bachelor of Science programmes in electrotechnology and teletechnology is also expected to be in balance by 2010.

One condition for bringing into balance the demand for, and supply of, workers proficient in IT, is a sufficient supply of teaching staff and skilled research staff to universities and university colleges. However, for a long time, universities and university colleges have had difficulty recruiting teaching staff to IT programmes, possibly because IT is still a relatively new scientific discipline (National Labour Market Board, 2000a).

International Data Corporation (IDC) has also made a study of supply and demand regarding a workforce proficient in IT (Miroy *et al.*, 1999). IDC warns for a rapidly growing shortage of IT proficiency in Europe. According to the IDC prognosis, the demand for IT proficiency is increasing at such a rate that all available resources will have been brought into use within a short period. The effect of this is an ever-widening gap between supply of, and demand for, a workforce proficient in IT. According to IDC, this trend is already reflected in rising wages and increased personnel turnover, which means increased costs and smaller profits for companies.

According to IDC, the supply of IT workers[30] in Western Europe[31] totalled 8.4 million persons in 1998. In the same year, the demand was 8.9 million persons, representing a shortage of five percent. The demand is expected to increase faster than the supply, which will lead to a shortage of 2.4 million IT specialists by 2002. This will correspond to 19 percent of the demand (see Table 6.1). The relative shortage in Sweden is thought to reflect the same trend as the whole of Western Europe. According to the report, the supply will increase from 321,000 persons in 1998, to 421,000 persons in 2002, while the demand will increase from 338,000 to 510,000.

IDC predicts the greatest growth in demand for technology neutral skills, which corresponds to the expression strategic IT skills (see Section 6.1), and Internet working skills. The supply of technology neutral proficiency is also expected to increase at a rapid rate, but not sufficiently rapidly to meet the demand.

Table 6.1: Shortage of IT workers, 2002.

Technology sector	Persons (thousands)		Percent of demand	
	Sweden	Western Europe	Sweden	Western Europe
Internetworking	7.0	599.1	16	37
Applications skills	54.2	1054.7	18	17
Distributed IT skills	27.1	525.9	20	17
Technology-neutral skills	8.0	182.1	13	13
Host-based skills	0.0	5.4	0	1
Overall IT skills	96.3	2367.2	19	19

Source: IDC (1999).

In absolute figures, the greatest shortage in both Sweden and the rest of Western Europe is expected to occur in that proficiency needed for the development of applications. In Sweden, the

30 IDC define an IT worker as “anyone doing work conceiving, developing, planning, implementing, operating or maintaining information technology as their primary work.”
31 In the IDC study, “Western Europe” comprises Belgium, Denmark, Finland, France, Greece, Ireland, Italy, Luxemburg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK, Germany and Austria.

shortage in different areas of proficiency is expected to lie between 13 and 20 percent of the demand in 2002, with the exception of the proficiency needed for work with host-based systems where there is expected to be a balance between supply and demand in 2002.

6.3.1 The wage pattern for IT specialists

One indirect way of determining whether there is a shortage of a certain professional category is to study the wage pattern for employees in that profession in relation to other professional groups with similar education. Another reason for looking at the wage pattern is that studies aimed at establishing whether there is a shortage of workers, are often based upon interviews with employers or sector organisations, which can mean that any shortage can be overexaggerated.

The wage pattern for a certain professional group is partly controlled by whether or not there is a shortage of workers in these groups. A general wage rise may be difficult to achieve for professional groups where there is a surplus of persons with the relevant proficiency, i.e. when persons in these groups are unemployed. On the other hand, if there is a shortage of a certain type of proficiency, the employers are forced to make higher wage offers to attract applicants with the desired proficiency.

NUTEK (1999c) has looked at the wage patterns of three groups: engineers and scientists with more than three years post-secondary education in IT, systems scientists, and persons with upper secondary education and who are employed in IT-related service industries. Comparisons are made with suitable control groups without IT-related qualifications and with no connection to IT-related service industries.[32] The study shows that the levels of income are generally higher on average for all the IT specialists compared to the reference groups. According to the study, the income effect of being an IT specialist means a higher income of 12 to 22 percent, compared with the proper control group.

