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THE SWEDISH NATIONAL INNOVATION SYSTEM 1970–2003

a quantitative international benchmarking analysis

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VINNOVA, the Swedish Agency for Innovation Systems, integrates research and development in technology, transport, communication and working life.

VINNOVA's mission is to promote sustainable growth by developing effective innovation systems and funding problem-oriented research. Through its activities in this field, VINNOVA aims to make a significant contribution to Sweden's development into a leading centre of economic growth.

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The present study is part of a larger project at VINNOVA, which aims at improving the understanding of strengths, weaknesses and policy challenges in the Swedish national innovation system. This report is an abridged version of the main report from this project. The main report will be published in September 2004.

In addition to its empirical ambitions, this study is part of a general methodological development effort related to innovation system analysis. The purpose is to contribute to improved methodologies used in innovation system analysis at VINNOVA. The ambition has also been to contribute to the international development of methods for innovation system analysis. Therefore, the present study has been part of a more general OECD effort, aimed at improving the methodologies of innovation system analysis.

A deep understanding of the major strengths, weaknesses, threats and opportunities of the Swedish national innovation system is necessary for adequate and efficient policy design at VINNOVA. In addition to the need for knowledge about the general innovation system challenges facing Sweden, sectoral and regional innovation policies require specific knowledge about the country's challenges and opportunities. Therefore, foresight and analysis of innovation systems at a national, sectoral and regional level are integral parts of VINNOVA's activities.

In 2004, VINNOVA will focus on sectoral and regional innovation systems in Sweden, in order to identify potential or actual centres of excellence in research and innovation within different sectors and regions.

Per Eriksson, Director General, VINNOVA, Swedish Agency for Innovation Systems

1 Introduction

The purpose of this study is to contribute to improved understanding of factors determining the long-term competitiveness of the Swedish economy. Innovation and the rate of economic success of innovation are the most important determinants of long-term productivity,[1] which, in turn, determines long-term value added and economic growth. Therefore, this study aims at identifying, characterising and valuing general and particular strengths and weaknesses in connection to innovation and economic growth in Sweden. In relation to this analysis, policy challenges for future Swedish innovation, value added and economic growth are discussed.

Knowledge-intensive industrial and economic activities are particularly important for the future competitiveness of national economies.[2] Therefore, the analysis of the Swedish national innovation system will primarily focus on strengths, weaknesses and policy challenges in relation to knowledge-intensive innovation and knowledge-based economic growth.

Innovation and innovation systems

Innovation is understood in the broadest sense, as productive renewal in the form of:

> *New goods or services, new business models or markets, new processes or organisation of production, new competences or input sources.*[3]

Many factors influence innovativeness and transformations of innovations into value-adding products, processes or other kinds of innovation. Innovation and economic growth are the result of numerous factors and micro-processes in different parts of the economy. In order to understand and value the role and importance of these factors and processes, they need to be analysed in a coherent context and in relation to each other.

The innovation system approach is a general analytical framework for analysing the role, impact and relationships of all factors that are important in generating innovation and in transforming innovation into economic value. In this study an innovation system is defined as:

> *The network of organisations, individuals and institutions which determine and shape the generation, diffusion and use of technology and other knowledge, which, in turn, explain the pattern, pace and rate of innovation and the economic success of innovation.*[4]

The present study aims at analysing the long-term international competitiveness of the Swedish national innovation system.

Comparative and long-term perspective

The competitiveness of different innovation systems can only be analysed by comparing different innovation systems. Therefore, this study bases the analysis of the Swedish national innovation system's competitiveness on comparisons with other national innovation systems.

Different innovation systems differ in terms of their capacity to generate innovations and in terms of the ability to exploit them economically. Depending on the characteristics of an individual innovation system, different organisational and institutional set-ups may lead to competitive innovation systems. Understanding the strengths and weaknesses of different innovation systems requires both a comparative analysis of key functions within different innovation systems and a deeper analysis of these functions within individual innovation systems. This is the approach that has been adopted in this study, where the analysis of key functions in the Swedish national innovation system has been based both on international comparisons and on an analysis of particular Swedish patterns and dynamics.

Economic systems in general and innovation systems in particular develop in an evolutionary manner. The present competitiveness of innovation systems is the result of organisational and institutional set-ups, together with patterns of investments and outputs that have developed over a long period of time. Changes in the overall functions of the organisational and institutional set-ups of innovation systems generally develop slowly. Therefore, a long-term analytical perspective is necessary. The period of analysis covered by this study is 1970–2003. However, in certain areas, data availability sets restrictions for the statistics used in figures and tables.

Innovation system indicators

To analyse innovation system competitiveness, a number of quantitative indicators are necessary, although as analytical tools, these are not sufficient to fully understand the dynamics and efficiency of innovation systems. The present study is primarily based on quantitative indicators of the key functions in national innovation systems. Based on these indicators, Swedish national innovation system performance is compared with that of other countries. Qualitative information on the Swedish national innovation system is used to understand the roots and implications of different indicators.

Individual indicators should only be seen as pieces in any innovation system analysis. Conclusions based on individual indicators are insufficient and may often be misleading in understanding the dynamics and competitiveness of innovation systems. Moreover, virtually all innovation system indicators suffer from more or less important qualitative limitations. Therefore, it is necessary to be restrictive in interpreting the competitiveness of innovation systems in the light of individual indicators. Instead, a number of different

indicators need to be analysed together in the same context. Moreover, on the basis of national data only, it is not possible to draw conclusions about the significance of different factors. Accordingly, innovation indicators not only need to be analysed together, but they also need to be analysed by means of international comparisons. This is the way in which innovation indicators are used in this report.

Outline of the study

This study comprises six parts. In the first part, chapter 2 provides a concluding integrative analysis of the Swedish national innovation system. This is followed by a discussion regarding important innovation policy challenges for Sweden in chapter 3. In the second part of the study, chapters 4–6 analyse Swedish innovation system competitiveness in terms of international comparisons of economic growth, job creation and innovation. In part three, chapters 7 and 8 analyse Swedish technology and science production performance. In part four of the study, chapters 9–11 analyse Swedish innovation activities and interaction patterns. In part five, Swedish R&D and human resources are analysed in chapters 12–13. In the sixth and final part, chapters 14–16 analyse the financing and incentive structures of the Swedish national innovation system.

I. CONCLUDING ANALYSIS

2 Innovation System Analysis – Executive Summary

The Swedish national innovation system has shown a relatively weak long-term competitiveness in terms of innovation, economic growth and job creation, despite large investments in the production, diffusion and use of knowledge. In terms of economic growth, job creation and value-adding innovation, Sweden was on average and for most of the period 1970–2003 far from the top in the OECD rankings.

The reasons for this relatively poor development of Swedish competitiveness are several. One is a gradual loss of efficiency in a previously efficient Swedish paradigm that strongly stimulated development and growth in large R&D-intensive multinational groups. While these industrial groups still have a large volume of R&D activities in Sweden, their value generation in Sweden has gradually been decreasing.

Another important reason is the relative lack of strong incentive and support structures for radical renewal and growth through knowledge-intensive start-ups and SMEs. Further, focus on service sector innovation and value added in both the private sector and public sector has been relatively weak. In the private sector, such innovation is closely linked to the degree of innovation in SMEs.

Another reason for this development is the relatively strong focus on curiosity-driven basic research in the Swedish research system, which has worked rather well for large R&D-intensive multinationals, but not as well for other innovation and value-adding production, in either the private sector or the public sector.

Finally, a number of problematic features have developed in the Swedish labour force and labour market, and their related incentive structures. These have undermined the effective labour supply, producing a rise in unemployment and health-related work absence and thus removing an increasing proportion of the population from the labour force.

The Swedish national innovation system has great potential compared to most other OECD countries. Firstly, Sweden's macroeconomic situation and public finances are strong by international standards, which provides a good basis for sound incentive structures, as well as for investments in resources and structures stimulating innovation and economic growth. Secondly, Sweden is an attractive market for qualified R&D investments and can boast substantial R&D resources in a number of large knowledge-intensive companies, as well as a highly-developed and scientifically capable university system.

Further, Sweden has a highly competent population, which is recognised for being relatively open to new technology. Finally, Sweden has a qualified public sector in great need of productivity and quality-improving solutions, which could generate a potentially strong leveraging demand for both radical and incremental innovation and production in both new and existing firms in Sweden.

Innovation system competitiveness

The long-term competitiveness of the Swedish national innovation system was relatively weak during the period 1970–2003. The legacy of high manufacturing labour productivity noted during 1970–2003, combined with a rapidly decreasing manufacturing sector, was not efficiently transformed into new high value-adding services and new jobs. Despite increasing productivity levels and considerable growth in certain high-technology manufacturing industries, the relative contribution of manufacturing value added to Swedish GDP and growth decreased considerably during 1970-2003.

Both private and public sector services in Sweden have performed relatively poorly in terms of value-adding innovation and job creation. Moreover, the Swedish labour market has in the past decade shown clear tendencies of a decline in sustainability, with a rise in unemployment and health-related work absence and an increasing dependency ratio,[5] due to demographic reasons. In terms of relatively radical renewal, through start-ups and high growth in such firms, the Swedish national innovation system has been considerably less competitive than in terms of large industrial groups with advanced technology. Low rates of R&D-based start-ups have been generated, particularly from university research environments.

Technology and science performance

Technology and science performance in the Swedish national innovation system was at the very top of the OECD rankings during 1970–2003, in terms of international patenting and scientific publication. Moreover, Swedish technology and science production continuously improved in an international comparison. However, a number of important challenges remain for Sweden.

To begin with, R&D-intensive manufacturing groups with a substantial R&D base in Sweden dominate Swedish international patenting and it is thus primarily the technological strengths of these industrial groups that are measured when Swedish international patenting is compared with that of other countries. Small and medium-sized enterprises and individual entrepreneurs represent a very small share of total Swedish international patenting. The technological dominance of large and increasingly foreign-owned industrial groups that are less inclined to invest in production in Sweden may become a threat to future Swedish technological renewal and innovation performance.

Also, while Swedish international science production has increased rapidly in recent decades, the quality measured in terms of the Swedish international ranking in terms of citation-rate per scientific article has decreased within all broad science fields. This development may be a threat to the future science and knowledge base of the Swedish national innovation system.

Innovation activities and interactions

In relation to the size of its population, Sweden invests more resources than any other country in the OECD on R&D and other activities related to the production, diffusion and use of knowledge. Most resources are invested by the business sector. Swedish industry has increased its investments rapidly in the last 15 years and is, in relation to the size of the country, a world leader in both manufacturing and services.

Swedish business sector R&D investments are dominated by large multinational manufacturing groups with high R&D intensity in Sweden. The strong position of these large multinational industrial groups and the high R&D intensities in Sweden have been strongly stimulated by long-term public-private user-producer relationships, based on technology-intensive public procurement by public monopolies or semi-monopolies. The relatively high stability and technically demanding content of these relationships have promoted a high level of long-term investments in business R&D in Sweden.

Sweden's public innovation system investments are also among the highest in the OECD. However, in recent years, stagnating investment trends have weakened the Swedish position in this respect. Swedish public R&D investments are by international comparison highly focused on curiosity-driven basic research in universities, while investments in mission-oriented research are by international standards low. The proportion of such investments has moreover declined in Sweden over the last two decades. By international standards, Sweden has a relatively low share of university research that is financed by the industry and this share has decreased further in recent years. At the same time, business sector R&D is increasingly focused on development activities closer to the market, while the share of more long-term research activities is decreasing.

Thus, the interactions between the scientifically strong Swedish university system and the technologically leading industrial groups may be weakening. This interaction pattern is a threat to future Swedish technological leadership and innovation performance.

R&D structures and human resources

R&D resources in the Swedish national innovation system have been highly concentrated to a small number of large multinational groups on the one hand and large established universities on the other. This has split the Swedish R&D system into two distinct R&D performing sectors.

The general level of people who have completed

some form of higher education has not been high compared to most other OECD countries. In the 1990s and early 2000s, the Swedish position improved considerably in this respect. In Sweden, people with a higher education, particularly at research level, have to a large extent been concentrated to knowledge-intensive services, high-technology manufacturing groups, universities and R&D institutes. Within the business sector, knowledge-intensive business services have rapidly increased the employment of people with a higher education and now employ considerably more natural scientists and engineers than the manufacturing industry. Moreover, the most qualified human resources within the manufacturing industry have to an increasing extent become more concentrated to large industrial groups.

Manufacturing SMEs belonging to large industrial groups generally have a considerably higher proportion of staff with a higher education background than independent SMEs. This concentration tendency is not as strong in the business sector for service SMEs as in the manufacturing industry.

The general mobility rate in Sweden is not particularly high by international standards, especially in higher age cohorts. While the mobility of people with a higher education has been high from university education to industry, the mobility of people with a similar background from the business sector to universities or other parts of the public sector has been very low.

Financing and incentive structures

The financing and incentive structures of the Swedish national innovation system have primarily been geared towards stimulating productivity improvements and growth in large manufacturing groups. The knowledge-intensive Swedish manufacturing industry has been spurred to continuously rationalise production processes. General tax structures, labour market structures, public attitudes and public-private partnerships have all been rather stimulating to large-firm capital accumulation and growth in Sweden.

The general incentives for starting firms and generating SME growth in Sweden have been much weaker. Moreover, the pre-seed and the earliest seed-stages financing of R&D-based start-ups have remained low and even decreased in Sweden in recent years. In addition, the Swedish support structure for stimulating commercialisation of R&D through start-ups and growth of such firms is fragmented, nationally and regionally.

The general incentive structures in the publicly funded and highly university-based Swedish research system do not provide strong incentives for knowledge interaction and learning between university researchers and businesses or public sector services. Even the incentives for interaction between different university departments, within or between different universities, are not particularly strong.

3 Innovation Policy Challenges

The analysis in the present study has identified considerable potential and strengths in the Swedish national innovation system. However, a general innovation system challenge in Sweden is to improve the impact of these internationally favourable conditions on long-term innovation, economic and job creation competitiveness of the Swedish economy.

Therefore, this study raises a number of important innovation policy challenges for Sweden. These challenges need to be addressed in a national innovation policy strategy for Sweden. Such a strategy would not only need to address the right issues, it also needs to design and establish an implementation strategy that covers and generates synergies between different administrative policy areas and bodies at both national and regional levels. The major innovation policy challenges could be grouped in five categories, which, however, are all interrelated and should therefore be addressed within the same general innovation policy framework:

- **Start-up, innovation and growth in knowledge-intensive SMEs**
- **Improved supply, use and mobility of human resources**
- **New regime for user-producer public-private partnerships**
- **Increased volume and impact of mission-oriented research**
- **Centres of excellence for research and innovation**

Start-up, innovation and growth in knowledge-intensive SMEs

One important challenge to Swedish innovation policy is how to improve incentives and support structures that would generate increased value added through the establishment of R&D-based SMEs. Industrial renewal through start-ups and growth in small, innovation-based firms has been a weakness of the Swedish national innovation system.

The weakening Swedish basis of the large industrial groups in Sweden, together with the limits to public sector expansion, have made it important to increase the rate of knowledge-intensive start-ups and high-growth, innovative SMEs in Sweden. Moreover, since small firms generally show higher rates of radical innovativeness than larger ones, the rates and growth of knowledge-intensive SMEs should be critical to Swedish innovation system renewal.

Improved supply, use and mobility of human resources

Another important challenge to Swedish innovation policy is how to secure a large enough future supply of highly qualified people to the Swedish labour force, together with improved use and mobility of existing human resources. In the recent decade, increasing labour market problems related to demography, job creation and use of the labour force have made labour market issues one of the most important challenges for improved innovation and economic growth in Sweden.

Human resources are the most important resources in innovation and production. Therefore, an effective supply and use of qualified human resources is essential to the long-term competitiveness of innovation systems. Inefficiency of national innovation systems in relation to human resources could hardly be compensated for in a long-term perspective by other innovation and growth policy measures.

New regime for user-producer public-private partnerships

A third important challenge for Swedish innovation policy is to find new routes to replace the old national innovation system regime, which in terms of technological and scientific performance has been quite efficient. Replacement is, however, inevitable and necessary, since the foundations of the old regime have been irreversibly outdated, due to international developments and the considerable deregulations of sectors that have historically formed an important basis of that regime.

A new public-private partnership regime should be based on the need for improved innovation in the Swedish public service sector which, by international standards, is large. The relative size of this sector in Sweden makes public sector innovation critical for Swedish economic competitiveness. At the same time, the size and high quality standards of this sector make it a potentially strong vehicle for generating effective leveraging demand for both radical and incremental innovation and production in both new and existing businesses in Sweden.

Increased volume and impact of mission-oriented research

A fourth important challenge for Swedish innovation policy is how to increase the volume and impact of the Swedish research system on innovation in both the business sector and the public sector. The Swedish research system has by international standards focused relatively little on mission-oriented research, which could be a threat to future developments as regards the location of and efficiency in industrial innovation activities in Sweden. Sweden also needs to improve the impact of the Swedish research system on innovation-based start-ups, innovation in existing SMEs and innovation in public organisations.

The Swedish research system, which has been highly based on curiosity-driven university research, has been efficient in supporting innovation in large R&D-intensive industrial groups, primarily through flows of people with a higher education. However, it has been relatively inefficient in supporting start-up innovation, innovation in SMEs and public sector innovation. At the same time, innovation and growth in these latter

three categories have increased in importance for future Swedish economic growth and welfare, while the large industrial groups have gradually been losing the connections to Sweden as their home base for production.

Centres of excellence for research and innovation

A fifth important challenge for Swedish innovation policy is how to improve the interaction efficiency in R&D and innovation within the Swedish national innovation system. The challenge is how to generate research and innovation environments that simultaneously continue to attract investments by technologically leading firms and improve the rate of innovation-based start-ups and growth in SMEs and large firms in Sweden. Start-ups and SME growth are weaknesses of the Swedish national innovation system and the globalisation trends have increased the risk that technologically leading firms will focus future R&D investments on countries other than Sweden.

Centres of excellence for research and innovation are environments with a simultaneous international competitiveness in science, technology, innovation and knowledge-intensive production. They are characterised by high efficiency in Triple Helix interactions. Such environments are delimited in terms of sector and technology focus, as well as in terms of geography, because of the need for critical mass in terms of competence and because of the need for geographical proximity for efficient interactive learning in innovation processes. In addition, their competitiveness is highly based on the intensity and quality of their co-operation and interactions with leading international and national centres of excellence that could improve their performance. Therefore, internationally connected centres of excellence and national networks of centres of excellence within different sectors should be an important focus for national and regional innovation policy strategies.

II. INNOVATION SYSTEM COMPETITIVENESS

4 Economic Competitiveness

The long-term Swedish economic competitiveness weakened considerably during the period 1970–2003, particularly in the early 1990s. The Swedish national innovation system is characterised by a shrinking, but still comparatively large, knowledge-intensive and export-oriented manufacturing sector, an increasing, but comparatively small, business service sector and, by international standards, a large public service sector. A relatively high manufacturing labour productivity rate has not been able to offset a declining overall share of value added from manufacturing. This was a consequence of a general trend towards increasing service shares in modern economies and of increasing relocations of manufacturing production value from Sweden to newly industrialising countries, closer to large markets and with a much cheaper, qualified labour force. In relation to many other countries, Sweden has shown relatively low average productivity levels in both business sector services and public sector services. Important structural changes have generated rapidly increasing manufacturing and service knowledge intensities, together with increasing foreign ownership of knowledge-intensive manufacturing and service firms.

Long-term economic development

Swedish long-term economic performance has been rather weak in international comparison. During the period 1970–1990, GDP growth was somewhat slower in Sweden than in other EU and OECD countries. In the 1990s, GDP growth slowed down considerably in most OECD countries, and Swedish growth was among the slowest in the OECD. Economic growth in Sweden improved in the second half of the 1990s, when it was faster than that of most other EU countries, albeit far lower than that of the most rapidly growing countries. In the early 2000s, Swedish economic growth has continued to be faster than the largest EU countries, but somewhat slower than several other EU and OECD countries, figure 4.1.

As a consequence of the slow Swedish long-term economic growth, Sweden fell in the OECD's rankings for GDP per capita from fourth place to fifteenth 1970–2003. Swedish national economic performance deteriorated substantially in the early 1990s, when Sweden fell considerably in international GDP comparisons. In the second half of the 1990s, when Swedish economic growth improved, Swedish GDP per capita improved somewhat in international comparison. In the early 2000s, Swedish GDP per capita resulted in the country's position fluctuating between thirteenth and seventeenth in the OECD's list. The main reason for these large changes in GDP rankings is that the distance between positions 12 and 19 is very small in terms of GDP per capita. Therefore, even relatively small annual changes may change positions considerably. On the other hand, the distance from the Swedish real GDP per capita to the top of the OECD has become significant.

The long-term deterioration of Swedish economic performance, culminating in the severe economic crisis in the early 1990s, was the result of gradually increasing structural problems in the Swedish economy. The rapid economic improvements in the late 1990s were primarily the result of a considerably improved macroeconomic situation, achieved by a drastic consolidation of public finances. It was also a result of rapidly increasing exports, as a result of the sharp currency depreciation in 1992.[6]

The major route to improved productivity gains in the late 1990s was substantial rationalisation in both the private and public sectors. Decreasing labour-intensity resulted in considerable improvements in overall labour productivity.[7] The downside of these productivity gains was rapidly increasing unemployment levels and increasing pressure on the active work force, which is likely to have contributed to the increasing tendencies towards health-related work absence in the late 1990s and early 2000s.

It should also be noted that annual average hours worked continuously have been falling in Sweden. Compared to 1960, average hours worked in Sweden are 15 per cent lower. As a consequence, Swedish employees on average work fewer hours than employees in most other OECD countries. One explanation for this is higher shares of part-time work within the work force than in other countries.[8] This could be one of the factors behind the relatively slower long-term economic growth in Sweden compared to several other OECD countries.

Swedish economic structure

The Swedish economy is dominated by large organisations, both in manufacturing and services. A small number of large multinational industrial groups dominate manufacturing employment, production and value added. By international standards, the public sector occupies a large share of the service sector. The public sector is also dominated by large organisations.

Since World War II, the Swedish national innovation system has been dominated by a regime based on advanced manufacturing technology led by a small number of multinational industrial groups. The Swedish manufacturing structure of R&D-intensive and export-oriented industrial groups has also been instrumental in generating what by international standards is a quite advanced Swedish structure of subcontracting SMEs. In this industrial system there has been a general division

of labour between the large industrial groups and the subcontracting SMEs. The former have generally been responsible for export markets, technological development and systems integration, while the latter have generally been responsible for the production of components and subsystems.[9]

Swedish manufacturing production is relatively large and knowledge-intensive in international comparison. The high-technology manufacturing industry in Sweden has for many years ensured Sweden's place among the top five countries in the OECD in terms of the volume of high-technology and medium high-technology manufacturing production in relation to the size of the economy. It should also be noted that Swedish high-technology manufacturing is broad in international comparison. Swedish high-technology manufacturing is quite large in all high-technology segments, particularly in telecommunications and pharmaceuticals. Swedish medium high-technology manufacturing industry is also large in international comparison. Further, Swedish medium-low and low-technology manufacturing industries are relatively knowledge-intensive compared to other OECD countries, which further underlines the comparatively high knowledge-intensity of Swedish manufacturing industry, figures 4.2 and 4.3.

Swedish knowledge-intensive services are, despite rapid growth in recent decades, rather small in international comparison. Production-related, knowledge-intensive services are particularly small in international comparison, despite a quite rapid growth. Moreover, the Swedish economy has in recent decades been more geared towards generating qualified financial services and activities related to the financial economy than to services related to the production and use of goods. This may be related to the particular incentive structures generated by the unstable macroeconomic situation in the 1980s and 1990s, which perhaps favoured financially-related entrepreneurship more than production-related entrepreneurship. This balance of entrepreneurial activities is probably not sustainable and should thus be a challenge to future value adding and long-term economic growth in Sweden, figure 4.4.

International trade

International trade is very important to the Swedish economy. This has been the case for many years, though it has increased considerably in importance during the last thirty years. In 1975, total Swedish exports accounted for about 27 per cent of GDP, while in 2002 the corresponding figure was around 43 per cent. The Swedish economy and national innovation system is thus highly internationally dependent. Increasing Swedish exports and trade surplus was also a vital element of the Swedish economic recovery in 1993–2002.

In terms of export volume, the most important Swedish industries are non-electrical machinery, motor vehicles, pulp and paper, telecommunications and iron and steel. Of these, the pulp and paper industry is clearly the most significant in terms of trade surplus, followed by the non-electrical machinery, motor vehicles and telecommunications industries. The pharmaceutical and wood industries are also, together with the iron and steel industry important in this respect. In terms of trade balance, i.e. export-import ratio, the pulp and paper industry, together with the wood and pharmaceutical industries, are particularly important, figure 4.5.

Taking a long-term perspective on Swedish international trade, the emergence and growth of the pharmaceutical industry during the 1980s and 1990s represents a striking change in Swedish trade specialisation. Even more impressive was the development of telecommunication exports in the 1990s, when telecommunications trade expanded very rapidly. Today, both these industries play important roles in Swedish exports and industry.

A comparison of trade balances with high-technology products shows that Japan has the most positive high-technology trade balance, followed by Ireland, Finland, France and Sweden. A closer look reveals that the high-technology trade balance is clearly better than the total trade balance in Japan, France, the UK, Ireland and the USA. In Sweden and Finland, as well as in most other countries, the high-technology trade balance is considerably less impressive than the total trade balance. The main explanation in the case of Sweden and Finland is the comparatively large raw-material based industries in these countries, which represent a large proportion of total exports.

Manufacturing dynamics and value added

One part of the explanation for the relatively poor Swedish economic competitiveness during 1970–2003 concerns the development of the multinational knowledge-intensive industrial groups that dominate Swedish manufacturing industry. Despite increasing R&D investments and productivity growth in Sweden in these groups, their share of total Swedish GDP has continuously decreased. This development is a consequence of two general trends. Firstly, there has been a general trend in modern economies of declining manufacturing shares and increasing service shares of total value added. Second, there has been a trend towards increasing production focus on newly industrialising countries, and even relocating manufacturing production from Sweden, to these countries.