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[32] The reference group for engineers and scientist with more than three years post-secondary education in IT, was chosen from persons with more than three years post-secondary education in the natural sciences. The reference group for the systems scientists were persons chosen with three-year, or longer, educational programmes in social science subjects (excluding systems science). The reference group for the group of individuals with upper secondary education, and who were employed in IT-related service industries, were persons chosen with upper secondary education who were not employed in IT-related service industries.

There are indications that the wage gap between IT specialists and the rest of the labour market is growing. According to the Statistics Sweden IT Consultant Index, the wage development in the IT sector is clearly higher in relation to other sectors. Between the first quarters of 1999 and 2000 respectively, the labour costs in the IT sector increased by 6.9 percent. This increase is double that of the total labour market in the same period. These figures give further support to the view that IT specialists are in short supply.

6.3.2 What has caused the shortage?

In spite of a great expansion of the number of spaces in educational programmes in the IT sector, there is still a shortage of workers proficient in IT. The traditional explanation for the shortage of workers with higher education qualifications is the lack of incentive to enter higher education when the education premium is low in Sweden. However, this explanation can be questioned, especially in the case of workers proficient in IT. The previous section showed that the income levels of IT specialists are higher than the professional groups with a corresponding length of higher education.

Jacobsson *et al.* (1999) put forward an alternative argument, that the current shortage of qualified workers with IT proficiency is the result of a shortage of educational services in these areas. For a long time, Sweden has been characterised by insufficient opportunities to study subjects such as electronics and computer science. A lack of variety in higher education up until the 1990s was the cause of this. Only just over 20 percent of students completing the science/technology programmes at upper secondary school have had the opportunity of going on to study at the university colleges of technology.

However, in the 1990s, the Swedish higher education system has been radically changed, with a growth of new university colleges and new educational programmes. In spite of this expansion of educational places, there is still a shortage of educational services in the IT sector, according to the authors. According to the National Labour Board (2000a), the number of educational programmes in the IT field has not increased in proportion to the interest in participating in these programmes. This shortage of programmes will probably be reduced as the number of spaces in higher education increases. According to Jacobsson *et al.* (1999), the shortage may instead be a shortage of applicants with science or technology qualifications from upper secondary school. Therefore, science and technology must be made more attractive, especially to females, to avoid a continued shortage of graduates with IT proficiency. The current gender distribution on the different upper secondary programmes, makes it hard to ignore the conclusion that the supply of workers proficient in the IT sector has a significant gender equality dimension. This also applies at higher education level where there is a much smaller demand from females, compared to males, for programmes within electronics and computer science.

6.4 Measures to enhance IT proficiency

In this section, measures are described that are aimed at enhancing IT proficiency in Sweden and some other OECD countries.

6.4.1 Examples of measures in Sweden

In March 1999, the Government presented a Bill, *An information society for all* (Bill 1999/2000:86). In the Bill (called the IT Bill from now on), the development of proficiency in IT is highlighted as an area of priority. Several of the measures and proposals described in this section originate in the IT Bill.

The need for IT proficiency in schools has been emphasised. The objectives of the National Curriculum for the compulsory years of education (Lpo94) state that the school has the responsibility of ensuring that every school-leaver should be able to use IT as a tool in searching for knowledge and for learning. The National Agency for Education has applied an IT perspective to the work on general curriculum revision.

The National Agency for Higher Education and the National Agency for Education were commissioned by the Government to implement the science and technology project (*NOT-Project*[33]), which aimed at stimulating interest in science and technology. The project went on from 1993 to 1998, and is now continuing in a second phase until 2003. The project has two overriding objectives, namely to change people's attitudes to science and technology, and

[33] Naturvetenskap och teknik

to stimulate the development of teaching methods in science and technology.