Many of the large industrial groups are now foreign-owned. And, the price of labour for producing high-technology products in many newly industrialising countries is much lower than in Sweden and in other industrialised countries. Moreover, the capacity and

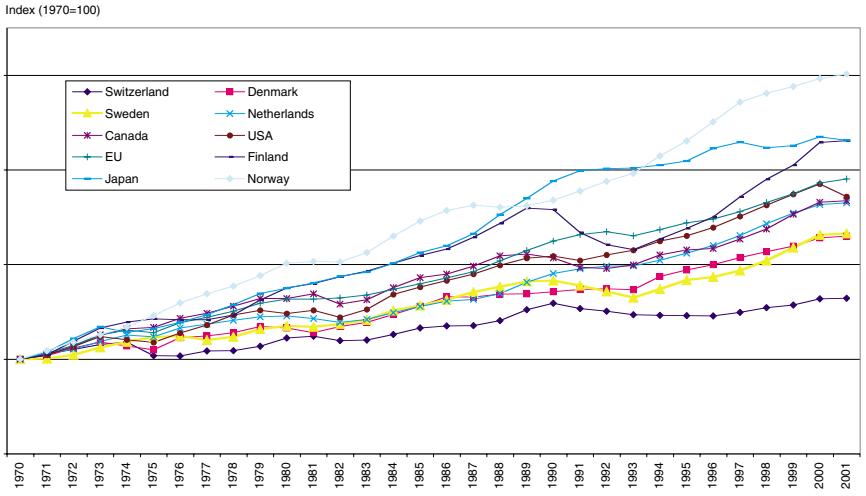
competence for such production have improved considerably in many of the newly industrialising countries in Asia and Eastern Europe. As a consequence, there is a strong and rising global tendency to outsource high-technology production to these countries, while most of the product development activities and company headquarters remain in Europe or North America. The large multinational industrial groups, with a strong competence and production base in Sweden, have expanded their production abroad, while slowly beginning to decrease it in Sweden, figure 4.6.

Service sector value added

Another explanation for the relatively poor Swedish economic competitiveness during 1970–2003 concerns the comparatively weak development of service sector value added. In terms of services and service sector development, the performance of the Swedish economy is apparently considerably poorer than for manufacturing development and production, figure 4.7.

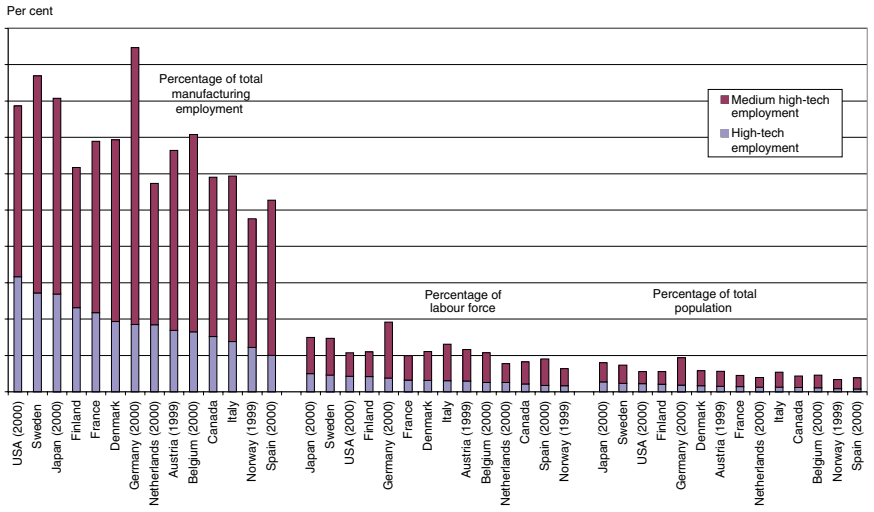
An important aspect of this, by international standards, rather low level of service value added and productivity is the poor development of value added in business sector services. This concerns both knowledge-intensive services and other services in Sweden, with the exception of transportation and storage. Another aspect of the relatively poor service sector development concerns the relatively low productivity rates in the public sector, which is bigger than in most countries. These factors have contributed to a reduction in Sweden's national productivity and value added in services. It should be noted though that public sector productivity rates are difficult to calculate properly, which makes all international comparisons of public sector productivity rates problematic,[10] figure 4.8.

4.1 Index of real GDP per capita 1970–2001 (PPP USD)



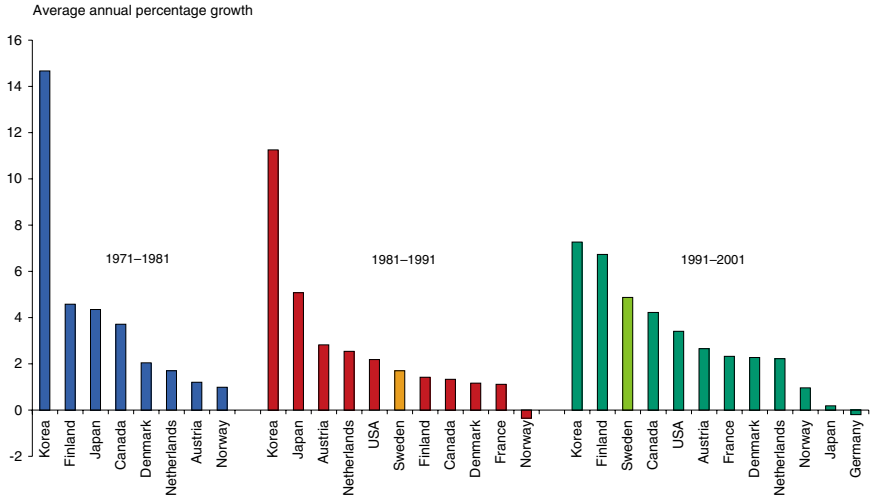
Source: OECD MSTI, 2003

4.2 Relative weight of high- and medium high-technology manufacturing employment in different countries 2001



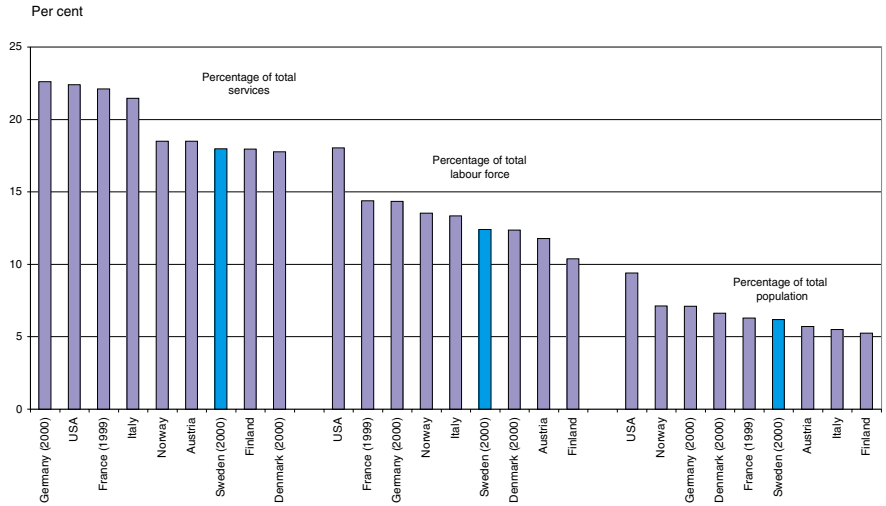
Source: OECD, STAN, MSTI and MEI, 2003

4.3 Real percentage growth in manufacturing value added 1971–2001



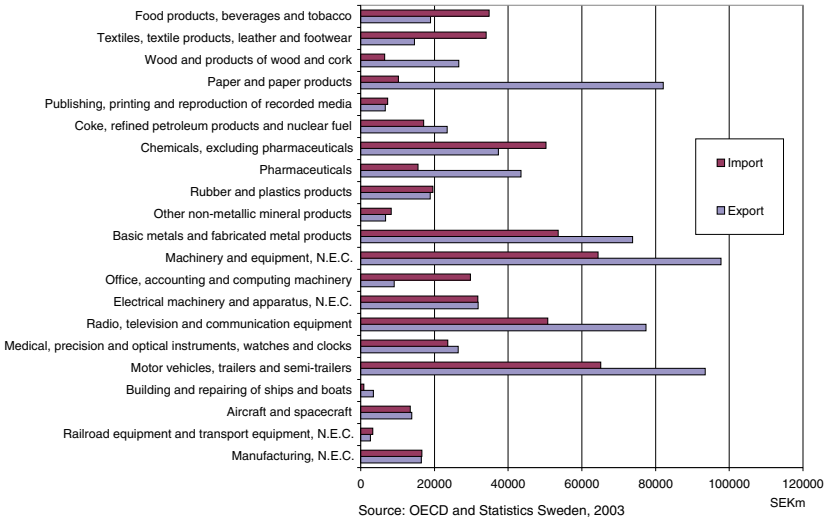
Source: ESF Nine-country project and VINNOVA, 2003

4.4 Relative weight of knowledge-intensive service employment in different countries 2001



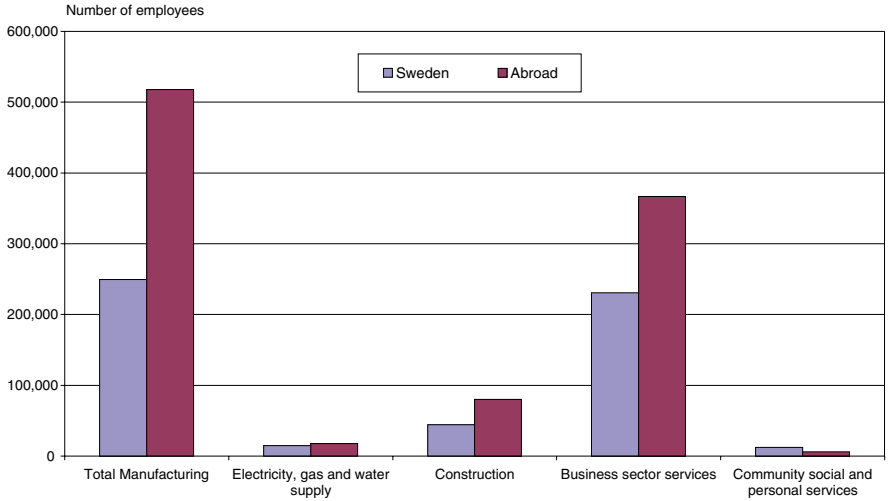
Source: OECD, MSTI and STAN, 2003

4.5 Swedish manufacturing trade in different industries 2001



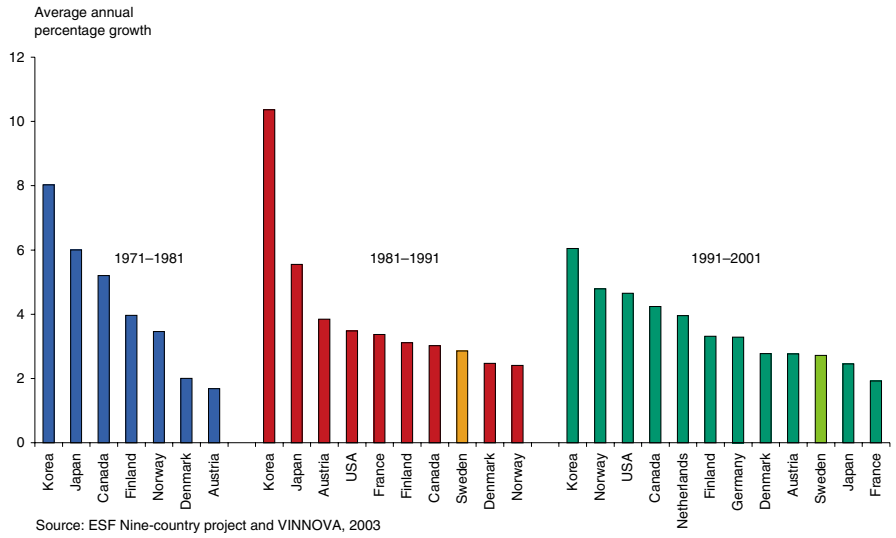
Source: OECD and Statistics Sweden, 2003

4.6 Number of employees in Sweden and abroad in the 20 largest Swedish industrial groups 2001



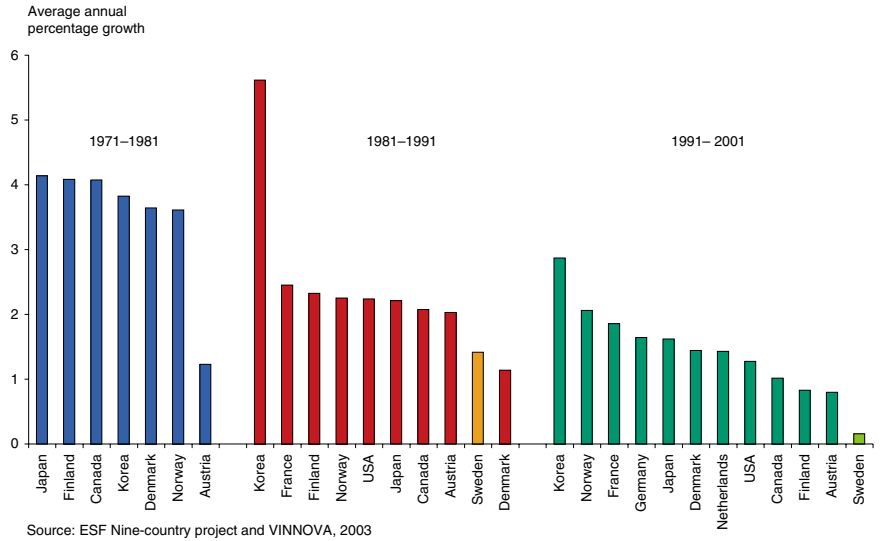
Source: ITPS, Svenskägda koncerner med verksamhet i utlandet, 2001 (S2003:006)

4.7 Real percentage growth in business sector services value added 1971–2001



Source: ESF Nine-country project and VINNOVA, 2003

4.8 Real percentage growth in community and social service value added 1971–2001



Source: ESF Nine-country project and VINNOVA, 2003

5 Job Creation

The Swedish national innovation system has in recent decades generated new jobs at a slower rate than in most other OECD countries. Particularly in the 1990s, net job creation was relatively slow in Sweden, since the main route to increased labour productivity was through high rates of rationalisation in the private and public sector. In parallel, Swedish unemployment rates increased to unprecedented levels, from a long period with one of the lowest levels in the OECD. In recent years, the Swedish unemployment rate has been somewhat lower than the OECD average. A particularly important problem is the labour market participation rates among immigrants in Sweden, which by international standards are low. Moreover, the Swedish labour supply has declined further due to a rapid increase in health-related absence from work. In addition, the demographic development has been comparatively negative for Sweden, where the Swedish labour force has decreased more than in most countries. The overall result has been a considerable deterioration of Swedish human resources sustainability in the past decade. Moreover, future demographic prospects for Sweden indicate substantial labour force challenges, particularly if immigration rates and labour market participation rates cannot be increased.

Net job creation

In the earlier part of the period 1970–2003, Sweden was leading among OECD countries in terms of the share of total population in employment. However, the Swedish situation worsened considerably in the latter half of the period.

Most OECD countries increased their labour market participation in the 1980s. An important source for this was increasing participation rates among women, which, by international standards, had traditionally been high in Sweden. Therefore, despite increasing net job creation in Sweden in the 1980s, Sweden fell from first to third place between 1981 and 1991 in terms of employment as a percentage of total population. During the period 1991–2001, most OECD countries increased their employment rates, while the proportion of the total population employed decreased in Sweden.[11] As a consequence, Sweden fell from third place to tenth place in 1991–2001 in terms of the proportion of total population employed, figure 5.1.

Sweden is still among the five leading countries in the OECD in terms of the proportion of women in the labour force in employment. In terms of the proportion of men in employment, Sweden's performance is somewhat less satisfactory in international comparison. More importantly however, Sweden has, despite increasing employment rates among immigrants, become the least efficient country in the OECD in terms of employment of immigrants, particularly male immigrants.[12] It should be noted that this is a relatively new trend in Sweden, related to the increased rates of political refugees among immigrants to Sweden. The labour market-related immigration to Sweden in the 1960s and 1970s resulted in high labour market participation rates among immigrants, figure 5.2.

Sectoral employment patterns

In all OECD economies, services clearly dominate over manufacturing in terms of sector contributions to economic growth. The trend towards increasing services shares in modern economies has been going on for a long time. Particularly professional and financial services, together with personal services have rapidly increased in importance in recent decades. An important explanation for this is a continuously increasing division of labour between different organisations in economic systems. Another important explanation is the increasing consumer demand for different kinds of services and, as a result of this, increasing shares of personal income that are allocated to this kind of consumption.

In Sweden, manufacturing employment declined continuously and substantially during 1970–2003. Construction and agricultural employment has followed a similar trend. Until 1985, a rapid increase in public service employment outpaced the decreasing manufacturing employment. Moreover, increase in knowledge-intensive services, combined with a relatively stable employment in other services, resulted in a net increase in private sector services until the middle of the 1980s. Private sector services continued to increase after 1985, due to rapidly increasing employment in knowledge-intensive services, while the employment level for the rest of the private service sector remained stagnant. Public sector employment expansion came to a halt after 1985 and has since then been stagnant and started to decrease in recent years. The net effect for Sweden has been a declining proportion of its total population in employment.

A trend analysis of net job creation in different industries in Sweden during 1970–2003 shows that – apart from public sector services – knowledge-intensive services and high-technology manufacturing industries are the only ones that have given a net contribution to employment in Sweden. Less knowledge-intensive services and manufacturing industries have together with the construction industry and the agriculture sector provided a net loss of employment in Sweden. It should, however, be noted that low, medium and medium high-technology industries within the Swedish manufacturing

sector, such as the Swedish iron and steel, non-electrical and motor vehicles industries, are still the most important manufacturing industries in employment terms. Likewise, in terms of employment, public sector services and less knowledge-intensive services still dominate the Swedish service sector, figures 5.3 and 5.4.

Unemployment rates and health-related work absence

The severe economic crisis in the early 1990s, followed by broad rationalisation processes in the Swedish economy and increasing labour productivity, in both the public and private sectors, generated rapidly increasing unemployment rates in Sweden.

From a situation with the lowest unemployment rates in the OECD in the 1980s, Swedish unemployment rates increased to unprecedented levels. This resulted in unemployment rates in Sweden that for most parts of the 1990s were relatively high in international comparison. In the early 2000s, the Swedish situation has improved, although the Swedish unemployment rate is still far from being among the lowest in the OECD, figure 5.5.

Even more unexpected for most labour market analysts, researchers and policy makers was the very rapid increase in health-related work absence. From a situation with an apparent trend of continuously improving labour market conditions, health-related work absence, i.e. ill-health, increased between 1995 and 2001 by 115 per cent. The rapidly decreasing rate of slack in different organisations in the Swedish economy probably contributed strongly to these rapidly increasing rates of health-related absence from work. However, the incentive structures in the social security system may also have contributed to this strong trend of increasing health-related work absence, figure 5.6.

Together, these two trends are threatening to undermine the long-term labour supply in Sweden. Moreover, they can seriously threaten the sustainability of human resources in the Swedish national innovation system, due to decreasing rates of learning and competence development in the labour force. Further, they may generate increasing problems with social cohesion in the Swedish society.

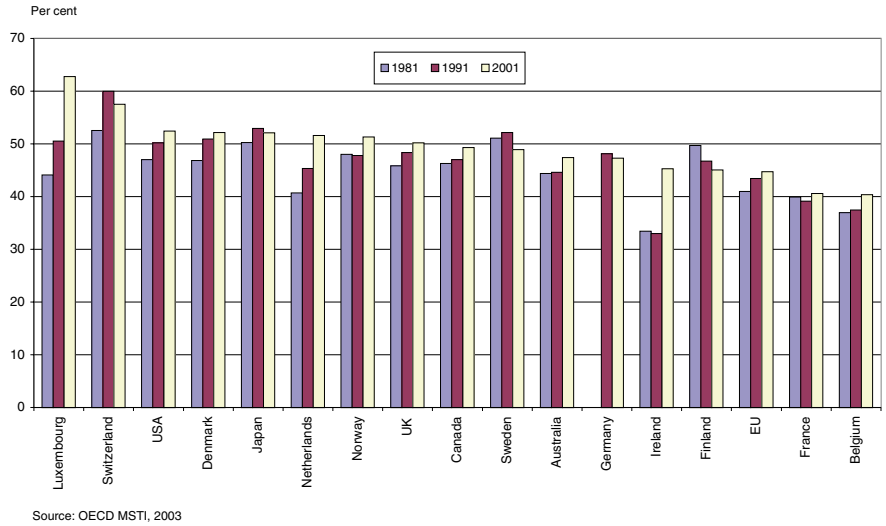
Labour force share of total population

One result of these developments has been rapidly increasing levels of withdrawals of human resources from the active labour market, which seriously threatens future growth potential and public budgets. In addition, the decline of the labour force share of total population in Sweden has, by international standards, been high in recent decades, figure 5.7.

The future prospects of the Swedish labour force indicate great challenges for Swedish labour market policy. In the coming thirty years, the working-age population in Sweden will increase in absolute numbers, if projected immigrant levels prevail. Otherwise, the total labour force will decrease substantially. Despite a growing labour force, the old-age dependency ratio, i.e. the ratio between the number of people aged 65 years or more in relation to the number of people in the labour force, will start to increase quite rapidly after 2005.[13]

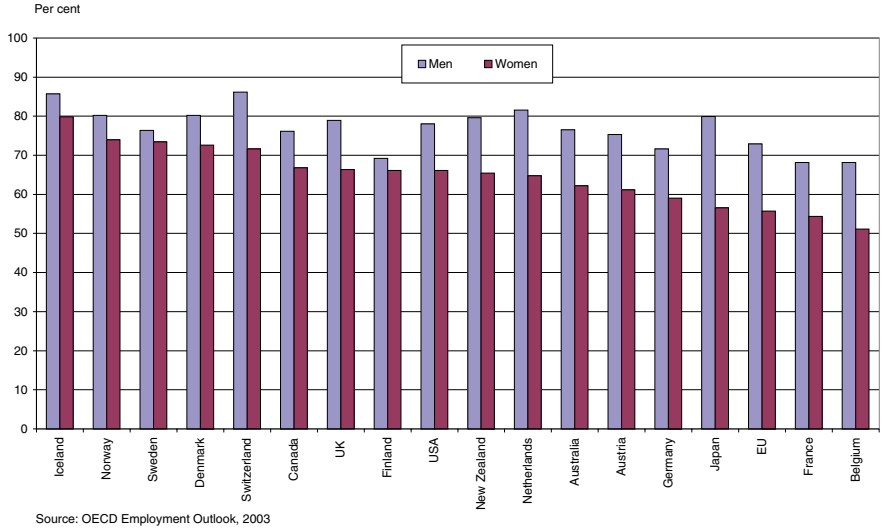
The expected rapid rise in the dependency ratio in Sweden will be an important challenge for sustained economic growth. Moreover, if immigrants continue to have a lower labour force participation rate than native-born Swedes, long-term economic growth may be even more hampered because of the relatively high future dependency on immigrating labour force for Swedish economic development.[14]

5.1 Employment in relation to population 1981–2001



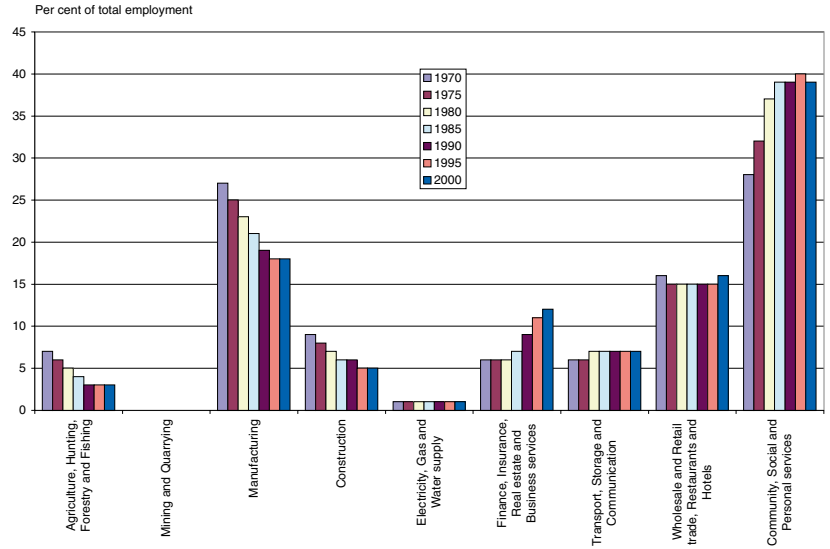
Source: OECD MSTI, 2003

5.2 Employment for men and women in relation to population 2002



Source: OECD Employment Outlook, 2003

5.3 The production structure in Sweden as sector shares of employment 1970–2000



Source: OECD, 2003

5.4 Net creation of new jobs in Sweden 1970–2002

	Employment change in absolute numbers (thousands) and in per cent					
	1971–1981		1981–1991		1991–2000	
Industry	Employment change	Percentage change	Employment change	Percentage change	Employment change	Percentage change
Grand total	337.4	8.6	241.3	5.7	-242.3	-5.7
Agriculture, hunting, forestry and fishing	-76.5	-28.4	-51	-26.5	-26.2	-22.7
Mining and quarrying	-2.1	-11.7	-5.7	-36.1	-1.9	-23.2
Total manufacturing	-76.6	-7.5	-108.7	-11.5	-84.3	-11.2
Food products, beverages and tobacco	-5.3	-6.3	-4.2	-5.3	-11.9	-18.8
Textiles, textile products, leather and footwear	-34.4	-46.7	-17.3	-44.0	-8.2	-59.4
Wood and products of wood and cork	-8.9	-15.0	-5.1	-10.1	-8.2	-22.1
Pulp, paper, paper products, printing and publishing	0.0	0.0	-13.3	-10.0	-25.3	-27.0
Chemical, rubber, plastics and fuel products	1.6	2.2	-9.3	-12.4	0.3	0.5
– Coke, refined petroleum products and nuclear fuel	-	-	-0.4	-12.1	-0.1	-3.6
Other non-metallic mineral products	-11.8	-29.0	-2.6	-9.0	-8.6	-48.6
Basic metals, metal products, machinery and equipment	-12.1	-2.5	-55.3	-11.7	-15.1	-3.7
Basic metals and fabricated metal products	-14.9	-8.6	-36.6	-23.2	-11.4	-10.4
– Basic metals	-	-	-24.3	-36.5	-10.7	-33.9
– Machinery and equipment, N.E.C.	-	-	0.5	0.5	-12.0	-12.2
– Electrical and optical equipment	-	-	-17.5	-16.4	9.3	9.5
Transport equipment	6.4	6.8	-1.6	-1.6	-1.1	-1.1
Manufacturing, N.E.C.	-5.7	-8.2	-1.7	-2.7	-7.3	-13.3
Electricity, gas and water supply	4.3	13.6	0.3	0.8	-3.7	-11.3
Construction	-45.9	-14.0	4.5	1.6	-68.9	-31.6
Wholesale and retail trade; repairs	-	-	21.4	4.0	-6.7	-1.2
Hotels and restaurants	-	-	30.1	37.4	5.8	5.0
Transport and storage	-	-	21.8	12.3	-1.4	-0.7
Post and telecommunications	-	-	2.7	2.6	-19.7	-23.1
Finance, insurance and real estate	34.4	15.0	168.6	63.7	87.2	16.8
Real estate, renting and business activities	-	-	147.3	76.3	88.0	20.5
Community social and personal services	475.5	41.7	157.3	9.7	-122.6	-7.4
Total services	534.0	23.8	402.1	14.5	-57.4	-1.8
Business sector services	58.5	5.3	244.8	21.0	65.2	4.4

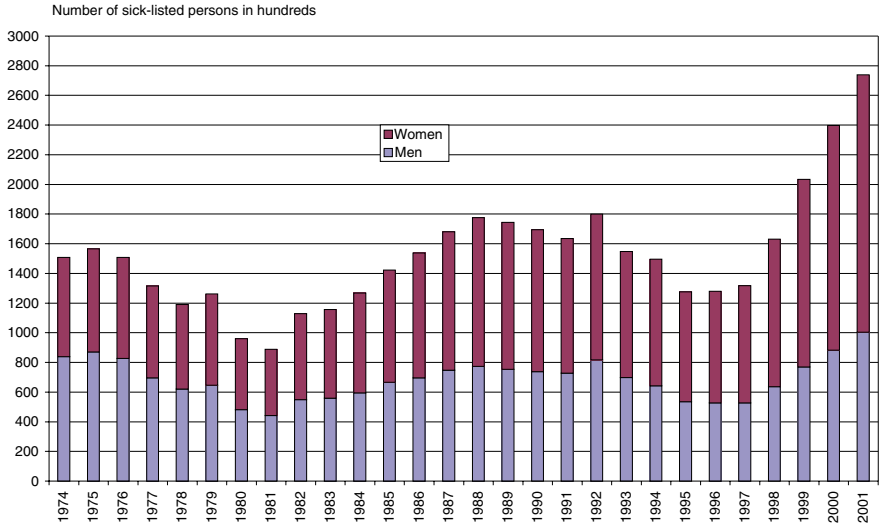
Source: OECD STAN, 2003

5.5 Unemployment rate among the active share of the population 1993–2002, per cent

1993		1996		1999		2002	
Japan	2.5	Luxembourg	2.9	Luxembourg	2.4	Netherlands	2.7
Luxembourg	2.6	Japan	3.4	Netherlands	3.2	Luxembourg	2.8
Austria	4.0	Austria	4.4	Norway	3.2	Norway	3.9
Portugal	5.6	Norway	4.8	Austria	3.9	Austria	4.3
Norway	6.0	USA	5.4	USA	4.2	Ireland	4.4
Netherlands	6.2	Netherlands	6.0	Portugal	4.5	Denmark	4.5
USA	6.8	Denmark	6.3	Japan	4.7	**Sweden**	**4.9**
Germany	7.7	Portugal	7.3	Denmark	4.8	Portugal	5.1
Belgium	8.6	UK	8.0	Ireland	5.6	UK	5.1
Greece	8.6	Germany	8.7	UK	5.9	Japan	5.4
Sweden	**9.1**	Belgium	9.5	**Sweden**	**6.7**	USA	5.8
Denmark	9.6	**Sweden**	**9.6**	Germany	8.4	Belgium	7.3
UK	10.0	Greece	9.6	Belgium	8.6	Germany	8.6
Italy	10.1	Italy	11.5	Finland	10.2	France	8.7
France	11.3	Ireland	11.7	France	10.7	Italy	9.0
Ireland	15.6	France	11.9	Italy	11.3	Finland	9.1
Finland	16.3	Finland	14.6	Greece	11.8	Greece	9.9
Spain	18.6	Spain	18.1	Spain	12.8	Spain	11.3

Source: Eurostat, 2003

5.6 Number of sick-listed for at least 30 days (in 100s) 1974–2001, per cent



Source: Miljöräkenskaper 2003:3. Indikatorer för hållbar tillväxt

5.7 Labour force in relation to population 1981–2001, per cent

	1981		1991		2001	
1	**Sweden**	**52**	Switzerland	58	Luxembourg	64
2	Finland	52	Denmark	57	Iceland	57
3	Denmark	52	Iceland	54	Switzerland	56
4	Switzerland	50	**Sweden**	**53**	Denmark	53
5	Canada	50	Japan	52	Japan	53
6	Japan	49	Canada	51	Canada	52
7	Iceland	48	Finland	51	Norway	52
8	USA	48	Luxembourg	51	Netherlands	51
9	Norway	48	USA	51	Finland	51
10	UK	47	Norway	50	Portugal	50
11	Germany	46	UK	50	Australia	50
12	Australia	46	Germany	49	Czech Republic	50
13	Total OECD	45	Portugal	49	USA	50
14	Portugal	44	Czech Republic	49	New Zealand	50
15	Luxembourg	44	Australia	49	**Sweden**	**50**
16	France	43	Slovak Republic	48	UK	50
17	Austria	42	New Zealand	47	Slovak Republic	49
18	New Zealand	42	Total OECD	47	Germany	49
19	Belgium	42	Netherlands	47	Austria	48
20	Italy	40	Austria	46	Total OECD	47
21	Netherlands	40	Korea	44	Korea	47
22	Turkey	39	Italy	43	Ireland	46
23	Korea	38	France	43	Spain	44
24	Greece	38	Belgium	42	France	44
25	Ireland	37	Spain	40	Belgium	43
26	Spain	36	Ireland	38	Italy	41
27			Greece	38	Hungary	40
28			Turkey	37	Greece	40
29			Israel	36	Mexico	39
30			Mexico	36	Israel	39
31					Turkey	33

Source: Eurostat, 2003

6 Innovation Competitiveness

The competitiveness of the Swedish national innovation system in terms of value-adding innovation has not been high by international standards. Value-adding radical or genuine innovation seems to be a particular weakness of the Swedish national innovation system. However, in terms of adopting existing technology in products and processes, Sweden seems to be highly competitive, in both manufacturing and services. Genuine innovations are relatively low in numbers and represent rather low shares of total turnover in Swedish industry, compared to many other countries. Moreover, the rate of start-ups is low in international comparison. University spin-offs and spin-offs from large companies or R&D institutes represent very low shares of total start-up volumes in Sweden. Few of the start-up firms in Sweden grow to become medium-sized and virtually none of them get really big.

Multi-factor productivity growth

Long-term multi-factor productivity growth is a strong indicator of innovative performance. It attempts to directly measure changes in the value ratio between total inputs and outputs, which, in turn, should be highly related to innovative renewal.[15]

In a special international comparison by the OECD, Swedish performance in terms of total business sector multi-factor productivity (MFP) growth was shown to be low in the 1980s. However, it improved in the 1990s, with Swedish business sector MFP climbing from fifteenth place in the OECD's list in the 1980s to eighth place in the latter period. Thus, despite the improvement, Sweden was still far behind the best countries in terms of MFP growth, figure 6.1.

It should be noted that the improved Swedish performance in terms of MFP growth in the 1990s is probably only marginally attributable to improved long-term innovativeness in the business sector. The recession in the early 1990s resulted in a considerable cleansing of the least productive parts of the economy. Through this one-time reduction of the less productive elements of production capacity, average multi-factor productivity increased in the remaining production capacity.[16] This is supported by the fact that the Swedish rate of MFP growth was at about the same level in the first and the second half of the 1990s, while for many other countries, MFP growth increased in the latter half of the 1990s.

Labour productivity growth

The rate of labour productivity growth is another indicator of innovation performance. It attempts to measure the relationships between total labour costs and production value.[17] An international comparison of labour productivity gives further indications of a relatively weak value-adding innovation performance in the Swedish national innovation system.

Swedish labour productivity growth was particularly low in the early 1980s, when both business sector manufacturing and services, as well as public sector services, showed low rates of productivity growth by international standards. In the late 1980s, Swedish labour productivity growth improved in the public sector, due to a halt in employment expansion. However, labour productivity growth in both manufacturing industry and in business sector services slowed down and lost further ground in international competitiveness. In the 1990s, as a consequence of the substantial personnel cutbacks in the wake of the severe economic crisis, Swedish labour productivity improved considerably in all sectors. In both manufacturing industry and public sector services, Sweden was close to the top of the OECD's rankings in terms of its labour productivity growth. Labour productivity in the Swedish business sector services also improved in the 1990s, although it still remained relatively far from the top of the OECD's rankings.

Value-adding innovation

The main source of innovation survey data is the Community Innovation Surveys produced by Eurostat. This survey measures innovations, i.e. the introduction of entirely new or significantly improved products that are also new to the market. It also measures products that are new only to the firm but not new to the market. The first measure indicates rates and importance of more radical renewal in industry, while the latter indicates rates and importance of adoption capacity of available technology, which in innovation terms is more incremental in nature.[18]

The Community Innovation Surveys indicate a rather low rate of value-adding innovation in Swedish industry, in terms of genuinely new products. Together with Austria, Sweden is in only ninth place in this European comparison, while Finland is a clear leader. A closer look at this data reveals that there are considerable differences between the pattern in manufacturing industry and in the service sector. Swedish industry seems to be more internationally competitive in service innovation than in manufacturing innovation, figure 6.2.

According to the European innovation surveys, Swedish industry is considerably more competitive in terms of the adoption of existing technology than in terms of innovations that are new to the market. In this respect, Swedish industry is highly competitive in both manufacturing and services. It is competitive in all firm sizes, particularly the largest firms,[19] figure 6.3.

Rate of new firm start-ups

Another indicator of the rate of renewal in an economy is the frequency of new firm start-ups, since establishing new firms is one of several channels for the economic exploitation of innovations. Sweden shows low levels of start-up firms compared to most other countries. Also the rate of shut-down is relatively low in Sweden, which means that a high proportion of the small firms tend to survive a relatively long time. However, start-ups in Sweden generally tend to remain very small, with only 1.5 employees on average after two years. This is a low rate of employment expansion compared to most other European countries.[20]

In terms of the number of individuals that are annually engaged in starting new firms, Sweden is ranked 33 in the world. Sweden is clearly behind all the other Nordic countries and most other EU member states, with the exception of Belgium, Finland, the Netherlands, Italy and France,[21] figure 6.4.

Most new firms in Sweden are started in the service sector, particularly in the trade, hotel and restaurant industries. The construction industry also shows a high level of start-ups. Apart from traditional service industries, knowledge-intensive services such as financial services and business services show high levels of start-ups. There is a clear trend towards an increasing proportion of start-ups in knowledge-intensive service industries.[22]

New technology-based firms

New technology-based firms (NTBFs) are important agents of radical renewal, variety and dynamics in innovation systems. They are generally assumed to be important in the early commercialisation stages of new knowledge, of which the creation of new markets, or niches, is an important part. While large firms generally have large financial, technological, production and network resources, they often have vested interests that tie them to existing technological trajectories.[23] Measures of the creation of NTBFs and their growth effects are therefore key indicators of the capacity of innovation systems to generate potential for radical industrial renewal and growth.

Sweden, Denmark and Finland show a similar level of spin-offs from high-technology industries, while Norway lags behind the other Nordic countries. Of all spin-off firms in Sweden during 1999–2000, 17.5 per cent were spin-offs from high-technology sectors. The corresponding figures for Denmark and Finland were 17.5 and 17.3 per cent respectively, but only 11.2 per cent in Norway.

Finland and Sweden show considerably higher levels of spin-offs from high-technology manufacturing industries, which is a reflection of the greater size of these industries in those countries compared to the other Nordic countries. Despite a broader high-technology manufacturing industry in Sweden, Finnish spin-offs from the high-technology manufacturing industry are about 50 per cent larger than in Sweden. This is primarily related to the comparatively high spin-off rates from the Finnish telecommunications industry. Most of the high-technology spin-off firms in Sweden are generated from the computer consultant industry, figure 6.5.

Sweden shows higher levels of university spin-offs than any other Nordic countries. However its overall share of such spin-offs is very low. Further, spin-offs from universities generally grow at a considerably slower rate than spin-offs from industrial firms or other NTBFs.[24] The rate of spin-offs from research institutes – and indeed the subsequent growth of such firms – is higher than for university spin-offs in Sweden. However, since the institute sector is very small in Sweden, the quantitative role of institute spin-offs is quite limited, figure 6.6.

Moreover, researcher-initiated or researcher participation in high-technology start-ups is very low. Only about 1 per cent of all new firms in Sweden are researcher-initiated. Despite the large research system in Sweden, this is considerably lower than in Finland, but somewhat higher than in Norway. Most researcher-initiated start-up firms are generated from high-technology manufacturing firms, figure 6.7.

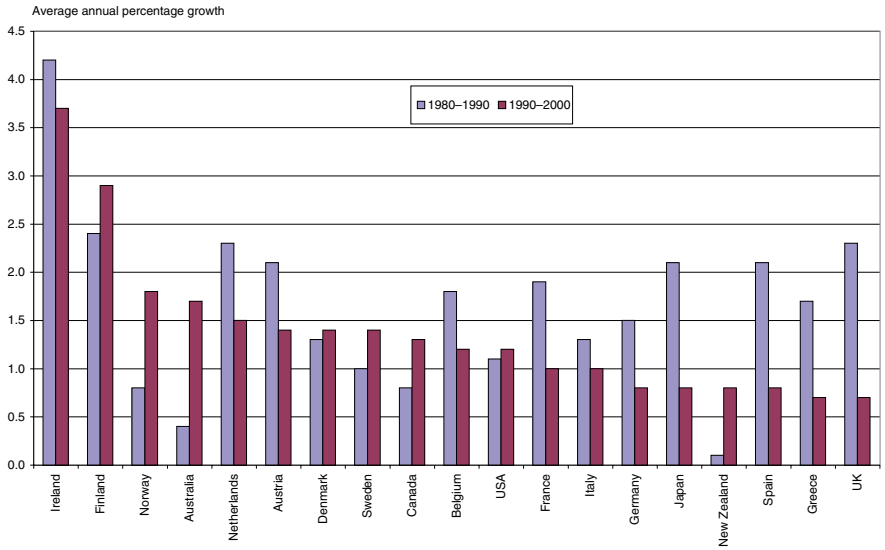
In Sweden, the proportion of higher educated individuals starting and running SMEs is about the same as the overall proportion of higher educated people in the country's population. The majority of NTBFs in Sweden started by people with a higher education in engineering, medicine or natural science were part-time firms. Most of these firms were started by people whose higher education was in medicine. A majority of the businesses started by people with a higher education were wound up within four years of start-up.[25]

Growth patterns in new technology-based SMEs

Not all NTBFs contribute significantly to economic growth, though when they do, the growth mechanisms involved may be one of several types. One concerns the direct growth of NTBFs themselves, another is growth within larger firms, subsequent to mergers, and a third mechanism is growth effects through their role in industrial networks.

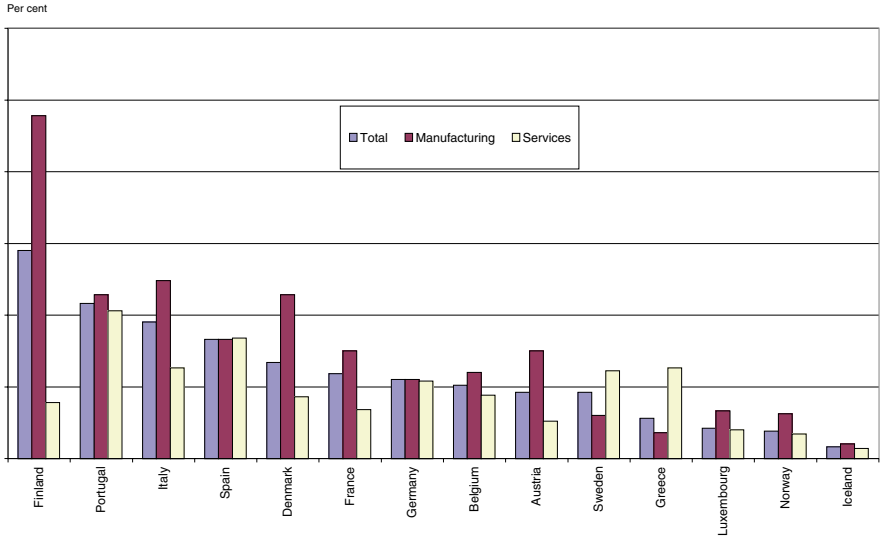
Not many NTBFs grow to be large by themselves. Of all Swedish high-technology spin-offs from 1996, about 63 per cent were still running in 2000. However, only about 28 per cent of the spin-off firms started in 1996 had generated any employment growth in the period 1996–2000. The proportion of surviving spin-off firms that generate employment growth is considerably higher in Finland than in Sweden, but much lower in both Denmark and Norway, figure 6.8.

6.1 Multi-factor productivity growth estimates 1980-2000, average annual growth rates, adjusted for hours worked



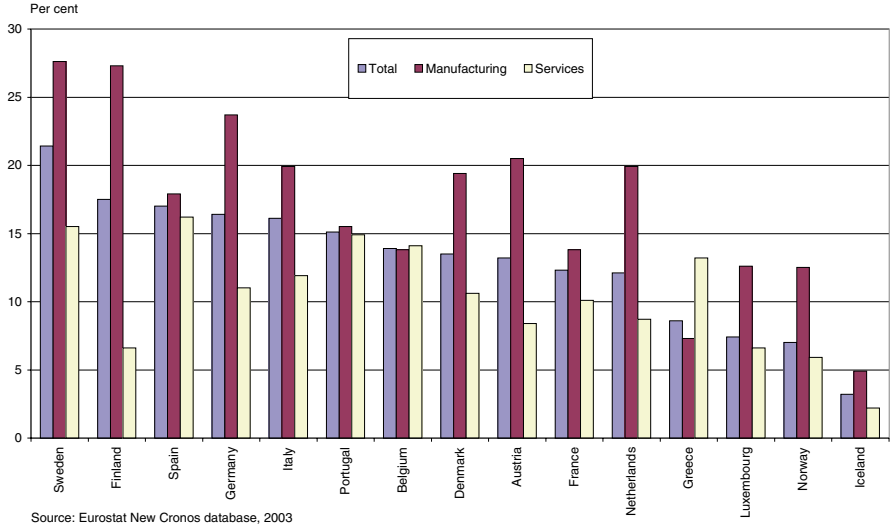
Source: OECD, The Sources of Economic Growth in the OECD Countries, 2003

6.2 Economic turnover generated by products that are new to the market 2000



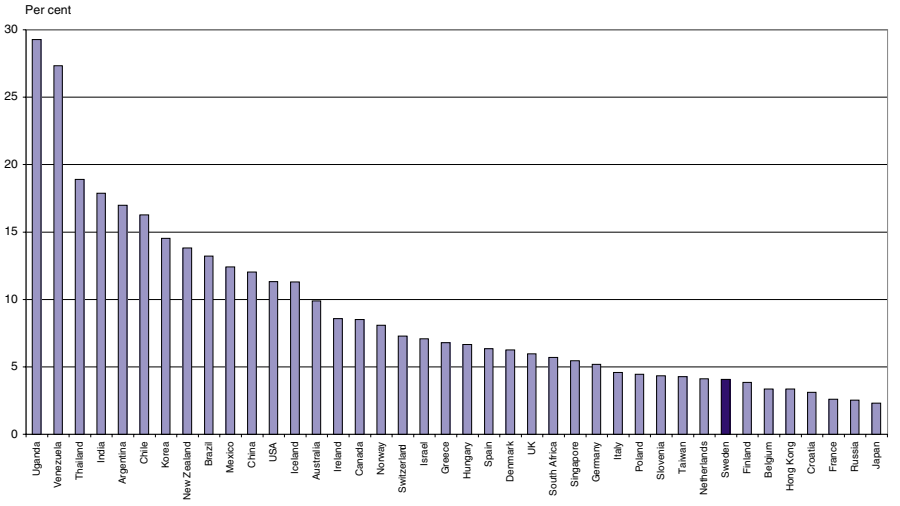
Source: Eurostat New Cronos database, 2003

6.3 Economic turnover generated by products that are new to firms 2000



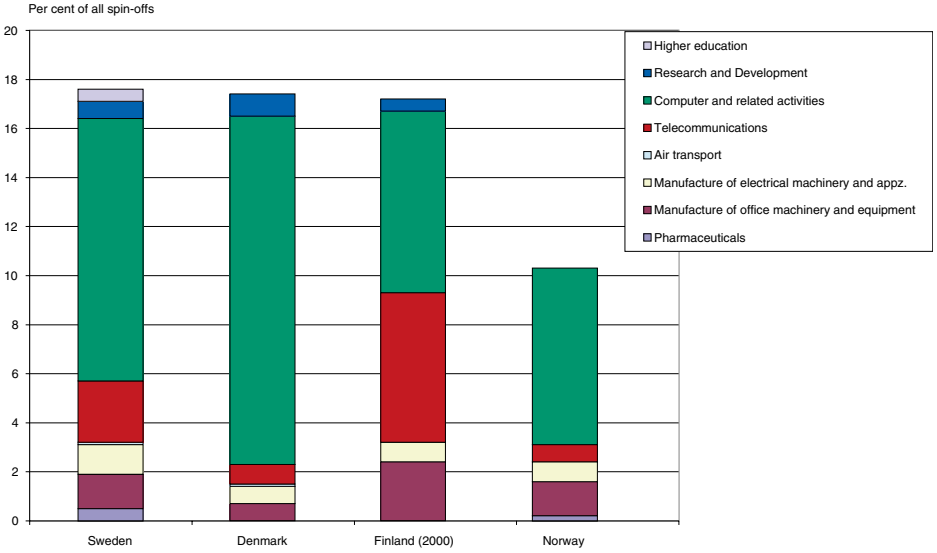
Source: Eurostat New Cronos database, 2003

6.4 Percentage of active population engaged in starting new firms 2003



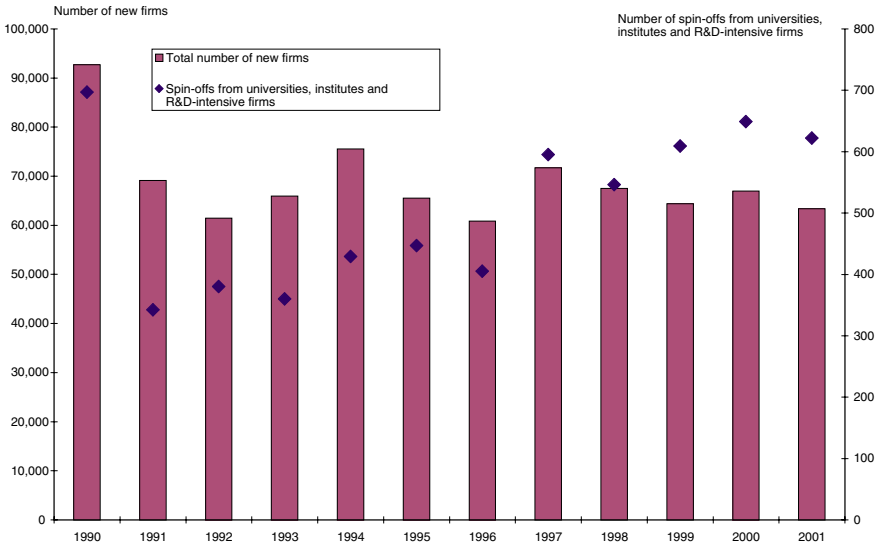
Source: Global Entrepreneurship Monitor (GEM), 2003

6.5 High-tech spin-offs in the Nordic countries 1999–2000



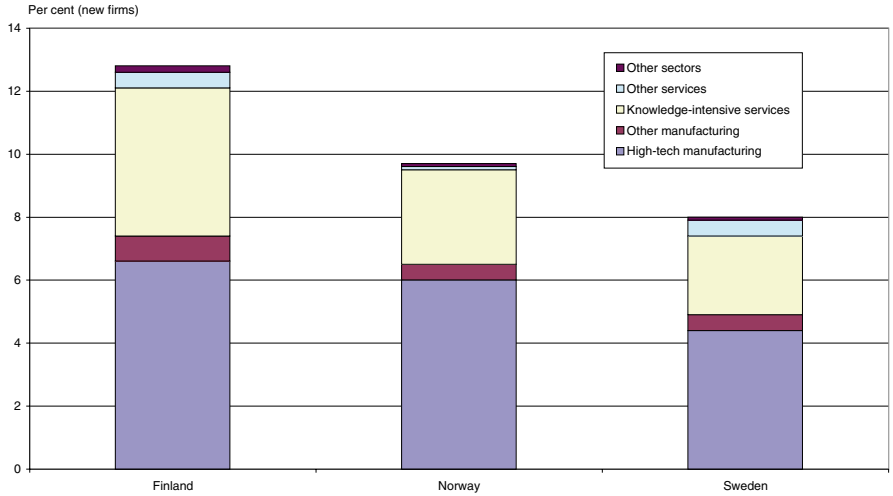
Source: SINTEF, High-tech spin-offs in the Nordic countries, 2003

6.6 New firms and spin-offs in Sweden 1990–2001



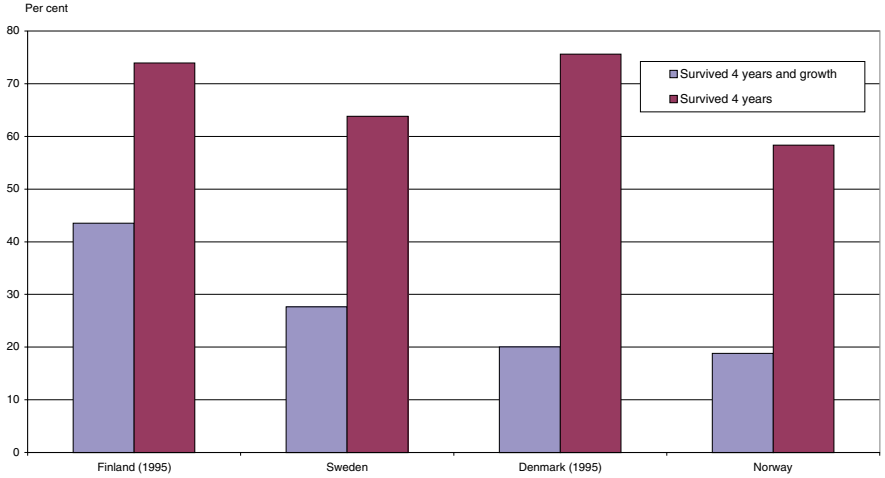
Source: Statistics Sweden and VINNOVA, 2003

6.7 Researcher participation in new firms 2001



Source: SINTEF, High-tech spin-offs in the Nordic countries, 2003

6.8 Survival and growth rate among spin-offs from the high-tech industry in 1996



Source: SINTEF, High-tech spin-offs in the Nordic countries, 2003.
Comment: Growth is defined by a formula requiring that establishments starting out with 1 or 2 employees in 1996 should have 3 or more employees four years later.