The national programme to promote IT in schools (ITiS) will continue in 2000 and 2001. In spring 1998, the Government submitted a publication to Parliament - *Lärandets verktyg - nationellt program för IT i skolan* (skr. 1997/98:176). The “IT in schools” delegation was appointed to plan and implement the national programme for IT in schools, and all the country’s municipalities were offered participation. The programme aims to develop the use of IT as a pedagogical tool. In the three-year period 1999 to 2001, around 60,000 teachers (nearly half) the teachers in preschools, primary, secondary and upper secondary schools are offered skills development in IT. From 2001, teachers in the municipal adult education programme will also be offered participation. The programme also includes state grants for improving the schools’ accessibility to the Internet, e-mail addresses for all teachers and students, support for the Swedish and European school computer network, as well as special measures for disabled students. In the Budget Bill for 2000/2001, the Government announced that ITiS should be extended to 2002. 170 million SEK will be allocated for this purpose, and the Government calculates that a further 13,000 teachers will participate in the in-service training.

The widespread use of computers in Sweden is also attributed to the special tax concessions for computers borrowed from employers (see Section 6.2). On 1 January 1998, tax legislation was changed so that the benefit of using an employer’s computer equipment for private use would not be taxed. The primary purpose of this tax concession was to make it easier for employers to introduce computers to the workplace by giving the employees the opportunity to learn how to use computers at their own pace in the home.

In its IT Bill, the Government proposed a national programme to enhance IT proficiency in small businesses. The Government has commissioned NUTEK to submit proposals for content and scope, as well as the organisation, of a project to enhance IT proficiency in small companies. The project is to be designed as a complement to existing measures in the area, and will start in 2001. In its Budget Bill for 2000/2001, the Government proposes that 15 million SEK be allocated per year in the period 2001 to 2002 to this programme, giving a total funding of 30 million SEK.

In accordance with its IT Bill, the Government has also commissioned NUTEK to submit proposals for content and scope, as well as organisation and implementation, of a programme for the use of IT in companies in areas prioritised in regional policy. The overall objective of the programme is to promote the development of a competitive business sector in these regions. In the first instance, the programme is to justify and facilitate the use of IT in different businesses, from the basis of their own requirements.

In addition, the number of higher education places will be increased by 20,000 in 2000, and just over 10,000 for each of the years 2001 and 2002. Science and technology programmes will be emphasised in the expansion.

The IT Bill proposes that a centre of expertise for Internet technology be set up in the higher education sector. Its primary objectives will be to conduct research and development regarding the Internet. The centre of expertise should be set up in association with the IT venture initiated by the Royal Institute of Technology (KTH) in Kista.

The activities at the “IT University” initiated by the KTH in Kista are aimed at the infrastructure of the information society. The venture is characterised by an all-round view of the information system with strong connections between different technological disciplines and new industrial applications. In its Budget Bill for 2000/2001, the Government has proposed funding for new permanent places at KTH for 2000 to 2002. Of these, KTH plan to allocate over half, or 1,275 places, to full-year students at the IT initiative in Kista.

Another item stressed in the IT Bill is that institutes of higher education should observe the need for proficiency in the areas of network construction and Internet Protocol technology (IP technology) when dimensioning their specialist IT programmes.

In March 2000, the Government decided to increase the resources for the expansion of a cluster focusing on silicon technology. The purpose of the initiative is to strengthen conditions in Sweden for applying the technology of the future in silicon and circuit construction. The cluster will comprise a new institute in Norrköping, which is allocated a single sum of 25 million SEK, and also parts of the Swedish business sector, including both large and small businesses, as well as international companies and guest researchers. The universities in Lund, Linköping and Stockholm, as well as KTH, will be allocated a total of 100 million SEK in the period 2000 to 2005 for research in this field.

In autumn 1999, the Government decided to set up a special council for gender equality issues concerning transport and IT services (dir. 1999:83). On 28 June 2000, the council (also known as *Jämit*) submitted an interim report, IT and Gender Equality (*Jämställdhet och IT*) (SOU 2000:58). The purpose was to show that IT as a technology is a male domain, in spite of the fact that women use IT nearly as much as men. Some of the council's proposals are that:

- The Government should immediately initiate a review of legislation to increase women's representation on the boards of companies.
- The Government should commission the public authorities concerned, to develop statistics on aspects of IT from the viewpoint of gender equality.
- The Government should initiate an evaluation of teaching materials from a gender perspective.
- Aspects of gender and technology related issues should be included in all teacher-led instruction in IT and in other technology-based education.

The Government has not yet decided on the proposals included in the interim report.

In the spring of 1997, the Federation of Swedish Industries brought to the Government's attention the need for professionally qualified personnel in the IT sector. In spite of a high rate of unemployment, employers had difficulty recruiting personnel at the interface between computer users and computer specialists. The result of the dialogue was that the Federation of Swedish Industries and the Association of Swedish IT and Telecom Industry together formed an association for SwIT vocational training. This was commissioned to implement a programme under the auspices of the Labour Market Board, with the aim of improving vocational skills for professions that were short of personnel in the IT sector. The Government allocated 1.3 billion SEK in its Budget Bill for 1997/1998, to a national IT programme (SwIT). The agreement between the Government and SwIT vocational training meant that 11,700 persons would go through training courses between 1998 and 31 March 2000, and that at least 75 percent of these places would be allocated to unemployed persons. The remaining 25 percent could be in employment, but with a need to renew, or change, work tasks. The agreement also stated that groups that were underrepresented in the sector – women, immigrants and people with occupational disabilities – should be given special opportunities to participate in the training. The Office of Labour Market Policy Evaluation (*IFAU*) has evaluated the success of SwIT. An ambitious objective of the programme was that all unemployed persons successfully completing a SwIT training course would be in employment within six months of completing the course. The Office concluded that the programme had failed to reach this objective. However, the SwIT training courses have put a higher proportion of persons into employment than the computer-related courses organised by the National Labour Board – 62 percent compared to 49 percent (Johansson and Martinsson, 2000).

In autumn 2000, the Government presented a proposal for tax concessions for specialists from other countries. The proposal is that foreign specialists, researchers and business executives who work temporarily in Sweden, are only taxed on 25 percent of their income for a maximum of three years. Other benefits, such as compensation for relocation costs, journeys for the family between Sweden and the home country a maximum of twice a year, as well as school fees for the children, would also be tax-free. The purpose is to facilitate for Swedish companies to recruit key personnel from other countries, and make it easier for foreign companies to invest in Sweden. The changes will come into effect at the start of next year.

6.4.2 Measures in some other countries

The issue of the shortage of workers proficient in IT has been highlighted in many other countries. In this section, measures are described that were aimed at enhancing IT proficiency in five other countries, namely the United States, Japan, the United Kingdom, France and Germany. A review of how other countries are tackling the problem of labour shortages, may be useful to the Swedish Labour Market. The review is based on a report, *Åtgärder för att stärka tillgången av IT-kompetens på arbetsmarknaden i USA, Japan, Storbritannien, Frankrike och Tyskland*, produced by the Swedish Technical Attaché Services (STATT) on commission from the Ministry of Industry, Employment and Communications.

USA

According to STATT, economists, politicians, representatives of industry and trades unions in the United States are unanimous about the shortage of workers in the American IT sector. In spite of problems defining and measuring the IT sector, a number of American studies indicate that there will be an increasing need for both general and specialist IT proficiency in the future, but the most acute problem at present is access to specialist proficiency.

Women are underrepresented in most areas of technology in the United States, including IT. Women are relatively well represented in IT professions requiring less training, but they are in a clear minority when the profession requires longer educational programmes. Like Sweden, the United States had peaks in the mid-1980s with regard to the proportion of female graduates from IT programmes at higher education levels (around 36 percent in 1984), but the proportion decreased in the 1990s (around 28 percent in 1996).