III. TECHNOLOGY AND SCIENCE PERFORMANCE

7 Technological Performance

The Swedish national innovation system has during the entire period 1970–2003 been among the leading countries in the OECD in terms of generating technological inventions, measured as international patenting in relation to population size. Swedish international patenting of new technology has risen considerably in recent decades, in total and across all high-technology and medium high-technology fields. Apart from the USA, Japan, Germany and Switzerland, Sweden has a higher level of patenting in relation to population size than any other country within most technology areas. A major reason for the strong Swedish position is that Sweden has the largest concentration of R&D-intensive industrial groups in the world. Also the industrial groups in medium-sized low-technology industries are relatively R&D-intensive and technologically competitive. Multinational R&D-intensive industrial groups in Sweden dominate Swedish international patenting, while independent SMEs patent very little outside Sweden and university researchers or R&D institutes even less.

Total international technology patenting

Technological performance is fundamental to innovation processes and is here understood as inventions, in a broad sense, i.e. ideas and results that are possible to commercialise and exploit in different kinds of production. Technological competitiveness is here measured in terms of different countries' patenting in the USA.[26]

Throughout the period studied Sweden has been highly competitive in terms of patenting in the USA and was ranked fourth in the world in 2001. Swedish patenting in the USA rose rapidly during the second half of the 1990s, from a level that was already relatively high by international standards. Other countries with high patenting in the USA have shown a similar trend, albeit not as pronounced, figure 7.1.

In terms of triadic patenting, i.e. patents assigned in the three patenting areas USA, EU and Japan, statistics show that Sweden is even more competitive. Only Switzerland reports a higher rate of triadic patenting than Sweden. As in the case with US-patenting, Swedish triadic patenting rose rapidly in the latter half of the 1990s.

Sectoral patenting performance

Swedish technological competitiveness is particularly strong in telecommunications. However, the most significant characteristic of the Swedish technological strength is its breadth. Sweden is highly competitive technologically in most high-technology and medium high-technology fields. This is a reflection of the breadth of the Swedish manufacturing industry across almost all the high-technology and medium high-technology industries. These industries are all dominated by large multinational groups with a strong R&D base in Sweden, figure 7.2.

Apart from the USA, Japan, Germany and Switzerland, Sweden has a higher level of patenting in relation to its population size than any other country within most technology areas. However, compared to the major patenting countries in the world, the USA[27] and Japan, the level of Swedish patenting is rather low in most high-technology and medium high-technology fields.

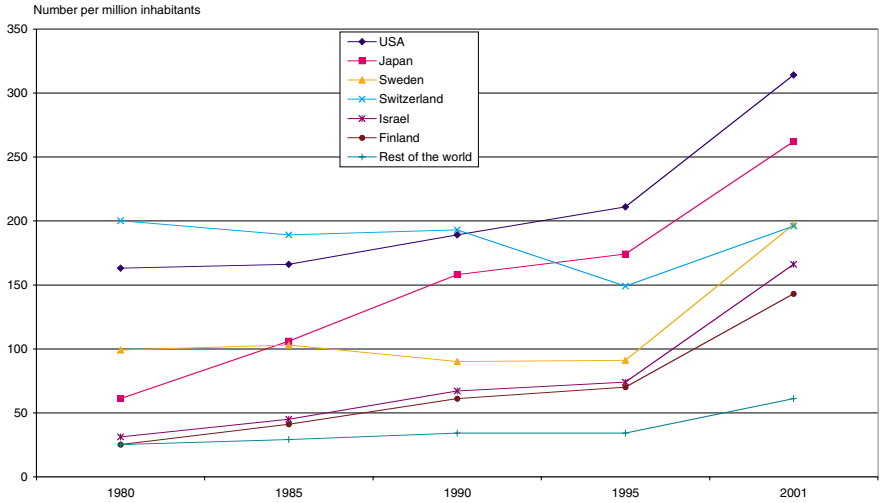
Patenting organisations

A major reason for Sweden's high technological competitiveness in terms of international patenting is the large share and dominating role played by large multinational and R&D-intensive industrial groups within the Swedish national innovation system.

Companies that accounted for particularly substantial patenting activities in the USA included the Swedish parts of Ericsson, AstraZeneca and Pharmacia Upjohn in the telecommunication and pharmaceuticals sectors. ABB and a number of other industrial groups with considerable R&D presence in Sweden also increased their patenting substantially in the latter half of the 1990s. The sharp rise in patenting activities by these industrial groups contributed to most of the rapid increase in Swedish patenting in the USA noted in the second half of the 1990s. Large multinational groups, with a strong R&D base in Sweden, dominate Swedish patenting in the USA, accounting for about 70 per cent of all patents in 2001, figure 7.3.

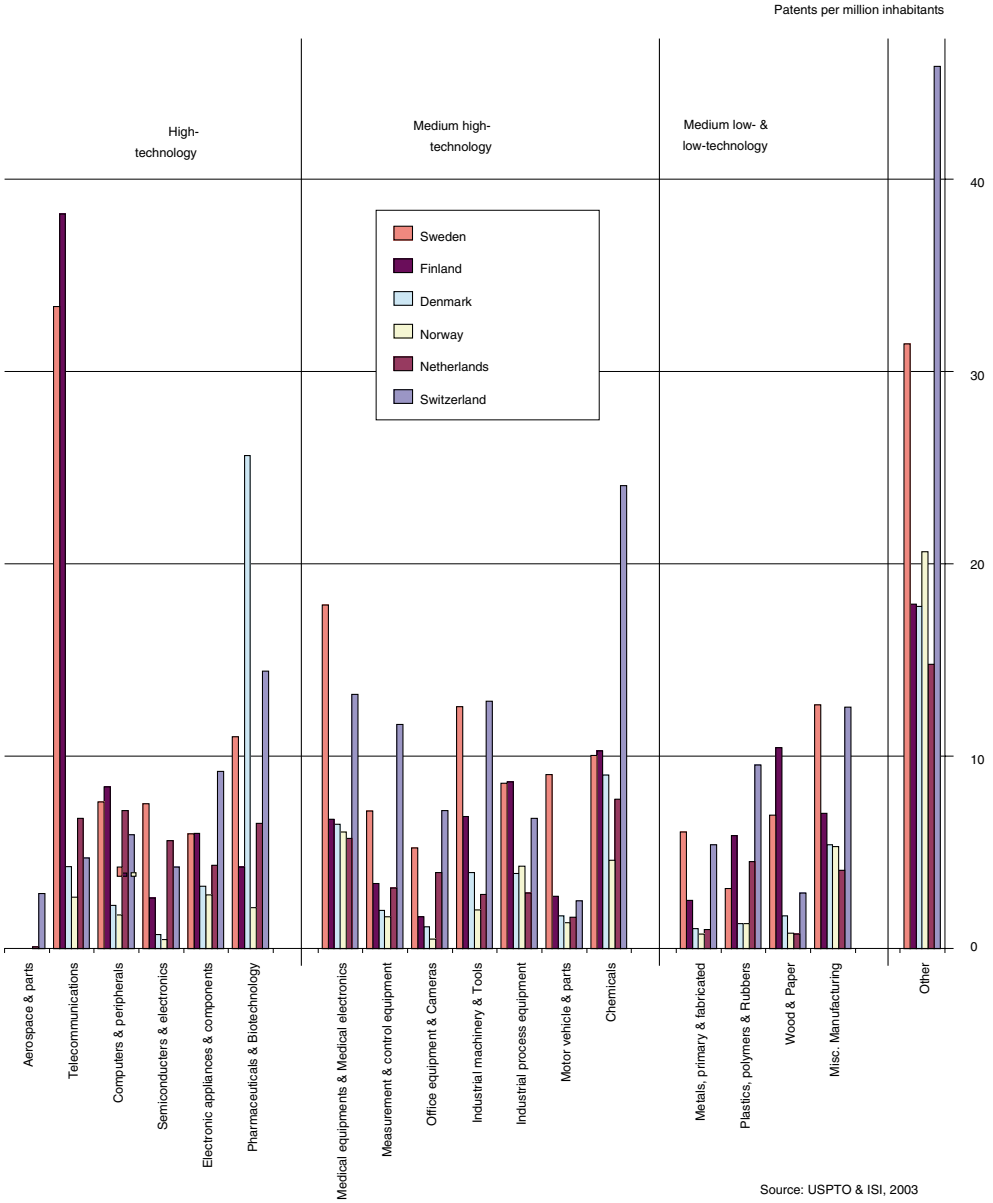
SMEs represent only a very small proportion of overall Swedish international patenting. Moreover, a majority of the patenting SMEs are firms belonging to large multinational groups. Patents by individual entrepreneurs, R&D institutes or special organisations patenting inventions from the research system account for only a minor proportion of Swedish international patenting.

7.1 Number of patents in the USA (USPTO) per million inhabitants 1980–2001



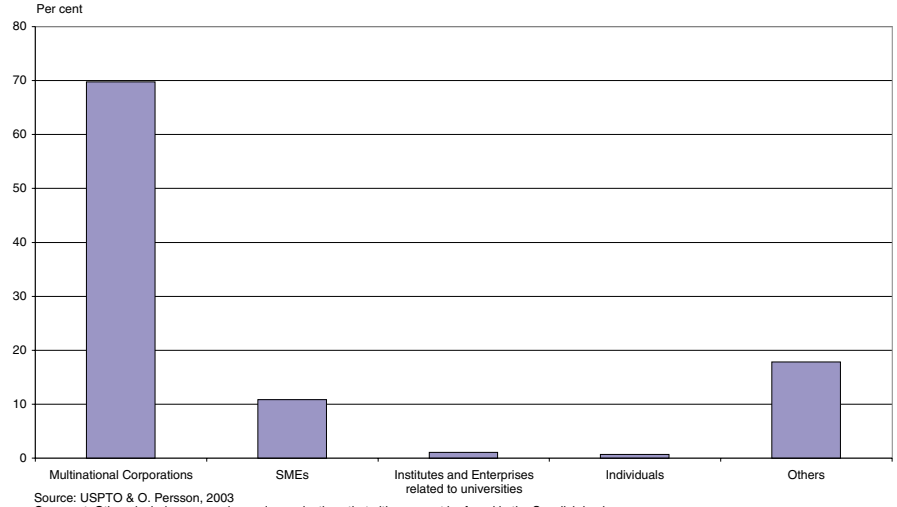
Source: CHI Research Inc, 2002

7.2 Number of patents in the USA per million inhabitants 2001



Source: USPTO & ISI, 2003

7.3 Parent organisation of Swedish inventions patented in the USA 2001



Source: USPTO & O. Persson, 2003
Comment: Others includes companies and organisations that either cannot be found in the Swedish business register or, are not specified by the USPTO or do not belong to the other categories.

8 Science Performance

The Swedish national innovation system tops the OECD's rankings in terms of science production, in relation to population size. Swedish scientific production and world science shares have increased rapidly in recent decades. In all three broad scientific fields of medical science, natural science and engineering, Sweden is ranked highest by the OECD in terms of scientific publications. One main reason for the strong Swedish position in science production is that Sweden, in relation to the size of its population, has the largest university system in the world. Universities dominate the world production of scientific results, globally as well as in Sweden. However, whilst the volumes of scientific production in Sweden have been rapidly increasing, the average scientific quality seems to have declined in all major scientific fields, particularly engineering.

Science production

Research of high scientific quality is of great importance to the dynamic competitiveness of innovation systems. Apart from the knowledge and competence of individuals, the most important product of scientific research is scientific publications that document scientific progress. The rate of scientific publications in internationally acknowledged scientific journals is a good general indicator of the scientific performance of different innovation systems.

Swedish research is, in relation to the size of the country's population, world-leading in terms of scientific results, measured in terms of the number of publications in internationally acknowledged scientific journals. Only Switzerland publishes more scientific articles per capita. Sweden has for many years been first or second in the world in terms of generating scientific publications, relative to the size of the country, figure 8.1.

Overall, Swedish scientific publications increased steadily during the 1980s and 1990s. During 1981–1991, the number of Swedish scientific publications increased by 31 per cent. The corresponding figure for 1991–2001 was 28 per cent. This resulted in an increasing world share of total scientific publications for Sweden, from 1.5 per cent in 1981 to over 2 per cent in 2001.

Science performance within different scientific fields

In all three broad scientific fields of medical science, natural science and engineering, Sweden is first or second in the world in terms of the number of scientific publications. In terms of the number of publications in relation to its population size, Sweden is world-leading in medical science and second only to Switzerland in natural science and engineering.

In absolute terms, the Swedish performance differs between these three broad science fields. In medical science, Swedish publications account for 2.7 per cent of all such publications in the world. The corresponding figures for natural science and engineering are 2 per cent and 1.7 per cent respectively, figures 8.2, 8.3 and 8.4.

Science-producing organisations

University research dominates the scientific results in all countries. In Sweden, about 85 per cent of all Swedish scientific publications are produced within Swedish universities. The main reason is, of course, that scientific publication is a central purpose of university research and the main driving force for most university researchers. Of all university papers, about two-thirds refer to life science papers. Despite the increase of scientific publications by businesses and R&D institutes during recent years, they still represent only a very small proportion of overall publications.

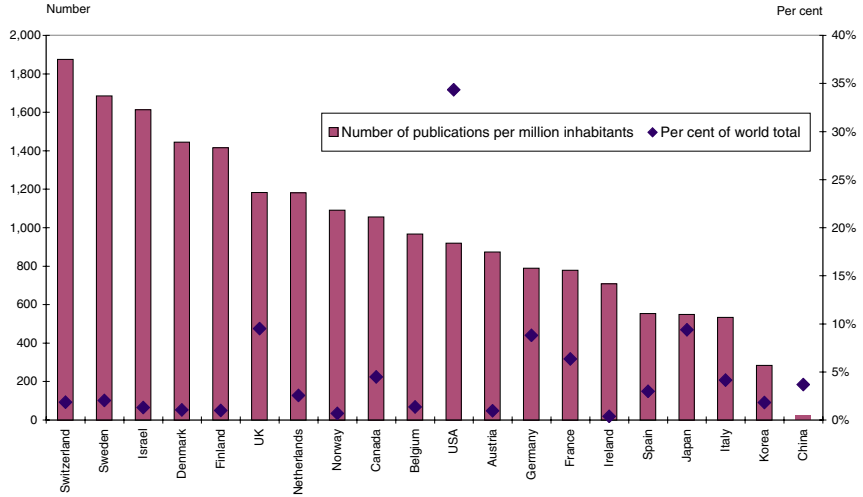
Businesses produce around 6 per cent of all scientific papers in Sweden, almost all in co-operation with universities. Also of these, nearly two-thirds are life science publications. Non-academic hospitals produce about the same amount of scientific publications as businesses, almost all of which are in life sciences. Other sectors produce together about 5 per cent of all Swedish scientific publications, most of which in the field of life science.[28]

Scientific quality

The scientific quality of Swedish research results, measured in terms of citations in scientific articles, is high in international comparison. However, in recent years the quality seems to have deteriorated.

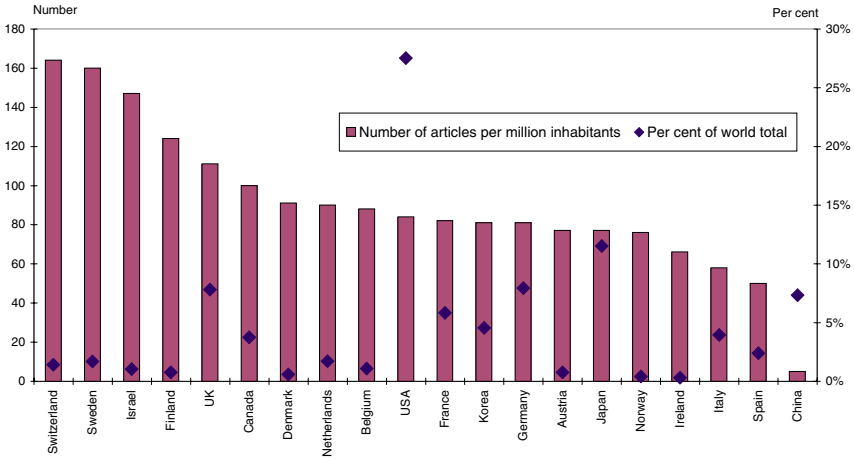
A closer look at different broad scientific fields reveals that the deterioration in Swedish scientific quality has been particularly noticeable in engineering research. Between the two periods 1992–1996 and 1997–2001 Sweden's world ranking went from third to sixth. Sweden's international performance in medicine also deteriorated in terms of scientific quality, falling from a sixth place in 1992–1996 to a ninth place in 1997–2001. In natural science, Sweden fell from fifth to sixth place in the world in terms of science citations.

8.1 Scientific publications in internationally acknowledged journals 2000–2001



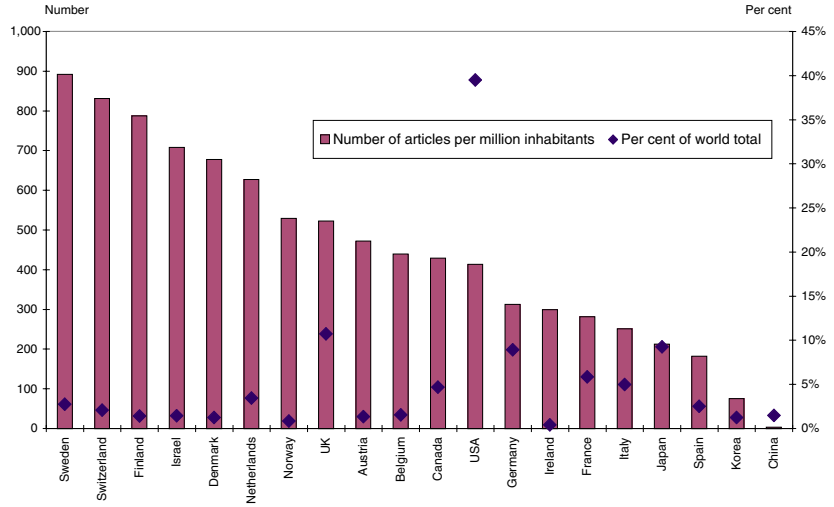
Source: National Science Indicators (NSI) database, 2002

8.2 Scientific publications in engineering 2001 – Numbers per million inhabitants and share of world total



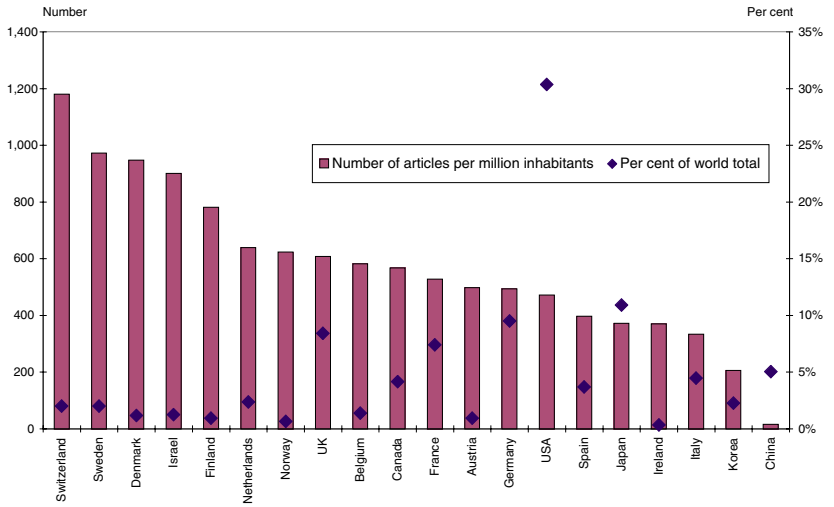
Source: National Science Indicators (NSI) database, 2003

8.3 Scientific publications within medical sciences 2001 – Numbers per million inhabitants and share of world total



Source: National Science Indicators (NSI) database, 2003

8.4 Scientific publications within natural science 2001 – Numbers per million inhabitants and share of world total



Source: National Science Indicators (NSI) database, 2003

IV. INNOVATION ACTIVITIES AND INTERACTIONS

9 Business Innovation Activities

The Swedish national innovation system is highly competitive in terms of business sector innovation investments. Particularly impressive are the internationally high levels of R&D activities. The Swedish business sector is at the top of the OECD's rankings in this respect, in relation to GDP. Business sector R&D investments in Sweden increased rapidly in the 1990s. The Swedish business sector innovation investments in general and R&D investments in particular have been dominated by large industrial groups. Moreover, the expansion in recent years has been highly concentrated to only three industrial groups. The Swedish national innovation system is considerably less competitive in terms of innovation activities in SMEs, both in general and in terms of R&D. Sweden seems to be relatively attractive to foreign investments in knowledge-intensive activities, though considerably less attractive for foreign investments in large-scale production of goods and services. In several value chains, there is a trend towards an increasing use of the Swedish national innovation system as a platform for value-adding, knowledge-intensive activities where the large-scale production to an increasing extent is taking place elsewhere.

Importance of innovation investments

A general conclusion from research into the economic impact of innovation investments is that such investments, particularly R&D investments, generally generate a value added corresponding to at least 5 times as much as the costs of these investments. The reason for this is the generally large multiplying effects generated by learning and imitation from the knowledge and innovations generated by innovation investments. It is thus the diffusion effects observed and accounted for in economic theory and in many empirical studies that generate socio-economic effects that are generally much greater than the cost of the original investments.[29]

Some empirical studies indicate that the average multiplying spill-over effects on economic value may be higher than 10.[30] It is also clear that the social returns from innovation are generally several times higher than the private returns. The latter returns are, generally at least, four times as high as the former, or about 80 per cent of the total value generated.[31] It can also be concluded from these studies that R&D activities carried out within the business sector contribute more to productivity growth than R&D activities carried out outside the business sector.

One particular kind of spill-over effect is spill-over from one industry to another. The present state of research indicates that such spill-over effects appear to correspond to at least 50–100 per cent of the direct effects in the firms or industry undertaking the R&D. Moreover, these spill-over effects are almost certainly underestimated, because spill-over is generally only estimated for a limited number of industries. As an example, the impact on productivity effects in service industries is often not measured. Since these industries are major users of manufacturing innovations this should be a major source of the underestimation of spill-over effects.[32]

Total business innovation investments

Data from the Community Innovation Survey (CIS) reveal that the Swedish business sector is highly competitive in terms of innovation investments. Sweden is both highly competitive in terms of total manufacturing innovation investments and in terms of total service innovation investments. The Swedish performance is largely based on investments in high-technology manufacturing and knowledge-intensive services that by international standards are high.

Of all the total innovation investments in the manufacturing industry, R&D accounts for a large proportion, while in services, R&D expenditure represents a relatively small proportion of overall innovation investments. This is an important sectoral difference to bear in mind in innovation policy development and design.[33]

Business sector R&D investments

Sweden's business sector investments in R&D are the highest in the OECD in relation to the country's GDP. This performance is to a large extent based on R&D investments made by the large high-technology or medium high-technology manufacturing industrial groups which have a substantial R&D base in Sweden. Sweden advanced to the world-leading position in terms of business sector R&D investments in the early 1990s and this position was further reinforced during the rest of the decade. The advancement was almost completely attributable to increasing R&D investments by the large industrial groups. And of these, R&D investments in telecommunications and pharmaceuticals accounted for a large proportion, figure 9.1.