In general, the United States has relatively many well-established programmes to satisfy the needs of the labour market for skilled workers, in both the short and long term. Both central government and industry are aware that the shortage of proficient labour can constitute a serious threat to the country's growth and competitiveness. Therefore, both the state and the business sector assume responsibility for development and growth in the IT sector. Public/private partnerships have been created to reduce the gap between the supply of job opportunities and the supply of workers. Most of the measures have concentrated on shaping the education system to correspond better with the needs of industry.

Another measure used to solve the most acute shortages in the United States has been to recruit from overseas. Special visas, for a maximum of six years, can be issued to individuals with qualified higher education degrees, mainly technology specialists who are offered positions in the United States. Congress is also looking at a proposal for international students, who have completed an engineering degree at an American university, to be given a residence permit to work at an American IT company.

Mentor programmes, information in schools at an early age, and new pedagogical techniques in mathematics, science and technology, are measures aimed at attracting more young women to a future in the IT sector. In addition, central funding has been allocated to a project run in collaboration between employers and teachers, to retrain unemployed persons for a career in IT. Special projects are aimed at unemployed women and disabled people.

Companies are attempting different ways to satisfy their need for IT-proficient workers, such as building up special training and recruitment programmes, new technology for internal training, and collaboration with universities and university colleges. “Aggressive” recruitment is being increasingly used to attract skilled workers from other companies. Examples include bonus payments, flexible working hours, distance work, day-care centres, and access to free health. Companies can not only recruit workers from the nearby surroundings, but use consultants from other parts of the world, such as India and Israel. The geographical location of an IT worker is not so important for software development.

In conclusion, it can be mentioned that the National Academy of Science (*NAS*) has been commissioned by Congress to look at the need for workers in the IT sector for the next ten-year period. NAS will examine the capacity of the education system, the supply of labour in other countries, and the opportunities to recruit labour from the local surroundings. The report will be presented in the autumn of 2000.

Japan

According to STATT, after a couple of years of economic depression, there are currently relatively few companies that are experiencing any acute general shortage of IT specialists in Japan. However, most companies with any significant element of IT in their operations greatly need to recruit experienced and skilled IT specialists in new areas of technology, which are not especially well-provided with these types of workers.

In Japan, companies have traditionally taken a big responsibility for in-service training of their employees, and this is also true for training in IT. The system of lifelong contracts is starting to be eliminated, and the business sector is making more demands on the universities’ capabilities to supply skilled workers for the IT sector. Initiatives to increase the IT educational programmes have mainly come from private universities, and a number of private universities specialising in IT in association with social studies, have grown in recent years. But for large companies, their own internal training schemes are still the main way of maintaining the supply of proficiency in the IT sector. Companies carry out internal training, often comparable to a university education, through these “company universities.”

The Japanese Ministry of Education does not seem to have any pronounced policy to promote the expansion of higher education programmes with a specialism in IT. However, individual universities have taken initiatives to set up new educational programmes or faculties that focus on IT. There are no official statistics, so it is difficult to quantify the extent of the expansion of university programmes with a specialism in IT, but there are indications that a significant expansion has taken place, according to STATT.

In Japan, there is a special system for post-secondary vocational education – vocational colleges that are mostly privately run. A standard system for certification of IT engineers regulates the proficiency requirements for graduates from the vocational colleges. In recent years, the rapid development of IT has forced several revisions of these proficiency requirements for the certificate. Only 20 percent of the students who took tests to become different types of IT engineers were successful in 1998.

In Japan, the formulation and implementation of IT strategies in companies is emphasised as a very demanding task. Therefore, the *Information-technology Promotion Agency* (IPA) gives support to persons in management positions, who are in charge of IT strategy in medium-sized companies. One of the aims of this is to create a forum for the exchange of experiences. The support includes information work - seminars and visiting activities to offer advice to the company management on questions related to investments in information systems.

United Kingdom

The shortage of qualified IT specialists is thought to constitute the greatest threat to continued rapid economic growth in the information, communication and electronic industries in the United Kingdom. In addition, the shortage of basic IT proficiency in the workforce has been pointed out. A survey of 75 multinational companies in the United Kingdom, Germany, USA, France, Japan and Singapore shows that the British workforce has the lowest level of IT proficiency in these six countries. An international benchmarking study conducted by the Department of Trade and Industry (DTI) in 1996 confirms the pattern. The study shows that only France has more companies that complain of insufficient IT proficiency in the workplace.

At present, there are a number of private and state-run initiatives to increase the access to workers proficient in IT. At the end of 1999, a national strategy for the securing of IT proficiency grew out of a commission, *Skills for the Information Age*. A central proposal was the creation of a council, the *Council for Information, Technology, Communications and Electronics Skills*, which consisted of representatives from different sector organisations. The idea is that the council will operate as a partner to the Government on questions relating to learning and proficiency. The council will assess the current and future needs for IT workers, attract more females to IT educational programmes, make it easier for companies to recruit workers from other countries, as well as help companies to develop strategies for recruitment. One example of the latter is that companies are encouraged to connect to *Investor in People*, a national standard for staff development as a first step in developing proficiency and recruitment strategies.

Another important question being discussed in the United Kingdom is the need to build bridges between industry and the education system. One example of this is *University for Industry* (UfI), which was launched in the spring of 2000. UfI is an initiative from the British Government with the purpose of stimulating and simplifying the lifelong learning. The initiative is based on a partnership between companies and educational organisations, and IT proficiency is an area of priority. Another proposal is for national coordination between the employers within the IT sector and the education system, regarding aspects such as work-related experience and the opportunity for the sector to influence the educational programmes.

France

The shortage of workers proficient in IT is also experienced as a serious problem in France. In relation to other European countries, France is lagging behind in terms of the extent of connection to the Internet. The French Government fears that this reflects a general lagging behind regarding the IT proficiency of the workforce. The debate on specialist expertise in the IT sector increasingly focuses on taking the confirmed shortage seriously, and taking suitable education and incentive measures.

In spite of this, the French state has taken relatively few measures to promote the development of IT proficiency. In general, the state implements measures to stimulate skills development and learning in working life, and IT is often an area of priority in these contexts. The Prime Minister, Jospin, has also laid the foundation for municipal educational initiatives, by stating on several occasions that the use of computers in schools must be prioritised. However, there is still a shortage of skilled teachers at present.

The number of university places has been increased on Master of Science programmes, partly as a measure to alleviate the shortage of IT specialists. Since 1983, the number of qualified Masters graduates has doubled, and totalled 25,500 in 1997.

The sector organisations often play an important role in France, and this also applies to the IT sector. Responding to the shortage of IT proficiency, five sector organisations joined forces in 1998 to work out an educational programme for new graduates, Masters graduates and economists. A number of intensive courses have been developed in the programme, with the aim of providing a basic, continually updated, further education in different IT-related subjects.

Germany

The IT sector is marching onwards in Germany, and the sector had a growth of over 9 percent in 1999. The strongest growth was within software and IT services. The shortage of workers in the IT sector has been identified as a major problem for the future growth. The sector claims that there is an accumulated need for around 75,000 specialists.

Like France, the low degree of IT maturity, both on a general and specialist level, is an important explanation to the shortage of IT proficiency in Germany. Therefore, central government is trying to promote a strengthening of the general level of IT maturity. One example of this is the project, *Skolor på nätet*, which aims to increase the number of computers connected to the Internet in schools. The objective is to reach full coverage in 2000, which should be seen in relation to the fact that only 30 percent of the schools were connected to the Internet in 1999. Another example of an attempt to improve the IT maturity in the country is the *Women on the Net* initiative, which was started in 1999 with the aim of promoting the number of female Internet users. The project attempts to remove obstacles to the use of the new technology, primarily through arranging courses aimed at women.