Sweden is also among the leading countries in the OECD in terms of R&D expenditure in medium low-technology and low-technology manufacturing industries. However, these industries account for a relatively low proportion of overall R&D investments in all countries. Innovation investments in services are to a much lesser extent based on R&D investments than manufacturing innovation. Though, as in terms of total business sector innovation investments, Sweden is quite

competitive in R&D in knowledge-intensive services, but much less competitive in R&D investments in less knowledge-intensive services and in public services, figure 9.2.

Attractiveness for R&D investments

The localisation of R&D activities within national borders is of key importance for national innovation systems. The presence of firms and other organisations undertaking such organised innovation activities is important both directly, through the technological knowledge they produce, and indirectly, through knowledge spill-over from such activities and through their contribution to the general technological environment.

The geographical location of industrial activities depends on the relative advantages of the specific environments in different locations. In relation to organised innovation activities, such as R&D, positive environment conditions may vary, but should, in general terms, be related to particularly good access to highly qualified competence. Therefore, key factors in attracting knowledge-intensive industrial activities, both in terms of new investments and in terms of keeping existing activities within national borders, are those that provide access to key competence for different industries. Such competencies vary from industry to industry and must therefore be analysed in relation to specific sectoral innovation systems.[34]

Internationalisation processes of R&D tend to diminish the relative concentration of R&D activities in large industrial groups to domestic units. In doing so, they may reduce the home country's innovative capacity. Generally, risks of this kind should be greatest in small countries, since their industrial R&D base is often dominated by a small number of large multinational industrial groups.[35] Therefore, the geographical location of R&D activities in large multinational industrial groups is also one indicator of the existence of positive location factors for organised innovation activities.

Data on R&D intensities in foreign affiliates in different countries indicate that Sweden in general terms is a relatively attractive location for R&D activities for large multinational manufacturing groups. However, as in most countries, domestic manufacturing firms are, on average, more R&D-intensive than foreign affiliates in Sweden. The average R&D intensity of national Swedish manufacturing firms is highest in the world, figure 9.3.

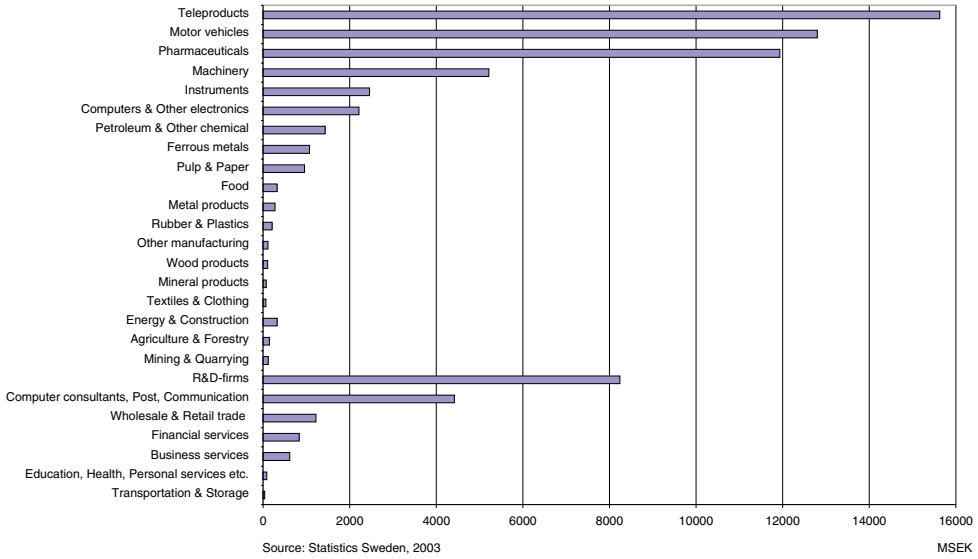
Considering the falling number of employees in R&D-intensive industrial groups in Sweden, as noted in chapter 4, it is likely that multinational industrial groups find Sweden considerably more attractive for R&D activities than for production. Particularly since several of them now have foreign owners, with less historical and practical bonds to Sweden. An important issue for innovation and growth policy in Sweden is therefore, if and how future value generation and flows could benefit the Swedish economy.

9.1 Business R&D investments in relation to GDP 1981–2001, per cent

No.	1981		1985		1989		1993		1997		2001	
1	Germany	1.7	Switzerland (1986)	2.2	Switzerland	2.1	**Sweden**	**2.3**	**Sweden**	**2.8**	**Sweden**	**3.3**
2	USA	1.7	USA	2.0	Germany	2.0	Switzerland (1996)	1.9	Japan	2.0	Israel	3.1
3	Switzerland	1.6	Germany	1.9	Japan	2.0	Japan	1.9	Israel	2.0	Finland (2000)	2.4
4	UK	1.5	**Sweden**	**1.9**	USA	1.9	USA	1.8	Korea	2.0	Japan (2000)	2.1
5	**Sweden**	**1.4**	Japan	1.8	**Sweden**	**1.9**	Germany	1.6	USA	1.9	USA	2.1
6	Japan	1.4	OECD	1.6	OECD	1.6	Israel	1.6	Finland	1.8	Korea (2000)	2.0
7	OECD	1.3	UK	1.4	UK	1.5	France	1.5	Germany	1.5	Switzerland (2000)	2.0
8	France	1.1	France	1.3	France	1.4	OECD	1.4	OECD	1.5	Germany	1.8
9	EU	1.1	EU	1.2	EU	1.3	UK	1.4	France	1.4	Iceland	1.8
10	Belgium	1.0	Belgium	1.2	Netherlands	1.2	Finland	1.3	Belgium	1.3	OECD (2000)	1.6
11	Netherlands	1.0	Netherlands	1.1	Finland	1.1	Belgium	1.2	Denmark	1.2	Belgium (2000)	1.5
12	Finland	0.6	Norway	0.9	Belgium	1.1	EU	1.2	UK	1.2	France	1.4
13	Austria	0.6	Finland	0.9	Norway	1.0	Denmark	1.0	EU	1.1	EU (2000)	1.2
14	Norway	0.6	Canada	0.8	Denmark	0.8	Netherlands	1.0	Netherlands	1.1	UK (2000)	1.2
15	Canada	0.6	Austria	0.7	Austria	0.8	Norway	0.9	Canada	1.0	Netherlands (2000)	1.1
16	Denmark	0.5	Denmark	0.7	Canada	0.7	Canada	0.9	Norway	0.9	Canada	1.1
17	Italy	0.5	Italy	0.6	Italy	0.7	Austria	0.8	Ireland	0.9	Australia (2000)	0.7
18	Ireland	0.3	Ireland	0.4	Australia	0.5	Ireland	0.8	Iceland	0.8	Italy	0.6
19	Australia	0.2	Australia	0.4	Ireland	0.5	Australia	0.7	Australia	0.8	Spain	0.5
20	Spain	0.2	Spain	0.3	Spain	0.4	Italy	0.6	Italy	0.5	Austria	
21	Portugal (1982)	0.1	Iceland	0.1	New Zealand	0.3	Iceland	0.4	Spain	0.4	Denmark	
22	Iceland	0.1	Portugal (1986)	0.1	Iceland	0.2	Spain	0.4	New Zealand	0.3	Ireland	
23	Israel		Israel		Portugal (1990)	0.1	New Zealand	0.3	Portugal	0.1	New Zealand	
24	Korea		Korea		Israel		Portugal (1995)	0.1	Austria		Norway	
25	New Zealand				Korea		Korea		Switzerland		Portugal	

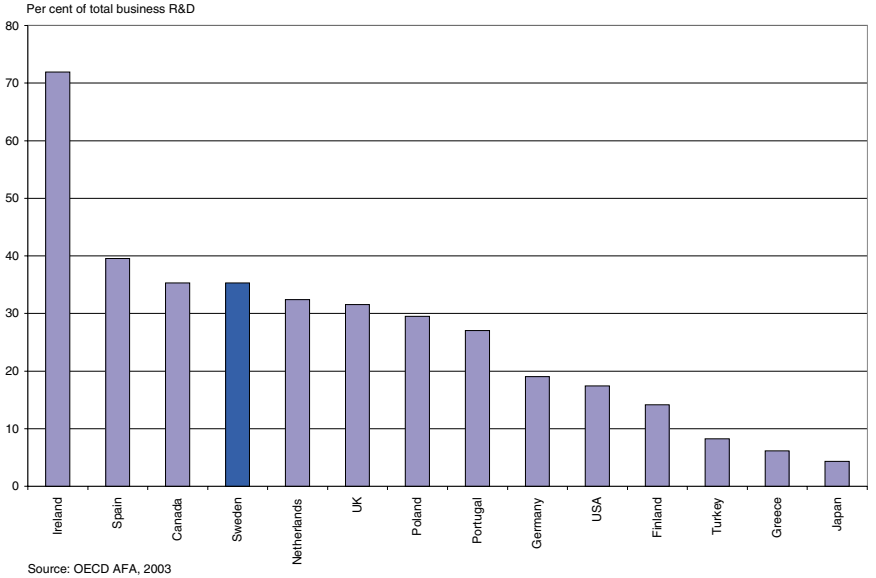
Source: OECD MSTI, 2003

9.2 R&D expenditure in different industries in Sweden 2001



Source: Statistics Sweden, 2003

9.3 Percentage of business R&D expenditure from foreign-owned firms 1999



Source: OECD AFA, 2003

10 University and Institute Research

The Swedish national innovation system is leading in the OECD in terms of university research investments, in relation to GDP. Public R&D investments outside the university sector are low in international comparison. As a consequence, the Swedish R&D institute sector is one of the smallest in the OECD. Therefore, the Swedish university sector is expected to co-operate efficiently with the rest of society. However, the incentive structures for this are weak in the universities and the university functions for this are therefore underdeveloped. As a consequence, the Swedish R&D system outside the business sector is by international comparison highly focused on curiosity-driven scientific research. The level and share of mission-oriented research is low and has continuously decreased in recent decades. By international standards, defence-related R&D accounts for a high proportion of total public investments in mission-oriented research. A consequence of the Swedish R&D system and the profile of public research financing is that overall investments in engineering R&D outside the business sector are not particularly high in international comparison, despite high levels of engineering research in universities.

University research

Research in Swedish universities and higher education colleges accounts for a larger proportion of GDP than in all other countries. In 2001, research in the higher education sector amounted to SEK 18.8 billion, which corresponded to 0.83 per cent of GDP. The OECD average was about half of that. Only Israel, with 0.82 per cent of GDP, comes anywhere near Sweden in terms of the volume of higher education sector research. Closest to Sweden and Israel are Switzerland, Canada and Finland, each with about 0.6 per cent of GDP in higher education sector research activities, figure 10.1.

Sweden has been a world leader in terms of the investments made in university research in relation to GDP, at least since the early 1980s. This reflects a long-term, determined focus of Swedish governmental research policy that was initiated as far back as World War II. This policy has been based on a rather firm view that university research and education are of key importance for social development and progress. On the other hand, the policy has been based on the view that universities should be the major performers of research and advanced learning in society.

Medical sciences, followed by engineering and natural sciences, dominate in terms of research investments in Swedish universities. The most rapid increases in the 1990s took place within engineering and medical sciences.

Institute research

As a consequence of the Swedish research policy developed in the early 1940s, the R&D institute sector and public funding of R&D institutes is by international standards small. In total, R&D activities carried out by governmental and private R&D institutes corresponded to about 3 per cent of overall R&D activities in Sweden 2001, which is considerably less than in other European countries.[36] As a consequence, Swedish R&D institutes tend to play rather minor roles in their main areas of focus, figure 10.2.

The Swedish R&D institute sector is dominated by industrial research institutes. These date back to the early 1940s, and most of them focus on individual manufacturing industries. The industry is represented by different owner constellations for each institute. Government ownership is administered through the holding company IRECO. Today, all industrial research institutes have been transformed into companies with a private-public shared ownership. The research institute sector will be further reorganised into larger institute groups in 2004.

The basic public funding of R&D institutes has over the past decade become among the lowest in Europe. As a result, it is very possible that their R&D activities will become more short-term in nature and less closely linked to the science base than institute research in other countries,[37] figure 10.3.

Mission-oriented research in universities and R&D institutes

Compared to most other OECD countries, the volume and share of mission-oriented research in the Swedish research system outside the business sector is small. First of all, the financing structure of Sweden's large university sector primarily promotes curiosity-driven research. The share of financing for explicit mission-oriented research in the Swedish university system has decreased considerably in Sweden in recent decades. Secondly, the small relative volume and share of research in R&D institutes in Sweden compared to virtually all other OECD countries should further contribute to a low level of mission-oriented research in the Swedish national innovation system, figures 10.4 and 10.5.

Engineering research in universities and R&D institutes is a particularly important investment in the performance of innovation systems. However, general international comparisons of the total engineering research carried out outside the industry are difficult to make, since such compilations are not made by national or international statistical agencies. However, through

special compilations of R&D data from the statistical authorities in different countries, it is possible – albeit problematic due to differing data quality – to compare the volumes of engineering research in universities, higher education colleges and R&D institutes in different countries.[38]

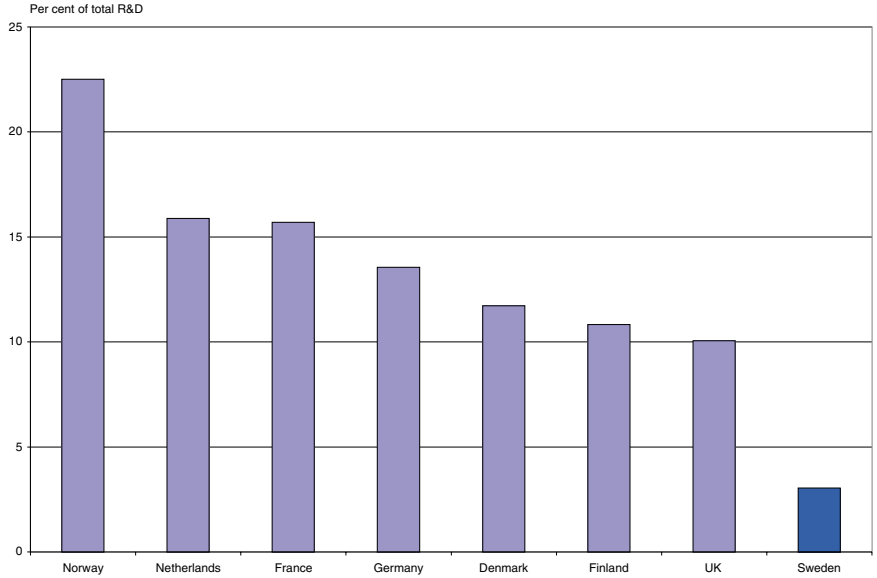
While Sweden invests relatively large resources in engineering research at universities, the resources invested in engineering research in R&D institutes are small by international standards. Overall, Sweden is not particularly competitive in terms of engineering research in universities and R&D institutes. Finland, the Netherlands and Norway show higher numbers of engineering R&D man-years in universities and R&D institutes in relation to the size of their population. Germany and Denmark account for a lower proportion than Sweden, due to their considerably smaller university sectors, figure 10.6.

10.1 R&D expenditure in the higher education sector 1981–2001 in relation to GDP

No.	1981		1991		2001	
1	**Sweden**	**0.65**	**Sweden**	**0.74**	**Sweden**	**0.83**
2	Japan	0.55	Israel	0.67	Israel	0.82
3	Switzerland	0.43	Switzerland (1992)	0.66	Finland	0.61
4	Netherlands	0.42	Netherlands	0.58	Switzerland	0.60
5	Germany	0.41	Japan	0.51	Canada	0.59
6	Norway	0.34	Canada	0.49	Iceland	0.58
7	Canada	0.33	Finland	0.45	Netherlands (2000)	0.57
8	France	0.32	Norway	0.44	Belgium (1999)	0.47
9	UK	0.32	Belgium	0.43	Denmark (2000)	0.45
10	OECD	0.31	Germany	0.41	Japan	0.45
11	USA	0.31	Australia (1992)	0.40	Norway	0.42
12	EU	0.30	USA	0.39	Australia (2000)	0.41
13	Denmark	0.28	Denmark	0.37	France	0.41
14	Australia	0.27	EU	0.36	UK	0.41
15	Finland	0.26	France	0.36	EU (2000)	0.40
16	Iceland	0.17	OECD	0.36	Germany	0.40
17	Italy	0.16	Iceland	0.35	OECD	0.40
18	New Zealand	0.16	UK	0.34	USA	0.40
19	Ireland	0.11	New Zealand	0.28	New Zealand (2000)	0.35
20	Spain	0.09	Italy	0.26	Italy (2000)	0.33
21	Belgium		Ireland	0.22	Korea	0.31
22	Israel		Spain	0.19	Spain	0.30
23	Korea		Korea		Ireland (2000)	0.23

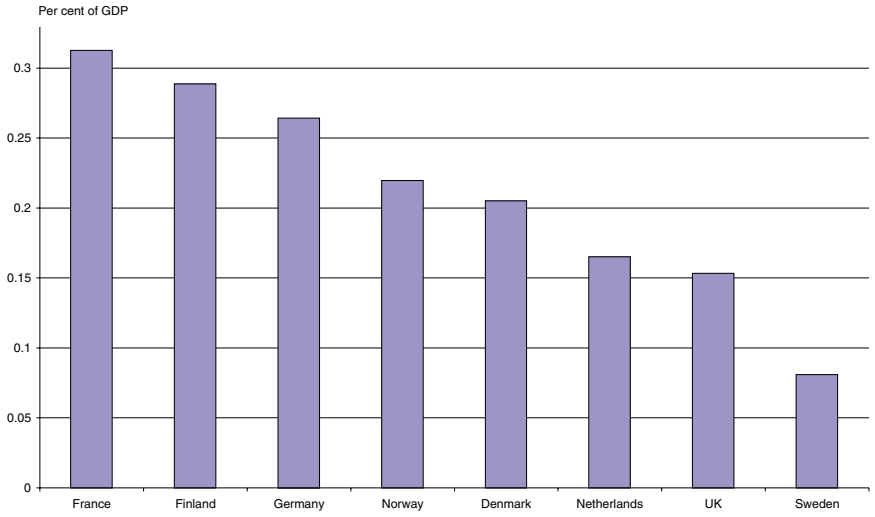
Source: OECD MSTI, 2003

10.2 Institute R&D in relation to total R&D expenditure 2001



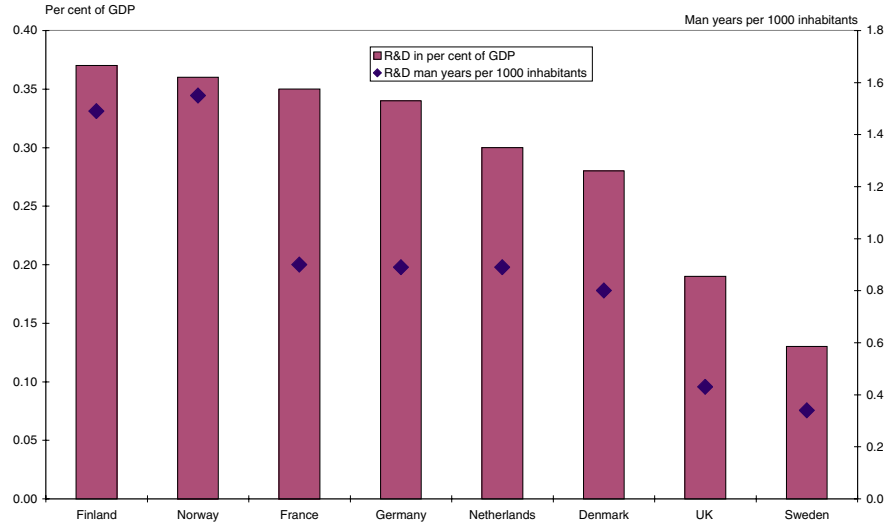
Source: INNO & Technopolis "Benchmarking Technology R&D", 2004

10.3 Government funding of the institute sector in relation to GDP 2001



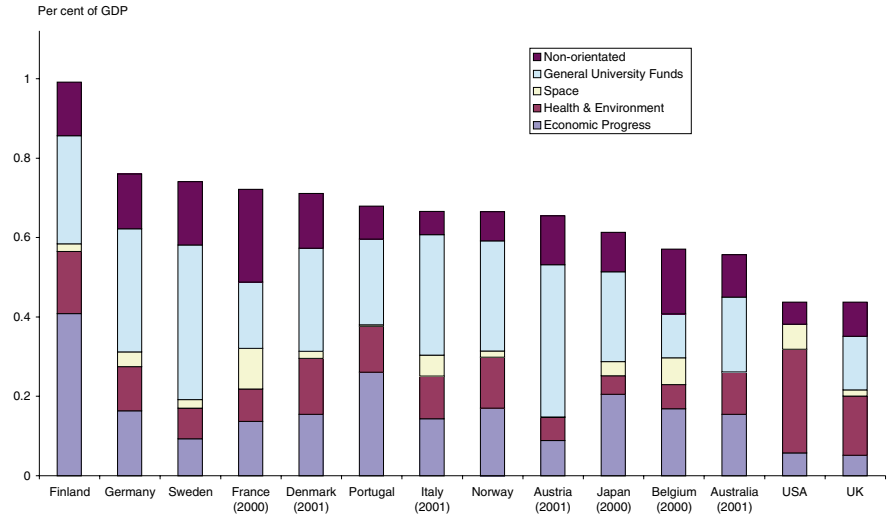
Source: INNO & Technopolis "Benchmarking Technology R&D", 2004

10.4 R&D activities carried out in the institute sector 2001



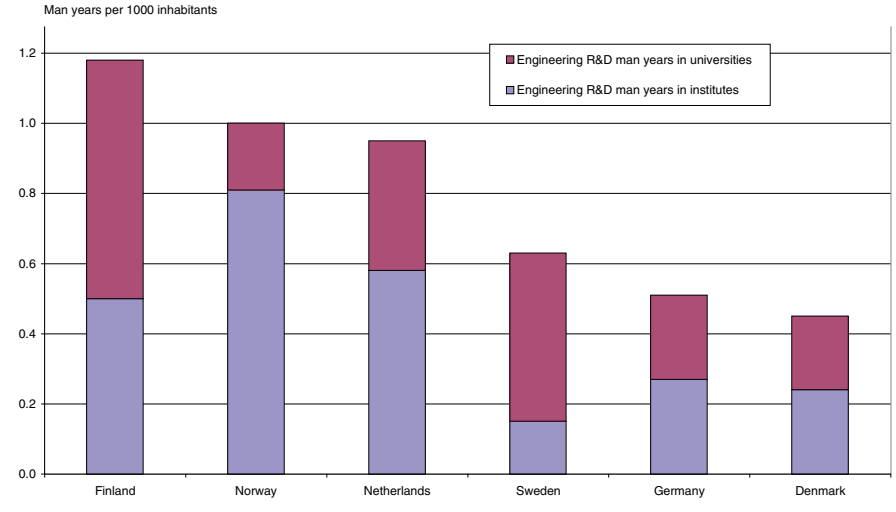
Source: INNO & Technopolis "Benchmarking Technology R&D", 2004

10.5 Government-financed civil R&D in relation to GDP 2002



Source: OECD MSTI, 2003

10.6 Engineering R&D in universities and institutes 2001



Source: INNO & Technopolis "Benchmarking Technology R&D", 2004

11 Interaction Patterns

Since World War II, the Swedish national innovation system has been dominated by technology-based, public-private partnerships between R&D-intensive manufacturing industrial groups and public agencies and companies. To a large extent, these partnerships explain the high R&D-intensity in Swedish-based industrial groups. In turn, the evolving technology and market leadership of these groups also illustrate the manufacturing subcontractor structures that have dominated Swedish manufacturing industry. Moreover, the R&D-intensive industrial groups in Sweden have provided major markets for knowledge-intensive services, which have rapidly expanded in recent decades, through outsourcing and market growth trends. The Swedish university-dominated research system has served the dominating technology-leading, public-private partnership structure rather well, even if it has been less efficient in supporting innovation through start-ups, in SMEs and in the public sector. The private knowledge-intensive business services play an increasingly important role in innovation system interactions. The relationship between the roles of such businesses on the one hand and R&D institutes and universities on the other merits further investigation. Some of the important strengths of the Swedish national innovation system include Swedish investments and the use of modern communications technology, together with home-market consumers that are open to new technology and solutions.

Importance of interactive learning in innovation

Few businesses have all the vital resources, primarily knowledge, but also financial capital, required in innovation processes. Innovating businesses are therefore generally in need of interactive learning transactions with other businesses, research organisations, financial organisations, etc. Many empirical studies have shown that innovation and technological development within a sector or an industry are largely the product of interactions between businesses and other agents.[39]

Innovation process interactions are generally not temporary transactions, but involve essential elements of relatively long-term social contacts and mutual trust, together with financial commitments of a reciprocal nature. For this reason, innovation and technological relationships tend to be more or less stable ventures, in which considerable resources, intangible and tangible, have been invested.[40]

A particular form of innovation interaction is technology consortia. Such consortia could bring considerable value added to the businesses in the consortia. Moreover, they generally generate efficiency gains in the form of different types of innovation and economic systems.[41] However, there is always a balance to be considered between such efficiency and monopoly power that could be detrimental to innovation and national economic growth.

User-producer relationships

In innovation-related interactions, user-producer relationships are particularly important.[42] Several studies have in fact shown that the single most important factor for successful innovation processes is the innovators' understanding of user needs. And, in many cases the users themselves are the locus of innovation, i.e. the main source of focus and knowledge for the innovation. An important determining factor for identifying which agents will become the locus of innovation is often found in the differences in appropriation patterns between different agents.[43]

The most important sources of knowledge and ideas in innovation processes are generally found internally in innovating firms or other firms within the same industrial group. Clients and customers are also generally important sources of knowledge and ideas for innovation, figure 11.1.

This underlines the findings from many case studies and broader empirical studies that user-producer relationships and internal innovation and absorption capacity of firms are of key importance for industrial innovativeness.[44] These patterns are similar across Europe, including Sweden. However, there are important differences between different sectors and industries in this respect. And, these differences also generate differences in critical innovation policy issues between countries, due to national differences in sector and industry structures, figure 11.2.