The Government, sector organisations, chambers of commerce, and employer and employee organisations have come together within the framework of the *sysselsättningspakten*[34]. This is an initiative from the Federal Government that aims to coordinate efforts to find ways of reducing unemployment. The shortage of workers, and the employment potential of the IT sector, has been identified as one of the areas of priority. All parties have agreed on a large number of objectives and measures to reduce the shortage of workers in the IT sector. In addition to increasing the volume of educational programmes, and an increased range of further education programmes in the IT sector, the creation of an education fund is proposed, in collaboration between private and public groups. Some of the uses of the fund would be to provide extra resources to IT at higher education level for students who are not specialising in IT, stipendia for students on IT programmes, and further education initiatives.

[34] Bündnis für Arbeit, Ausbildning und Wettwerbsfähigkeit.

6.5 Concluding remarks

The current restructuring process has consequences for the business sector's need for proficiency, in terms of general, specialised, and strategic IT proficiency.

There are many indications that, in an international perspective, Sweden has good access to general proficiency in IT. However, this does not mean that the general IT proficiency need not be improved. Different groups in society, such as the elderly, have less access to computers and the Internet than other groups. The education system must be continually reviewed so that basic and vocational educational programmes provide the skills required by information technology. The educational programmes must be adapted to the ongoing developments in society. The rapid restructuring process and development of technology demand continual skills development and lifelong learning in the workforce, where knowledge and skills have a sell-by date.

One positive step is the savings scheme for individual skills development that Parliament has decided to introduce. The commission on individual savings for skills development was to submit proposals on 15 December 2000 about how this type of system could operate.

Most observers agree that there is a shortage of IT specialists in Sweden at present. The shortage of qualified workers with IT proficiency has been pointed out as one of the biggest obstacles to the expansion of both the IT sector and for the other parts of the business sector, and therefore must be taken seriously.

Several countries have drawn attention to the shortage of qualified workers with IT proficiency, including the United Kingdom, Germany and the United States. All these countries have appointed some sort of commission, consisting of representatives from central government, the business sector, different interest and sector organisations, and the arrangers of educational programmes, with the aim of achieving an overall grasp of the problem. In the United States, one of the tasks of the commission has been to review the needs of the economy regarding workers proficient in IT, both in the short and long term. The results will be used to map the capacity of the education system, the supply of workers from other countries, and the possibilities of recruiting workers from the surrounding area. The use of existing resources has also been analysed in this context. One example is that unemployed persons should be offered training programmes that complement and broaden their existing skills and enable them to find employment in the IT sector. Setting up a similar commission could also be a suitable measure to implement in Sweden.

It is hard to draw any general conclusions regarding the supply of, and demand for, strategic IT proficiency. However, there are indications that this type of proficiency is in short supply.

A key issue for the strategic use of IT is awareness within companies of the value of, and opportunities created by, IT. Therefore, it is important to work towards an enhanced understanding of the business opportunities created by an organisation adapted to IT. In particular, small and medium-sized companies need this type of information.In Japan, the Information-technology Promotion Agency (IPA) has the task of supporting companies in the implementation of IT strategies, and in questions concerning investments in information systems. One of the functions of IPA is to operate as a forum for exchanging experiences. An example of a support function is to help companies avoid unnecessary or unsuccessful investments in IT. Attention has been drawn to the need for a similar support function in Sweden.

The proportion of female graduates with qualifications from an institute of higher education, and the proportion of women in employment with IT training, is low in Sweden. The low proportion of female IT specialists means that society is missing out on an important resource. One way of remedying the shortage of IT proficient workers in the long term, is to work towards increasing the interest of females for educational programmes in the IT sector. A study conducted by Statistics Sweden, focusing on the interest of upper secondary students for higher education in technology, shows that the interest has decreased in recent years, and mainly amongst the female students. This can indicate a negative trend.

One of the tasks of Jämit has been to highlight proficiency issues regarding IT from the perspective of gender equality. The task is to be completed by 30 June 2001.

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