Public-private partnerships

In Sweden, important long-term, technology-based, user-producer public-private partnerships have been important for technological development within the Swedish national innovation system. From the public perspective, these partnerships have focused on satisfying public needs, represented by public procuring organisations. From the business perspective, they have provided a long-term basis for substantial R&D investments as a basis for international competitiveness on export markets.

An important general framework for these public-private partnerships has been the market, financial and ownership regulations that have guaranteed some degree of stability in these semi-monopolistic public-private relationships. These structures have contributed

a great deal to the high R&D-intensity in Swedish industrial groups. Through the leading multinational industrial groups within these R&D-intensive sectors, large sections of Swedish manufacturing industry have been characterised by a high level of technology. These public-private partnerships have for many years determined the pace and pattern of technological development within these sectors and subcontractor structures. In doing so, they have played an important part in shaping the innovation networks within Swedish manufacturing industry.[45]

In recent decades, the foundations of the dominating Swedish public-private partnership regime have begun to erode in several different and mutually reinforcing ways. As a consequence of intensified globalisation, multinational industrial groups worldwide have increasingly been locating their exploitation and production activities to areas where the conditions for these activities are best met. Historical and geographical roots have decreased in importance as determinants for the location of value-adding industrial activities. In addition, the deregulation or re-regulation of almost all sectors that were previously regulated through monopolistic or semi-monopolistic private-public partnerships has further reinforced these trends.

Because of the importance of such private-public development blocks in recent Swedish economic history and their significance for the dynamic competitiveness of the Swedish national innovation system, these developments generate particular challenges for Swedish innovation policy.[46]

Universities and R&D institutes

As direct sources of knowledge and ideas for innovations, universities and R&D institutes are generally of limited importance. However, they are quite often vital as co-operation partners in relation to innovation processes. Universities have a particularly important role to play in innovation-related co-operation with manufacturing and service firms that have relatively high R&D or knowledge intensities, i.e. with considerable internal absorptive capacity. They are generally of considerably less importance as co-operation partners for firms with less developed internal absorptive capacity, figure 11.3.

Despite the large Swedish university sector, total business sector financing of university research is not particularly high in Sweden. Moreover, the share of business sector financing of overall university research financing is comparatively low in Sweden. This is an indication of a low rate of industrial use of university-based knowledge and competence. Since the universities dominate the Swedish research system, this may be an important challenge for the future development of the Swedish national innovation system, figure 11.4.

Swedish R&D institutes are, relatively speaking generally more important than universities as co-operation partners in innovation to manufacturing firms with medium or low internal technological and absorptive capacity. However, they are generally of limited importance for service innovation in most service industries, figure 11.5.

University research has provided a scientific basis for R&D-intensive multinational groups with in-house technological capacity to use scientific knowledge in their own R&D activities. Moreover, the continuous outflows of R&D specialists from universities have to a large extent been absorbed by the large R&D-intensive groups in Sweden. This combination has thus been a strength of the Swedish national innovation system. On the other hand, the relative difficulties for SMEs to interact with university research, combined with the small R&D-institute sector in Sweden, which is generally more SME-related, has been a weakness for the development of innovative SMEs in Sweden.

University-industry science linkages

Science-based co-operation between R&D-intensive firms and university research increased globally in the 1980s and 1990s at a considerable rate, albeit from a quite low level. This is a clear indication of the increasing importance of scientific knowledge and results in industrial innovation processes.

Also in Sweden, the increase in science-based co-operation between firms and universities has increased considerably over the last two decades. These co-operation patterns reveal that scientific knowledge is particularly important within bio-science fields, in which the increase in the co-authoring of scientific articles between firms and universities increased rapidly both globally and in Sweden. However, industry-university co-operation also increased within certain other industrial high-technology fields in Sweden in the 1980s and 1990s. Scientific co-operation between firms and universities is highly restricted to large R&D-intensive firms, primarily multinational industrial groups with a high internal R&D capacity.

Knowledge-Intensive Business Services

Knowledge-intensive business services (KIBS), such as R&D firms, computer-related services and other business services are often important sources of knowledge and ideas for innovation. R&D firms belonging to industrial groups are particularly important sources of innovation inside their industrial groups, reflecting the basic business logic behind their existence. However, KIBS firms are generally more important as co-operation partners to different kinds of firms in their innovation processes than as original sources of knowledge and ideas for innovation. Thus, they are generally more important as advanced problem-solvers in innovation processes than the source of original ideas.

Compared to most other industries, KIBS firms generally have much closer relationships with universities. Most R&D firms regularly co-operate with university partners in their own innovation processes. However, computer-related services and other business services also show considerably higher intensity in their innovation-related co-operation with universities than other industries. This supports much of the research that has characterised and described KIBS firms as important vehicles for the learning, packaging and diffusion of science-based knowledge to different firms and other organisations. Thereby, their activities and business models are often similar to the activities of and logic behind public or private non-profit R&D institutes in different countries. Such institutes are generally supposed to support R&D and innovation in the business sector.[47]

Together with private KIBS firms, public or private non-profit R&D institutes constitute a sector of research and technological development organisations (RTOs) engaged in knowledge storing, packaging and providing. Private and public boundaries within national RTO sectors are generally quite blurred, both from a business or organisation logic perspective and from a financing perspective. For an efficient innovation policy, it is vital to fully understand the characteristics and dynamics of the national private-public RTO sector. However, in most European countries, including Sweden, data and analysis of this sector are scarce, partial and often of quite low quality. A substantial increase in the attention to statistics and analysis of RTOs is thus called for, as an important analytical basis of innovation policies in Europe, at national, sector and regional levels.[48]

ICT investments and use

Communication is essential to interaction. Investments in and the use of advanced communication infrastructure, technology and services are therefore of key importance for the interaction pattern, intensity and quality within innovation systems. Availability and use of the most modern communication technology and services are particularly important in determining the efficiency of interaction patterns in innovation systems. ICT systems and services have in recent decades emerged as the key technological paradigm for communication in modern economies.[49]

Sweden has for many years been a leading player among OECD countries in terms of its investments in and use of advanced communication technology. In terms of ICT infrastructures, Sweden has increased its ICT investments in the period and advanced to the top or close to the top of the OECD rankings in recent decades, figure 11.6.

Also in terms of its use of ICT, Sweden has throughout the period studied been among the leading countries in the OECD, both in terms of ICT use among individuals and in terms of ICT use within the production system. The Swedish business sector and the Swedish public sector are both among the most intensive ICT users in the OECD, figures 11.7 and 11.8.

Consumer demand

An important, though still rather poorly documented, strength of the Swedish national innovation system is the relatively open attitude of consumers and markets to innovative products and services. This seems to be a particular feature of the Nordic countries, compared to the rest of Europe.[50] It is likely that such consumer habits, as most habits and attitudes, have been gradually built up over a long period of time. This may have been influenced by the early and for many years rather ambitious policy of modernising infrastructures and equipment at work, at home and in education, combined with a relatively broad participation of the population in education and working life.

11.1 High use of different sources for innovation 2000, in relation to innovative enterprises, per cent

	Sources of information for innovation								
Country	Within enterprise	Clients & Customers	Suppliers	Within enterprise group	Competitors	Fairs & exhibitions	Universities	Conferences, meetings & journals	Government and R&D institutes
France	44	34	16	12	15	9	2	5	3
Austria	45	21	13	13	8	8	5	11	3
Belgium	51	28	27	17	12	15	5	10	2
Germany	33	35	17	9	15	20	7	17	2
Denmark	34	35	17	-	14	13	4	6	2
Spain	35	20	25	11	11	18	3	10	5
Finland	45	26	10	12	4	5	3	2	4
Greece	60	26	33	7	11	30	7	21	4
Iceland	26	16	7	3	4	5	1	3	2
Italy	27	15	18	3	7	12	2	6	2
Luxembourg	66	33	30	32	16	14	2	20	1
Netherlands	51	17	12	12	7	5	2	5	3
Norway	47	35	20	14	10	11	3	13	5
Portugal	35	21	27	8	7	25	4	9	2
Sweden	50	48	22	16	11	7	7	3	3

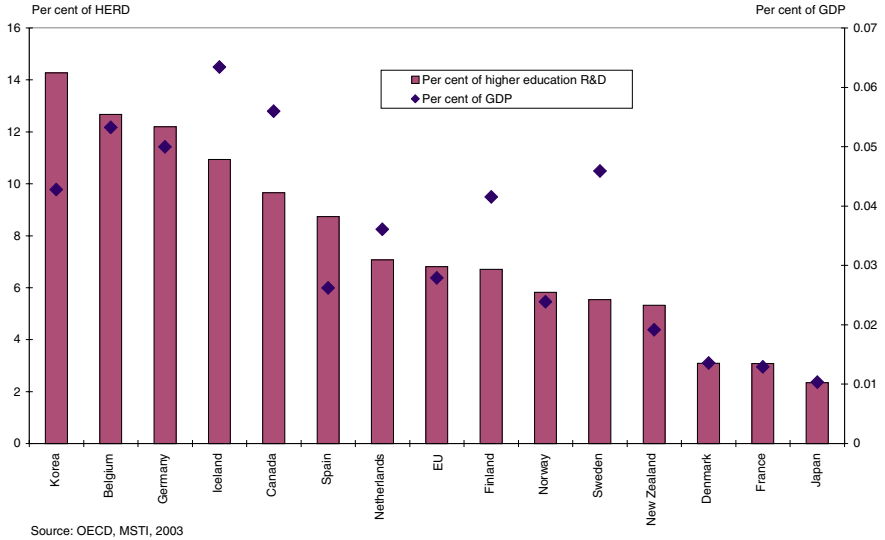
Source: Eurostat New Cronos, 2003

11.2 High use of different sources for innovation 2000 in Sweden, in relation to innovative enterprises, per cent

	Sources of information for innovation								
Industry	Within enterprise	Clients & Customers	Suppliers	Within enterprise group	Competitors	Fairs & exhibitions	Universities	Conferences meetings & journals	Government and R&D institutes
Total	50	48	22	16	11	7	7	3	3
Manufacturing	50	43	21	9	7	6	4	3	2
Services	50	53	22	22	14	7	9	3	5
Food products	74	19	18	9	3	9	15	7	3
Real estate, renting and business activities	74	60	17	13	9	5	11	4	5
Electrical and optical equipment	69	61	18	14	13	6	7	5	2
Transport, storage and communication	56	36	32	13	13	8	2	6	1
Rubber and plastics products	55	46	20	11	5	5	3	0	5
Machinery and equipment	49	66	15	11	7	7	0	4	0
Financial intermediation	48	24	14	12	9	0	1	1	1
Transport equipment	47	38	20	18	9	14	0	2	0
Textiles	46	39	23	3	0	20	0	5	0
Basic metals & fabricated metal products	45	36	30	4	14	0	3	0	0
Other manufacturing	44	40	17	3	5	18	3	1	9
Chemicals and chemical products	38	22	7	11	4	7	7	1	1
Pulp & paper products	36	37	26	6	3	5	3	7	1
Wholesale & retail sale	34	58	23	32	18	9	11	2	6
Electricity, gas & water supply	32	11	17	13	9	3	8	12	7
Non-metallic mineral products	31	27	14	11	0	3	7	0	0

Source: Eurostat New Cronos, 2003

11.4 R&D in the higher education sector financed by industry, in relation to higher education R&D and in relation to GDP 2001



Source: OECD, MSTI, 2003

11.3 Co-operation arrangements on innovation activities in Sweden with universities 2000, in relation to innovative firms, per cent

	Location of co-operating university				
Industry	Universities (Sweden)	Universities (EU/EFTA)	Universities (USA)	Universities (Japan)	Universities (other)
Research and development	73	36	12	2	4
Communication equipment	38	8	8	2	6
Other business activities	31	3	3	-	-
Medical & optical instruments	31	12	6	3	-
Basic metals	30	17	6	-	-
Manufacture of pulp and paper	27	13	2	-	-
Chemicals	26	10	4	1	-
Electrical and optical equipment	26	-	-	-	-
Non-metallic mineral products	22	8	8	-	-
Other transport equipment	21	-	-	-	-
Machinery and equipment, N.E.C.	17	3	1	-	-
Electrical machinery, N.E.C.	16	2	-	-	-
Rubber and plastic products	15	-	-	-	-
Computer and related activities	15	-	3	-	-
Transport equipment	15	-	-	-	-
Manufacturing	15	4	1	-	-
Wood and products of wood	13	-	1	-	-
Services	12	1	1	-	-
Motor vehicles etc.	12	3	3	-	-
Manufacturing, N.E.C.	10	6	-	-	-
Food products etc.	9	9	-	-	-
Office machinery & computers	9	-	9	-	-
Insurance and pension funding	8	-	-	-	-
Fabricated metal products except machinery	7	-	-	-	-
Transport, storage and communication	7	1	-	-	1
Wholesale trade and commission trade	7	-	-	-	-
Textiles and textile products	6	4	4	-	-
Publishing and printing	5	-	-	-	-
Financial intermediation	-	-	1	-	-
Activities auxiliary to financial intermediation	-	-	4	-	-

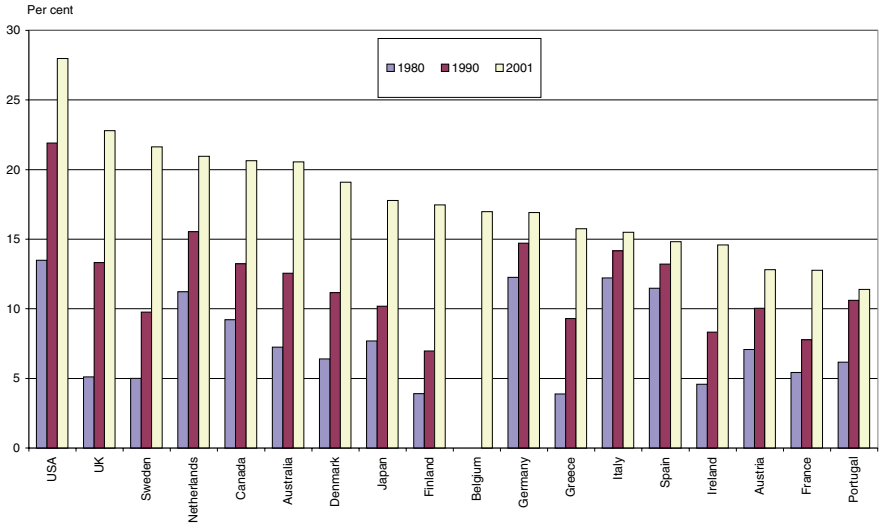
Source: Eurostat, New Cronos, 2003

11.5 Co-operation arrangements on innovation activities in Sweden with research institutes 2000, in relation to innovative firms, per cent

	Location of co-operation research institute				
Industry	Research institutes (Sweden)	Research institutes (EU/EFTA)	Research institutes (USA)	Research institutes (Japan)	Research institutes (Other)
Research and development	41	25	4	2	2
Basic metals	17	6	2	-	-
Other business activities	15	5	3	-	-
Other transport equipment	15	-	-	-	-
Transport equipment	15	-	-	-	-
Motor vehicles etc.	15	1	1	-	-
Medical & optical instruments	13	6	1	-	-
Manufacture of pulp and paper	12	5	-	-	-
Communication equipment	11	-	-	-	-
Non-metallic mineral products	11	-	-	-	-
Manufacturing, N.E.C.	10	6	-	-	-
Insurance and pension funding	10	4	-	-	-
Office machinery & computers	9	-	-	-	-
Chemicals	8	4	3	-	-
Electrical and optical equipment	8	-	-	-	-
Wood and products of wood	8	1	-	-	-
Food products etc.	8	3	-	-	-
Machinery and equipment, N.E.C.	7	5	-	-	-
Textiles and textile products	7	3	-	-	-
Manufacturing	7	2	-	-	-
Services	5	1	1	-	-
Rubber and plastic products	5	-	-	-	-
Computer and related activities	5	-	-	-	-
Wholesale trade and commission trade	2	-	-	-	-
Transport, storage and communication	1	-	-	-	1
Fabricated metal product excp. machinery	1	-	-	-	-
Electrical machinery, N.E.C.	1	-	-	-	-
Financial intermediation	-	-	1	-	-
Activities auxiliary to financial intermediation	-	-	1	-	-
Publishing and printing	-	-	-	-	-

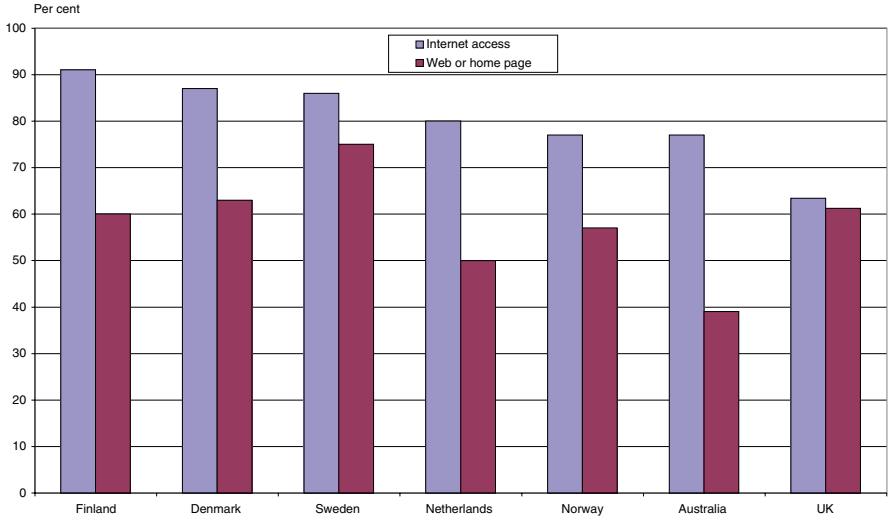
Source: Eurostat, New Cronos, 2003

11.6 Investment in ICT in relation to non-residential fixed capital formation 1980–2001



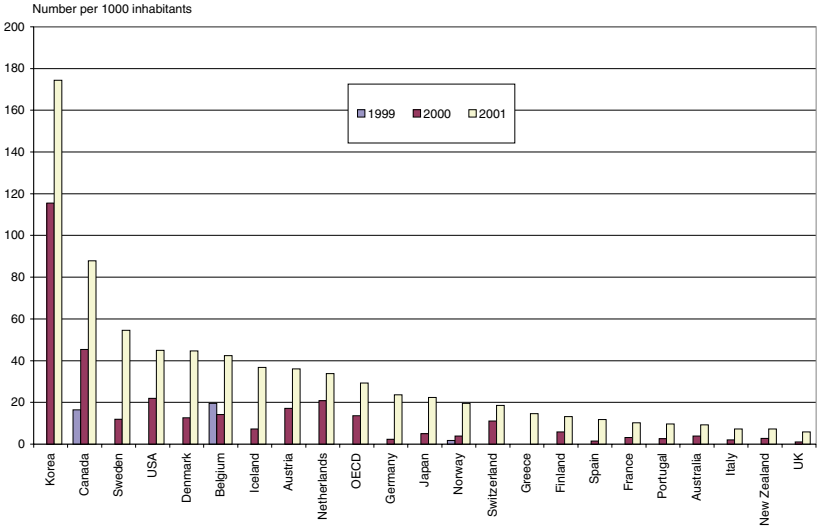
Source: OECD, Science Technology and Industry Scoreboard, 2003

11.7 Percentage of firms with more than 10 employees having Internet and websites 2000



Source: OECD, 2003

11.8 Broadband users per 1000 inhabitants 1999–2001



Source: OECD, Telecommunication database, 2003

V. R&D STRUCTURES AND HUMAN RESOURCES

12 R&D Structures

The Swedish national innovation system is at the top of the OECD rankings in terms of its R&D expenditure and the number of people engaged in R&D. Total Swedish R&D expenditure and R&D man-years increased rapidly in the 1990s and Sweden went from fourth place to the top of the OECD list in terms of its R&D investments in relation to the size of the country. The business sector dominates total Swedish R&D activities and Sweden's rapidly increasing R&D expenditure in relation to its GDP in the 1990s can be attributed solely to the rapid increase in business sector R&D investments. University research expenditure kept pace with the GDP development, while R&D outside the business and university sectors stagnated. The Swedish national innovation system is split into two distinct R&D performing sectors. Industrial R&D concentrates largely on a few large multinational and knowledge-intensive industrial groups, while research outside the business sector focuses mainly on the largest and oldest universities. There is a substantial difference in the relative size of the Swedish R&D system if comparisons are made in terms of R&D expenditure or R&D man-years. This difference reveals important problems with the statistical comparability of R&D statistics in different OECD countries. It should thus be a methodological challenge for the OECD and Eurostat in the further development of data for innovation system comparisons.

R&D expenditure

In international comparison, Sweden is second in the world after Israel in R&D when expenditure is expressed as a percentage of GDP, with total R&D expenditure amounting to about 4.3 per cent of GDP in 2001. Most of this R&D work, about 77 per cent, is carried out by businesses. Compared to other countries, this is a high percentage, only the USA has a comparable business sector share. The OECD average was less than 70 per cent in 2001, figure 12.1.

As shown in part IV, a distinct feature of the Swedish R&D system is its split into two performing sectors, which distinguishes it from most other OECD countries. The system is dominated on the one hand by R&D activities in about ten multinational industrial groups, led by Ericsson and AstraZeneca, and on the other hand by the R&D activities of Sweden's largest and oldest universities. R&D activities in various kinds of public and private R&D institutes are very limited compared with most other countries. The same is true for public R&D activities outside the higher education sector, figure 12.2.

R&D expenditure trends

R&D activities in Sweden have expanded considerably during the last two decades. In the early 1980s R&D increased, followed by a period of stagnation during the latter half of the decade. During the entire 1990s and up to 2001 R&D activities grew at a constant and rapid rate. Among OECD countries, only Finland (and later Israel) reported a more rapid increase during the 1990s.

During both these expansion periods for Swedish R&D, the business sector dominated the expansion. University R&D increased at a steady rate, just ahead of GDP during the entire 1980s, but stagnated during the 1990s. The result is that the entire net expansion of R&D activities during the 1990s was generated by the business sector. R&D performance in other organisations has remained on a low level during the entire twenty-year period, figure 12.3.

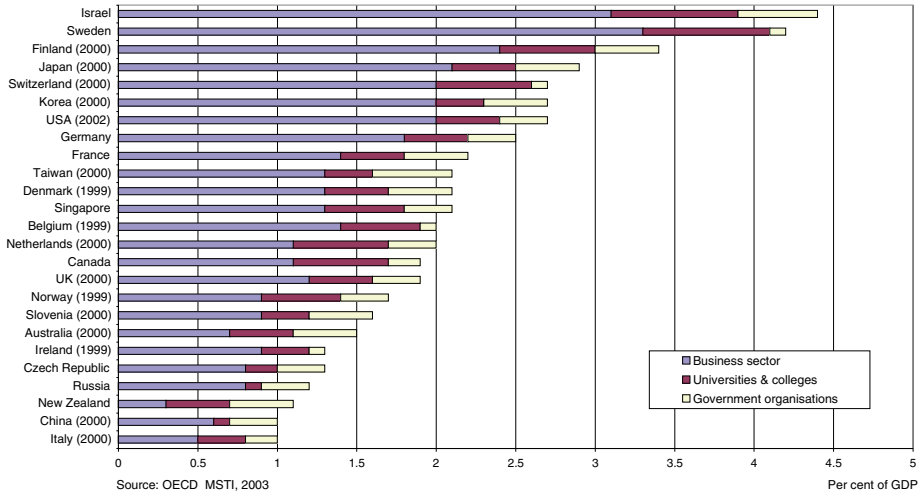
Human resources in R&D

Also in terms of R&D man-years Sweden is fourth in the world in the OECD rankings, in relation to the size of its population. However, the Swedish leadership in the OECD is considerably smaller in terms of the number of people engaged in R&D than in terms of R&D expenditure. In fact, in terms of R&D man-years, Finland and Israel have reported higher business sector R&D activities than Sweden, even though they are far behind Sweden in terms of business sector R&D expenditure, figure 12.4.

The rapid business sector R&D expansion in Sweden in the 1990s can also be seen in terms of R&D man-years, even though the increase in terms of man-years was considerably slower than the increase in terms of expenditure. As a result, the ratio between business sector R&D expenditure and man-years is very high in international comparison. The costs of research man-years in universities are also considerably higher in the Nordic countries, with the exception of Finland, than in all other OECD countries. Finnish research man-years in universities are instead remarkably low in international comparison.

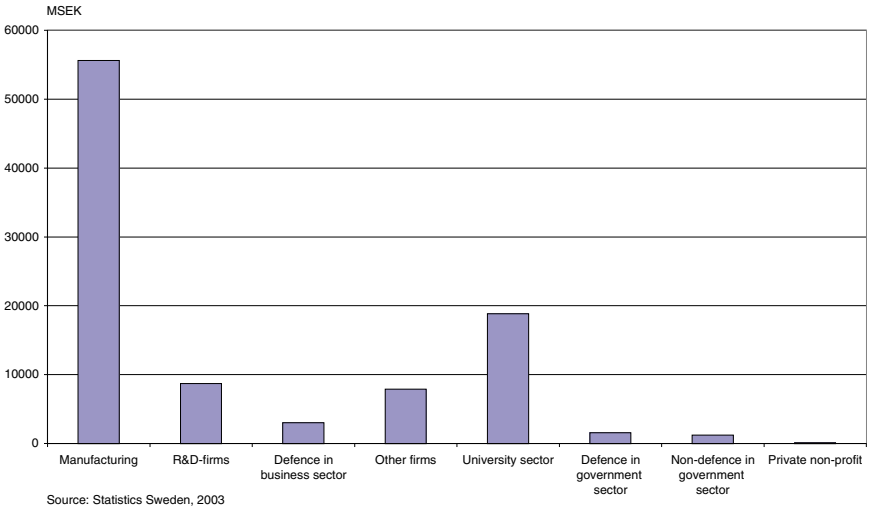
It is highly unlikely that this significant difference in cost-labour ratio reflects real differences between countries. Therefore, the large differences between data on R&D man-years and R&D expenditure in different OECD countries put R&D data quality and comparability at the OECD level in question. This problem should be seriously looked into by the OECD and Eurostat in co-operation with different national statistical agencies.[51]

12.1 R&D expenditure in relation to GDP 2001



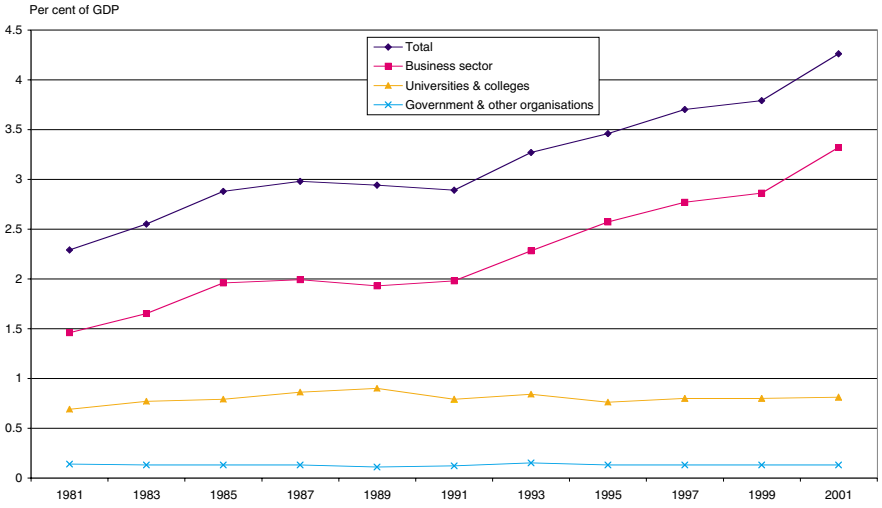
Source: OECD MSTI, 2003

12.2 R&D expenditure in Sweden 2001 by performing sector



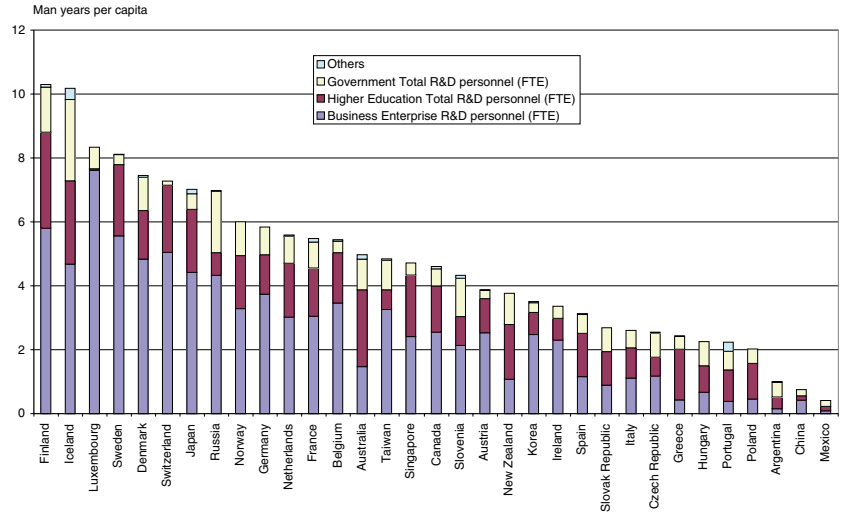
Source: Statistics Sweden, 2003

12.3 Swedish R&D expenditure in different sectors in relation to GDP 1981–2001



Source: OECD MSTI, 2003

12.4 Total R&D personnel (FTE) per capita 2001



Source: OECD MSTI, 2003

13 Human Resources

The Swedish national innovation system is not at the top of the OECD rankings in terms of the number of higher educated people in the population. However, the situation improved considerably in the 1990s and early 2000s. The Swedish education system has increased its focus on higher education and at the same time increased the education rates considerably in recent years. As a consequence, Sweden is now among the leading countries in the OECD in terms of the rate of increase in the total number of higher educated people, higher educated natural scientists and engineers, as well as in terms of the number of PhDs. The majority of those individuals with a higher education and PhDs in the Swedish national innovation system are employed in the public sector. Of these, most have been educated in social sciences or humanities. An overwhelming majority of those with a higher education in natural sciences and engineering, NSEs, are employed in businesses. Business sector employment of NSEs is highly concentrated to knowledge-intensive business services and high-technology and medium high-technology manufacturing firms. SMEs belonging to industrial groups generally have a substantially larger percentage of NSEs on their payroll than independent SMEs. Business sector employment of PhDs has increased substantially in recent decades. PhD employment is highly concentrated to large industrial groups and the PhD-intensity in SMEs belonging to industrial groups is higher than in independent SMEs. This indicates a considerably higher absorptive capacity in SMEs within industrial groups than in independent SMEs. Outside the business sector, universities and technical colleges dominate in terms of NSEs. The general labour market mobility rates are not particularly high in Sweden and the mobility of researchers from the business sector to universities seems to be low.

Importance of higher educated human resources

The knowledge and competence of individuals are the most important resources in innovation. The availability of competent individuals to a large extent determines the innovation capacity of innovation systems. Therefore, the volume, distribution and flows of human resources are important for the performance of innovation systems.[52]

The distribution and intensity of higher educated workers within different industries should be important determinants for the absorptive capacity for new knowledge in the firms in these industries. Research competence is a particularly important capacity in relations between firms and the science-producing system. The mobility of human resources can be considered as an important factor for knowledge transfer, both within and between sectors.[53]

Percentage of higher educated people in the population

In terms of the percentage of total population with at least a theoretically based tertiary education, Sweden is ranked twelfth in the OECD's list. It should be noted that the Swedish education system has historically been less geared towards theoretical higher educations than several other OECD countries.[54] Therefore, Sweden would be considerably more competitive in human resources terms if tertiary educations of a practical or vocational nature were included. In terms of the percentage of tertiary graduated NSEs of the total number of graduates from tertiary education, Sweden is more competitive and is ranked third by the OECD. Leading countries in this respect are Korea and Germany, figures 13.1 and 13.2.

In terms of the total numbers of new university degrees in relation to the population size, the Swedish performance has improved substantially in the last two decades, particularly within the field of engineering. This is partly a consequence of structural changes of the engineering education system, marked by a shift towards longer programmes of study, which can more closely be compared with international standards for higher education, and partly a result of a volume expansion of higher education, with a rather strong focus on the field of engineering.

The Swedish national innovation system has in the past decade achieved a significant improvement in performance in terms of generating new research graduates. In terms of research graduates between 25 and 34 years of age, Sweden is at the top of the OECD rankings. This indicates that Sweden is taking active steps to build a foundation for future research competence in the national innovation system. This is a consequence of increasing examination pass rates in the Swedish university system in recent years. Sweden is particularly competitive in terms of the number of people with new PhDs in engineering and less competitive within natural sciences.

Distribution of higher educated people in the economy

A large proportion of those employed people in Sweden who have completed a tertiary education, 78 per cent, are educated in social science, humanities or in some other field than natural science or engineering. About 55

per cent of the higher educated workers in Sweden are employed in the public sector and about 45 per cent in the business sector. In the public sector, a large majority of those with a higher education have studied social science or the humanities, while NSEs are in majority, 59 per cent, in the business sector.

In 2000, 145,194 employees in Sweden were higher educated NSEs, which represented 22 per cent of the total stock of higher educated employed in the Swedish economy. A large majority of these, 83 per cent, were employed in businesses, about 6 per cent in the higher education sector, 1 per cent by other services, while about 10 per cent were employed in public authorities and other non-business organisations. The largest NSE-employing sector in the Swedish economy is that of KIBS firms. In 2000 about 42 per cent of the NSEs employed in firms were employed in knowledge-intensive business services (KIBS), which was considerably more than in manufacturing industry, where 33 per cent of the NSEs were employed,[55] figure 13.3.

Within the business sector, KIBS are also clearly the most NSE-intensive of all industries. The highest knowledge intensity is shown by R&D firms. In manufacturing, the high-technology and medium high-technology industries dominate NSE employment. These industries are also considerably more knowledge-intensive than other manufacturing industries in terms of the percentage of NSEs. There is thus a close correspondence between the high-technology manufacturing classification by the OECD, based on R&D intensities, and the knowledge intensity measured in terms of NSE employment, figures 13.4.and 13.5.

Knowledge-intensive SMEs in services generally have a higher NSE-intensity than manufacturing SMEs. SMEs belonging to industrial groups generally have a substantially higher percentage of NSEs than independent SMEs. This indicates a considerably higher absorptive capacity for SMEs within industrial groups than in independent SMEs. However, there is a considerable number of very small independent SMEs run by NSEs, particularly in KIBS-industries. These firms should be of considerable interest to innovation policy.

Distribution of research graduates in the economy

The total number of PhDs and licentiates employed in the Swedish economy in 2000 was 36,097. The majority of these were employed in the non-business sector, primarily in universities. In the business sector, the majority of PhDs were employed in KIBS firms. In the late 1990s, the number of PhDs in the business sector increased considerably. From a relatively stable percentage of around 35 per cent of total employment of PhDs in the 1980s and early 1990s, the business sector share of PhDs increased to 45 per cent in 2000, figure 13.6.

In the manufacturing sector, high-technology and medium high-technology industries dominate employment of PhDs. The majority of the PhDs in manufacturing industry are employed in the telecommunications, instrument, transport equipment, pharmaceutical and machinery industries. In the service sector, KIBS industries dominate PhD employment. A large percentage of the overall number of PhDs employed in services work for R&D firms, figures 13.7, and 13.8.

An overwhelming majority of all PhDs in the business sector are employed by large firms. Of the overall business sector employment rate for PhDs in 2000, large firms accounted for 71 per cent. Moreover, the concentration to industrial groups is even stronger than for higher educated NSEs.

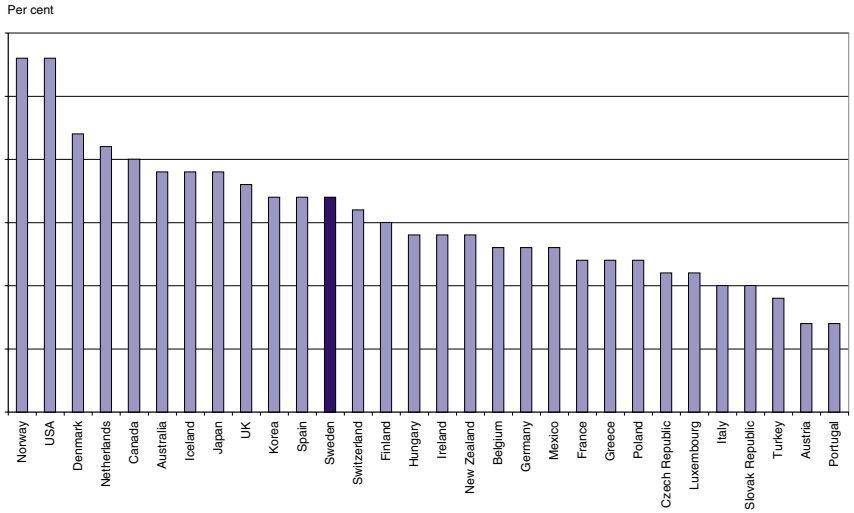
Human resources mobility

Swedish labour market mobility shows a relatively low rate of inter-firm job mobility by international standards. About 5–10 per cent of employees change employers once a year and the average employee spends 10.5 years in the same job. This may be a consequence of Sweden's relatively strict employment protection legislation, which may stimulate employees to stay in their jobs, because of the resultant loss of job protection associated with mobility.[56] It should also be noted that there has been a sharp decline in inter-firm job mobility by older employees. This reveals some important structural and incentive rigidities in the Swedish labour market that tend to lock older employees into rather fixed positions on the labour market.[57]

A comparison of mobility patterns between Sweden, Finland and Norway shows quite similar general patterns of human resources mobility. In general, internal flows within the same sector are considerably larger than flows between sectors. One difference between the Nordic countries is a wider sectoral distribution of the flows of higher educated employees in Sweden than in Finland and Norway. This is a reflection of the larger Swedish manufacturing sector, from which substantial mobility rates have developed in recent decades. However, in relative terms, considering the structural differences between the three countries, there are strong similarities in terms of the distribution and mobility of higher educated employees within the three national innovation systems.[58]

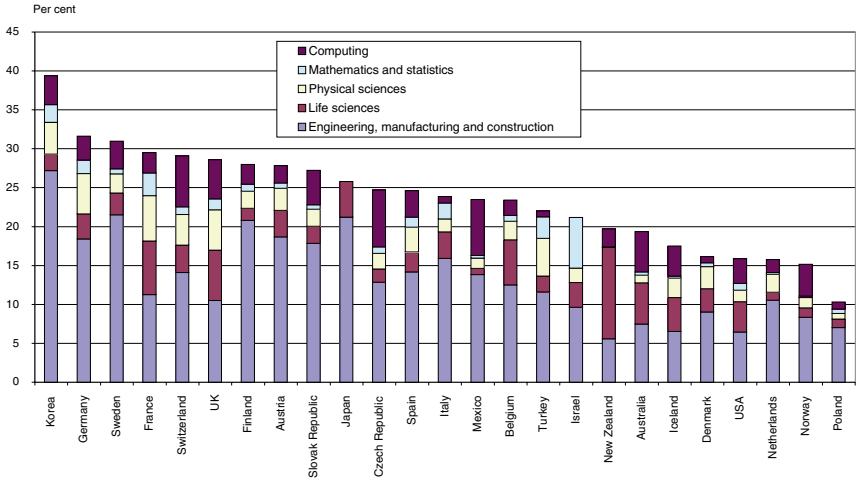
A special study of the return mobility to universities of research graduates that were employed at universities three years after their PhD examination shows rather low figures. Of all PhDs employed at a university in 1993 and with a PhD degree from 1990 within natural science or engineering, about 10 per cent went back to work in universities some time during the period 1994–2000.[59]

13.1 Percentage of active population, 25–64 years old, with a tertiary education 2002



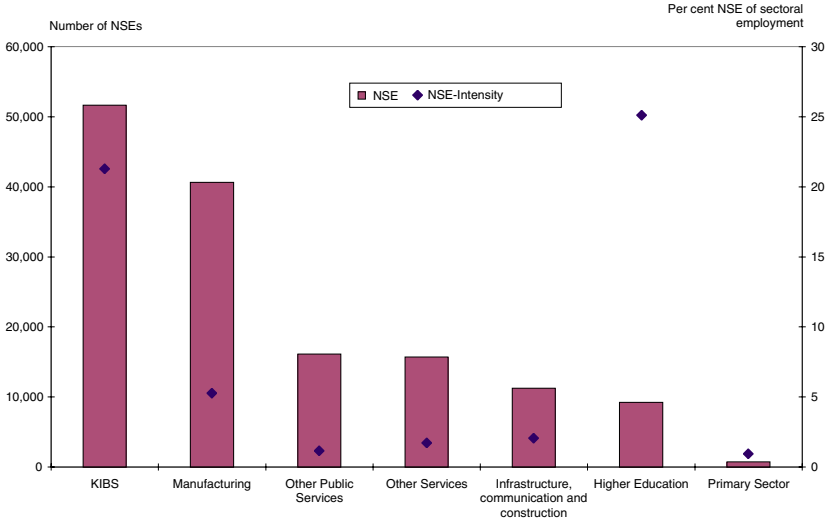
Source: OECD, Education at a Glance, 2003

13.2 Percentage of tertiary educated NSE of total tertiary educated 2001



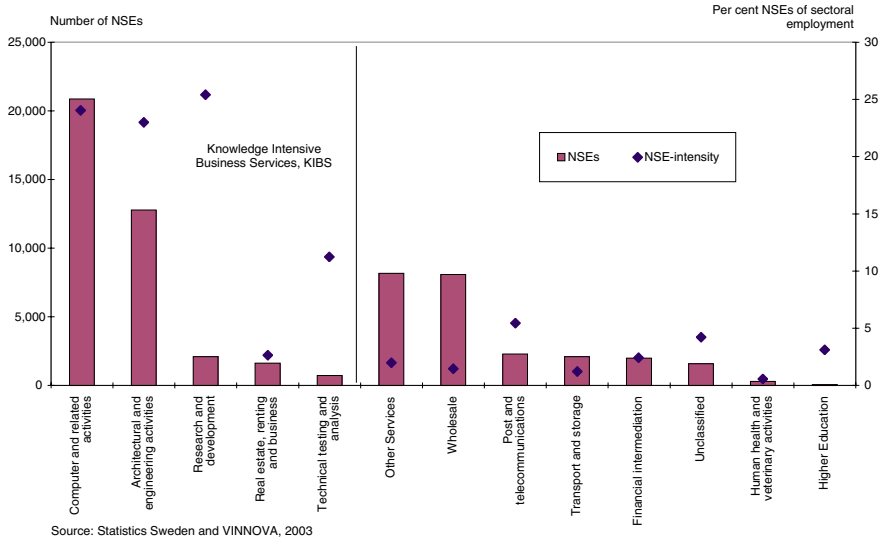
Source: OECD, Education at a Glance, 2003.
Comment: In the case of Japan, the category life sciences also includes those educated in physical sciences, mathematics and statistics, and computing. In the case of Israel, the category mathematics and statistics also includes those educated in computing.

13.3 NSEs and NSE-intensity in the Swedish economy 2000



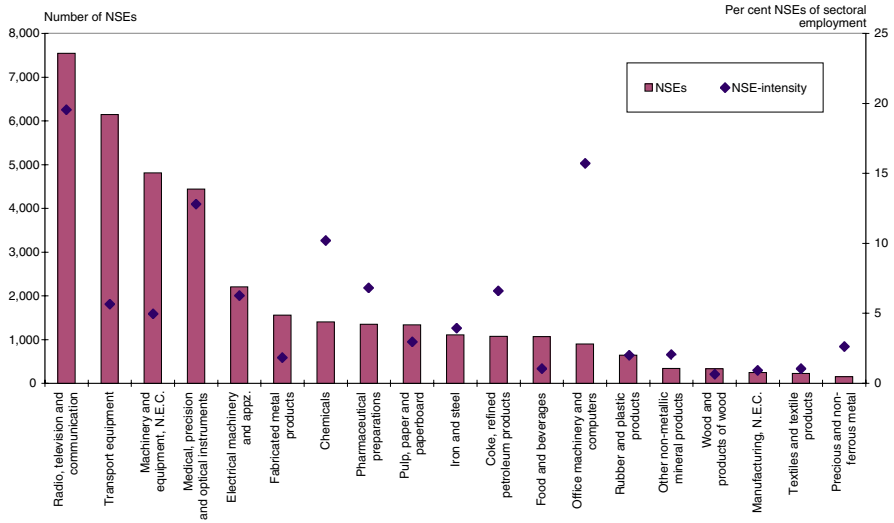
Source: Statistics Sweden and VINNOVA, 2003

13.4 NSEs and NSE-intensity in different service industries 2000



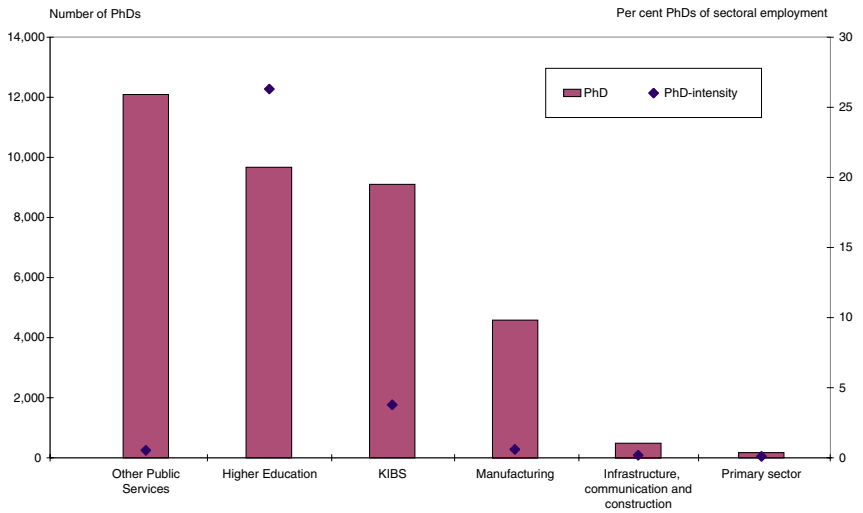
Source: Statistics Sweden and VINNOVA, 2003

13.5 NSEs and NSE-intensity in manufacturing industries 2000



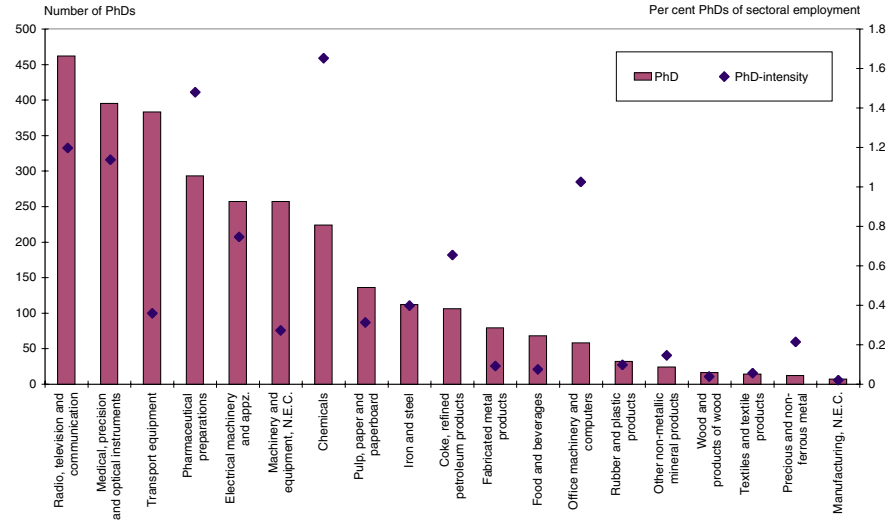
Source: Statistics Sweden and VINNOVA, 2003

13.6 PhDs and PhD-intensity in the Swedish economy 2000



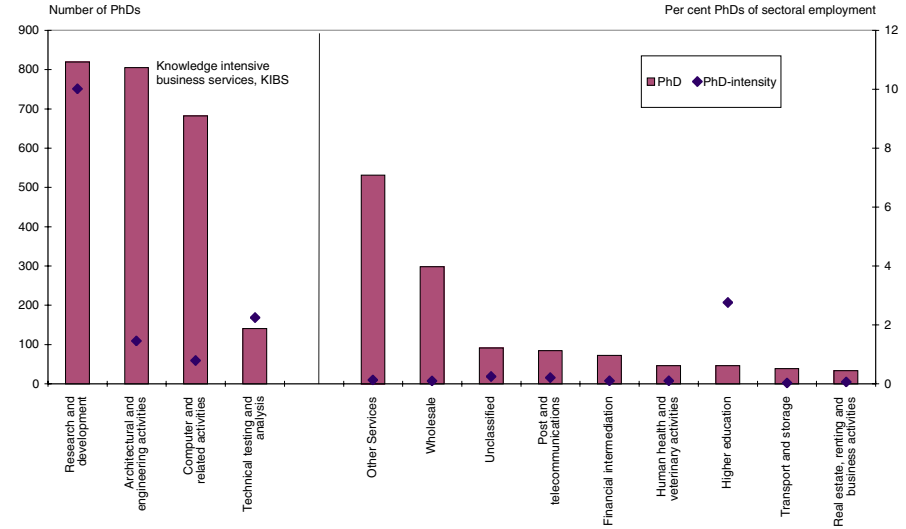
Source: Statistics Sweden and VINNOVA, 2003

13.7 PhDs and PhD-intensity in manufacturing industries 2000



Source: Statistics Sweden and VINNOVA, 2003

13.8 PhDs and PhD-intensity in different service industries 2000



Source: Statistics Sweden and VINNOVA, 2003

VI. FINANCING AND INCENTIVE STRUCTURES

14 Financing of R&D

R&D financing in the Swedish national innovation system is dominated by the business sector. Business sector R&D financing is dominated by a small number of large multinational manufacturing industrial groups with a large R&D base in Sweden. As a consequence of the rapidly increasing R&D expenditure in the Swedish business sector in the 1990s, the Swedish share of business sector R&D financing is the highest in the OECD. Accordingly, Swedish public sector R&D financing represents a small proportion of total R&D financing in Sweden by international standards. However, in relation to GDP, Swedish public sector R&D financing is high by international standards. Swedish public sector R&D financing is heavily focused on curiosity-driven university research. Financing of mission-oriented research decreased considerably during 1970–2003.

Total financing of R&D

Most R&D activities carried out in Sweden are financed by the business sector. The same is true for most OECD countries, but the share of business sector financing is particularly high in Sweden. Only Japan and Korea have a higher proportion of business sector R&D financing.

If R&D activities carried out abroad but financed from Sweden are taken into account, a more complete picture of the financing structure is obtained. Of all Swedish-based financing of R&D activities, whether carried out inside or outside Sweden, the Swedish business sector finances 77 per cent. This is primarily financing of R&D activities carried out in the business sector in Sweden. However, more than one quarter of the R&D financing from the Swedish business sector goes towards financing R&D activities abroad. Only a little over one per cent of total business-financed R&D goes towards R&D at Swedish universities and colleges, figure 14.1.

The Swedish public sector represents 18.5 per cent of all R&D financed by Swedish sources and 21 per cent of all R&D activities carried out in Sweden. This is primarily financing research at Swedish universities and colleges. However, about one fifth goes towards financing business sector R&D. Most of this concerns defence-related R&D activities carried out by large multinational industrial groups in Sweden.

Business sector R&D financing

Business sector R&D financing increased rapidly in the 1990s and generated virtually all of the net increase reported in the rapidly growing business sector and total R&D performance in Sweden since 1991. This led to Sweden advancing from fifth place in 1981 to third place in 1991 and later to second place in 2001 in OECD's rankings for total R&D financing in relation to GDP, figure 14.2.

In the process, the proportion of business sector financing of total R&D activities carried out in Sweden rose from 55 per cent in 1981 to 62 per cent in 1991 and 72 per cent in 2001. The corresponding proportions for government financing of R&D decreased from 42 per cent in 1981 to 34 per cent in 1991 to 21 per cent in 2001.

During 2002 and 2003 two of Sweden's leading players in R&D, Ericsson and ABB, radically reduced their R&D investments, due to severe financial problems. Other industrial groups in Sweden seem to have kept their R&D levels relatively constant. This reduced total business sector R&D investments by about 8.5 per cent, with the result that Swedish business sector R&D expenditure in 2002 fell from 3.3 per cent of GDP in 2001 to about 3.0 per cent of GDP in 2002. The reduction of R&D resources continued in 2003 and will continue in 2004, and this, in turn, is expected to lead to further reductions in overall Swedish business sector R&D in the near future.

Engineering research in universities and R&D institutes will be particularly affected by this process, since their dependence on business sector financing is considerably higher than is the case for research in other scientific fields, figure 14.3.

Public sector R&D financing

As noted above, Swedish government R&D financing represents a relatively small proportion of the overall financing of R&D activities in Sweden, about 21 per cent. However, since overall R&D expenditure in Sweden is large in international comparison, the relatively small proportion of public shares of total financing nevertheless represent quite high levels in relation to GDP, figure 14.4.

In fact, despite a rather stable, and even declining, level of governmental R&D financing in relation to GDP in Sweden 1981–2001, Sweden advanced from sixth to second place in the OECD rankings in terms of governmental R&D financing. The reason for this is that most countries showed stagnating or declining levels of government R&D financing in relation to GDP during the period 1981–2001. Finland and Israel were the major exceptions, with rapidly increasing levels of governmental R&D financing. However, analysis of government budget data shows that Sweden has in recent years been passed by the USA, Finland and France in terms of total governmental R&D financing in relation to GDP.

Purpose of government-financed R&D

In Sweden, about 85 per cent of all publicly financed research is performed within universities. Only

Switzerland and Turkey show similarly high rates. Other OECD countries are far from the Swedish concentration of public research resources to the universities. And, Japan, the USA and France put almost as much public research resources outside as inside the universities. This pattern of the Swedish research system is part of the explanation behind the scientific performance of the Swedish research system, measured in terms of scientific publications. Swedish public research resources are heavily focused on investments in such research that leads to international publications and, thereby, to academic careers for the researchers.[60]

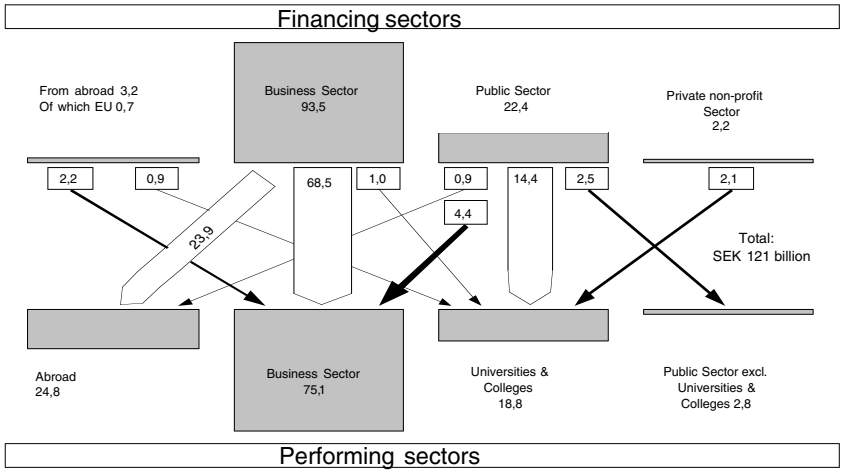
Despite the relatively large governmental R&D investments in Sweden, mission-oriented, or strategic, research investments are quite small in international comparison. Thereby, the percentage and volume of governmental R&D funding devoted to economic development is low in international comparison. Governmental research investments are dominated by basic university funds aimed at general advancement of knowledge through research in universities and colleges. This also explains the internationally high share of university research in Sweden, figure 14.5.

Private non-profit R&D financing

Apart from the Government, semi-public or private non-profit research foundations are quite important financers of R&D in the Swedish R&D system. Particularly important among these are the wage-earner funds, but also some major private research foundations. The research foundations' financing of R&D in Sweden amounts to approximately SEK 1.5 billion per year, which corresponds to about 0.08 per cent of GDP in Sweden. This means that they represent about 10 per cent of the total volume of R&D financing from public, semi-public and private non-profit sources.

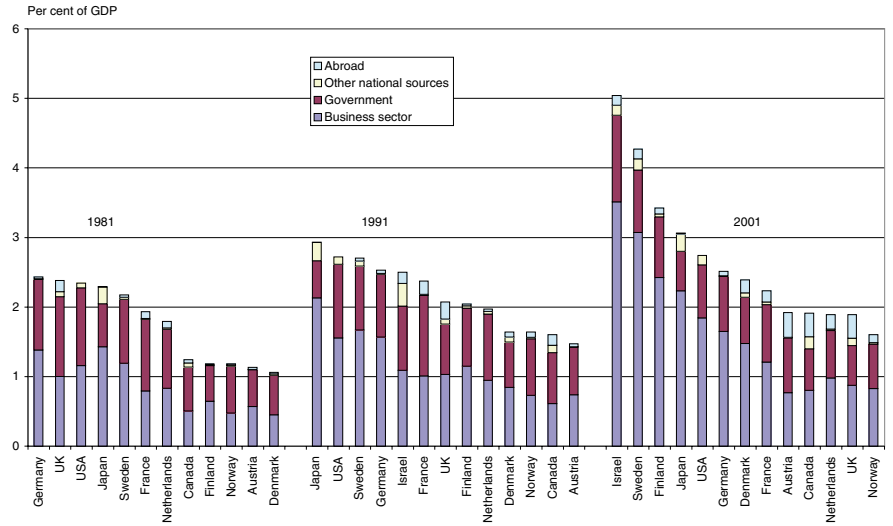
Private non-profit R&D financing in Sweden is primarily used for financing different kinds of mission-oriented R&D. Even if the figures for semi-public financing are added to the overall figures for governmental financing, total publicly and semi-publicly financed civilian mission-oriented R&D in Sweden have still fallen in the 1990s. It did not keep pace with the moderately increasing governmental financing of general scientific development. Nor has it kept pace with the governmental resources invested in mission-oriented R&D in other countries, figure 14.6.

14.1 R&D in Sweden by financing and performing sector 2001 (SEK bn)



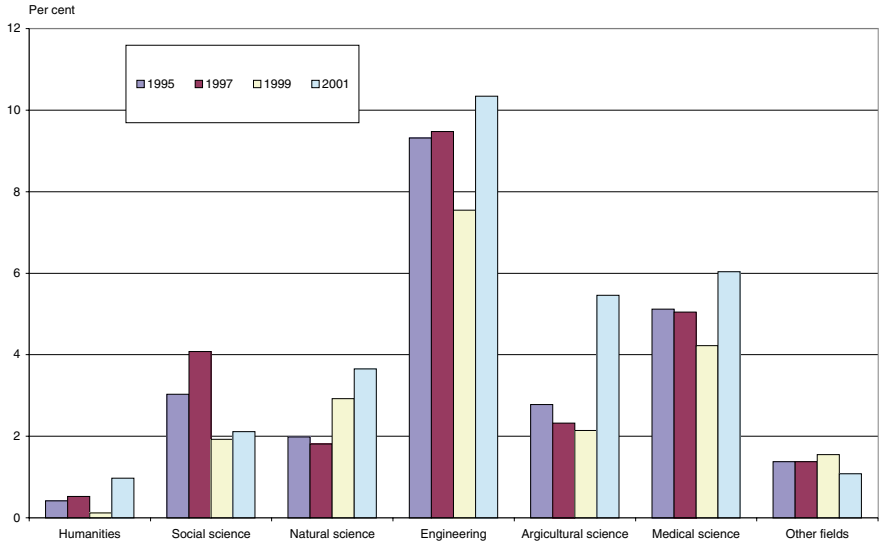
Source: Statistics Sweden, 2003

14.2 R&D financing in relation to GDP 1981–2001



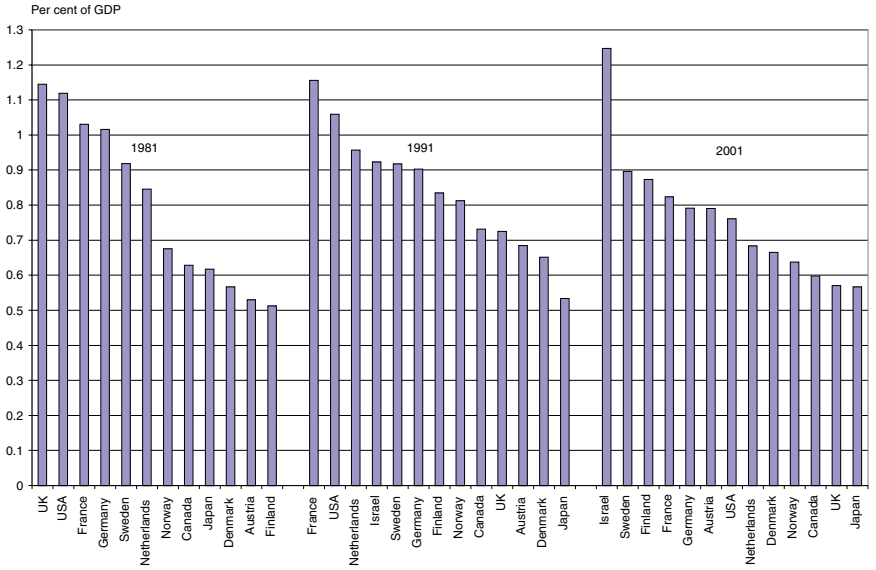
Source: OECD, MSTI, 2003

14.3 Business R&D funding of different research fields 1995–2001



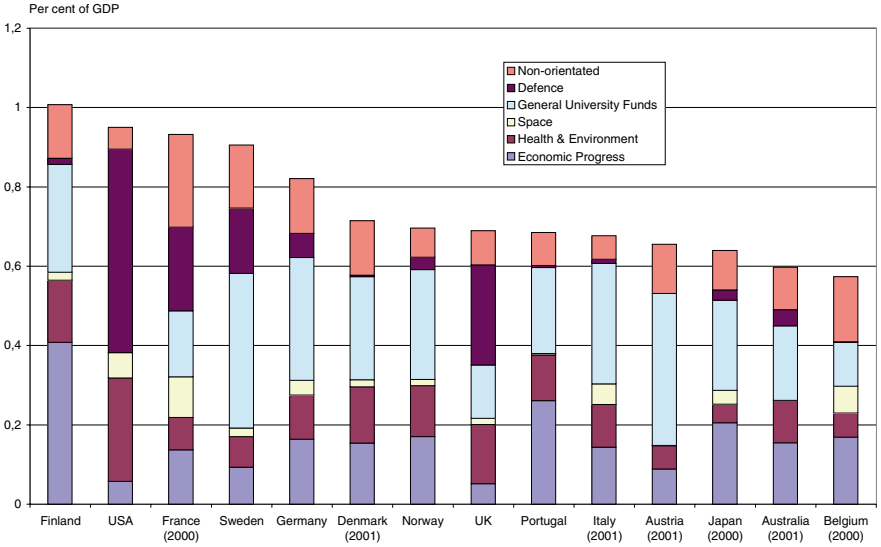
Source: Statistics Sweden, 2003

14.4 Government-financed R&D in relation to GDP 1981–2001



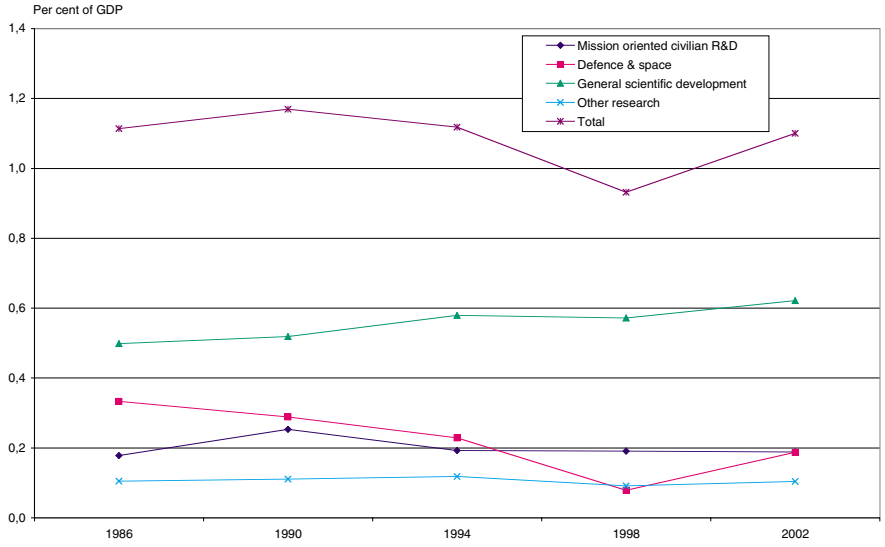
Source: OECD MSTI, 2003

14.5 Governmental R&D financing in relation to GDP 2002



Source: OECD MSTI, 2003

14.6 Governmental and semi-public research foundation R&D financing in Sweden 1986–2002



Source: Statistics Sweden, 2003

15 Seed-financing and Venture Capital

The Swedish national innovation system was for most of the period 1970–2003 characterised by an underdeveloped venture capital and seed-financing market. It has only very recently attracted substantial volumes of capital. It is, however, still characterised by institutions that have not yet fully matured and the actors are still developing in terms of competence and structures. The pre-seed and initial seed-financing stages present a great innovation policy challenge in all countries. Because of the very high risks involved in the initial stages of start-up commercialisation, there is generally a significant market failure related to this stage of the innovation process. Since the public benefits from a high flow of potentially high value-adding, new knowledge-based firms, public pre-seed and early stage commercialisation financing is an important part of efficient innovation systems. Such financing has been very limited in Sweden in the period studied and in recent years it has fallen to extremely low levels.

Total venture capital and seed-financing

Venture capital and seed-financing increased rapidly in the 1990s in most OECD countries. Sweden was among the countries that experienced the most rapidly increasing volumes of venture capital. In many countries, venture capital started to decrease in the early 2000s, particularly in the USA and Iceland. In 2002, the Swedish venture capital market was the largest in the OECD, in relation to GDP, figure 15.1.

This was a considerable improvement compared to the mid-1990s, when Sweden's international position was much worse. Before the second half of the 1990s, the Swedish venture capital market was quite small and institutionally underdeveloped, figure 15.2.

Early stage seed-financing

A quite small but increasing proportion of the Swedish venture capital market focuses on early stage financing, while the majority focuses on expansion stages. However, early stage venture capital is nevertheless relatively high in Sweden. The latest available data reveals that a comparatively small proportion of the venture capital in Sweden is directed towards high-technology areas, figure 15.3.

Pre-seed financing

The level of high-risk pre-seed financing, based on different kinds of grants, rather than ownership principles, has in most countries increased at a considerably slower rate than the venture capital market. Since private capital is generally reluctant to finance the initial stages of the commercialisation process in start-up ventures, there is generally a significant market failure rate at these stages. A substantial part of such seed-financing is in most countries provided by public sources. The Swedish national innovation system does not seem to have been particularly well equipped with public pre-seed financing mechanisms.

Further, such high-risk pre-seed financing actually declined and virtually disappeared in the early 2000s, which has considerably worsened Sweden's international performance in terms of investments in the initial stages of the start-up commercialisation processes,[61] figure 15.4.

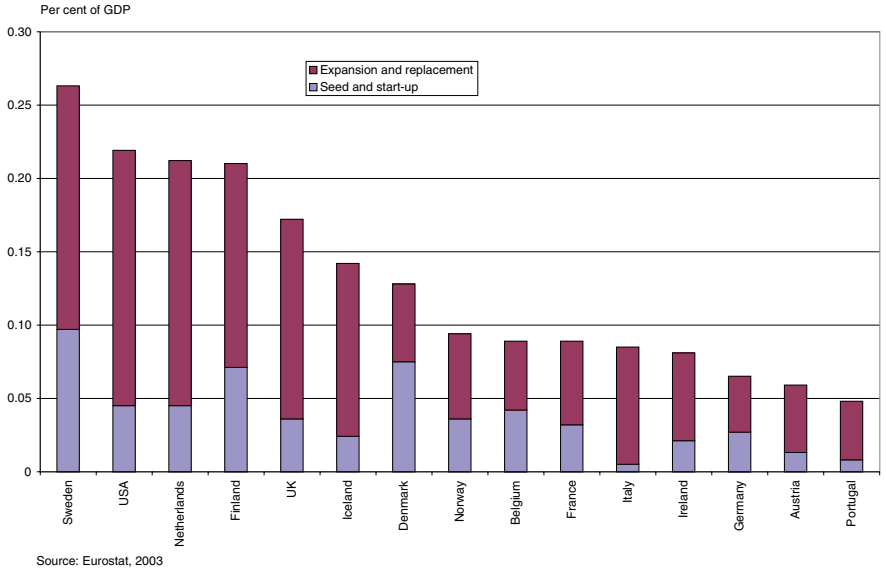
Incubators, science parks and university spin-off organisations

The Swedish support structure for stimulating the commercialisation of R&D through start-ups and the growth of such firms is fragmented, nationally and regionally. The Swedish university sector has shown a general inefficiency in promoting spin-offs of research-based firms. Moreover, the numerous organisations that focus on similar or related issues often lack a critical level of financial resources, relevant business competence and a highly professional organisation.[62]

On the public side of this support, a general lack of national and regional structures for stimulating the early steps towards commercialising R&D-based inventions has been an important weakness. Thereby, a loosely connected structure of technology and science parks has evolved, for which the financial resources, business competence and national co-ordination and support have failed to reach critical mass.

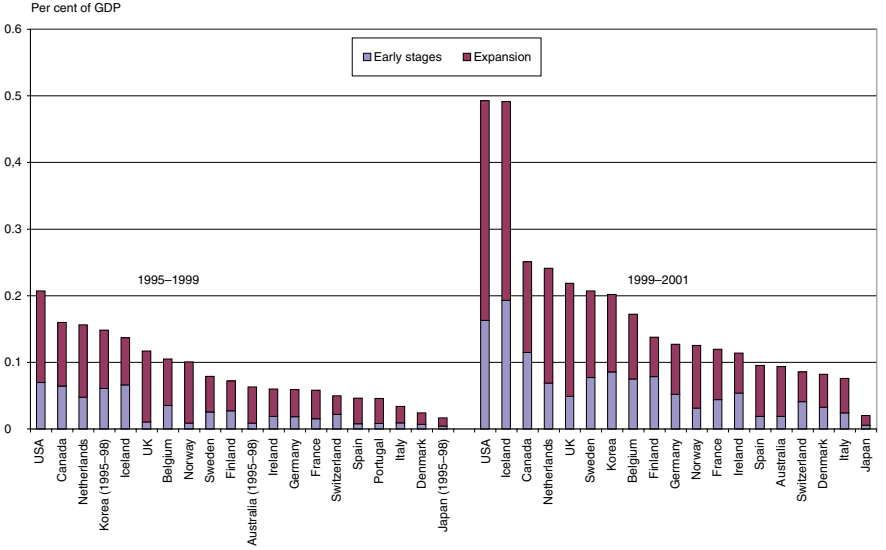
Swedish universities, with a few exceptions, have not developed professional structures and organisations for stimulating the commercialisation of university research. Moreover, the Government has not allocated any substantial funding for such activities at or around universities, though universities have been urged to engage in activities that would make use of research results for the benefits of society. However, as shown in chapter 6, university spin-offs have not been a major source of new technology-based firms in Sweden. And, it does not seem that the Swedish university sector has been particularly efficient in generating knowledge-based firms, compared to other countries.

15.1 Venture capital in relation to GDP 2002



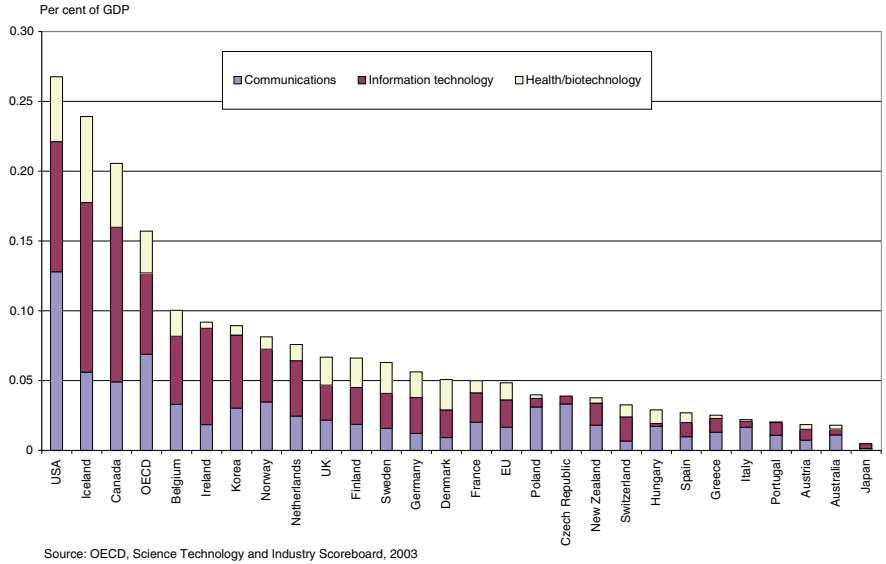
Source: Eurostat, 2003

15.2 Venture capital in relation to GDP 1995–1999 and 1999–2001



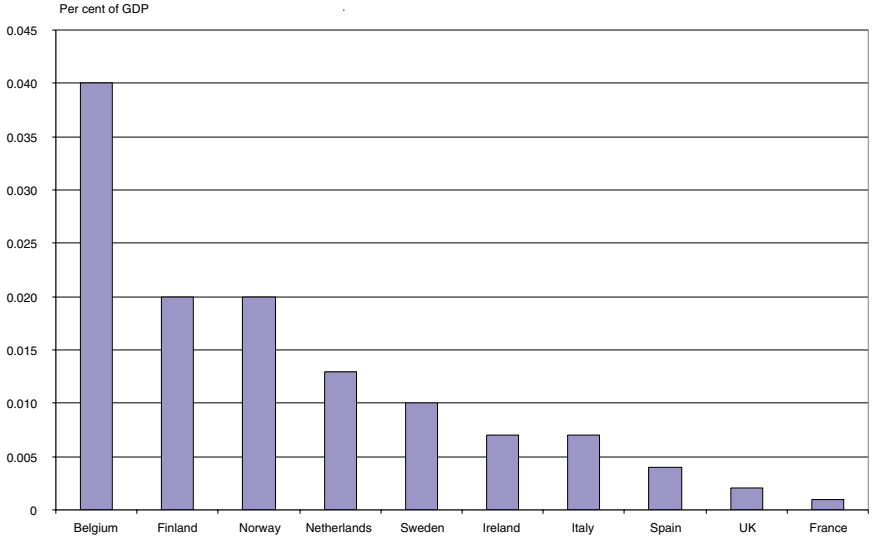
Source: OECD, Science Technology and Industry Scoreboard, 2003

15.3 High-tech venture capital in relation to GDP 1999–2001



Source: OECD, Science Technology and Industry Scoreboard, 2003

15.4 Supply of government funds to the VC industry in relation to GDP average 1989–1999



Source: Manigart & Beuselinck, "Supply of venture capital by European Government", 2001

16 Incentive Structures

During the period 1970–2003, the Swedish national innovation system primarily generated incentive structures that were favourable to productivity improvements and growth in large manufacturing groups. The knowledge-intensive Swedish manufacturing industry has been spurred to continuously rationalise production processes. General tax structures, wage structures, public attitudes and public-private partnerships have all been stimulating to large firm capital accumulation and growth in Sweden. General incentives for starting firms and generating SME growth in Sweden have been much weaker. Moreover, the pre-seed and initial seed-stage financing of R&D-based start-ups has remained low and even declined in Sweden in recent years. The general incentive structures in the publicly funded – and to a large extent university-based – Swedish research system do not provide strong incentives for knowledge interaction and learning between university researchers and businesses, public sector services or between different university departments, within or between different universities.

Macroeconomic conditions

To a large extent, general macroeconomic conditions determine the general business climate, which, in turn, influences the innovation climate in national innovation systems. There are several links between general macroeconomic conditions and innovation incentives. Three major links of this kind are public deficits, inflation and interest rates.

Swedish public deficits were relatively high compared to many other OECD countries in the 1980s. In the 1990s, Swedish public deficits rose, as in all other OECD countries, due to the economic crisis in the early years of the decade. However, Swedish public deficits rose rather rapidly in international comparison. In the early 2000s, Sweden has improved its budget balance considerably and more efficiently than most countries, figure 16.1.

The Swedish inflation rate followed average international levels in the 1970s, which in most countries meant very high levels compared to the present situation. In the 1980s and the early 1990s, the Swedish inflation rate was high in international comparison, although declining in line with the general international trend. In the late 1990s and the early 2000s, Sweden's inflation rate was in line with the inflation rate in most other OECD countries, as a consequence of a purposeful policy to reduce inflation, figure 16.2.

For most of the period studied, Sweden's real interest rates were on a par with the OECD average. In the 1970s, international real interest rates were low or even negative, due to high inflation rates in most countries. Real interest rates rose considerably in the 1980s and the 1990s and have been relatively high in Sweden. Compared to increasing stock market values however, the interest rate has been low in the past decade, which has stimulated increased savings in stocks and shares,[63] figure 16.3.

The exact impact of the macroeconomic conditions and the macroeconomic development are difficult to analyse in detail, since they simultaneously influence numerous interrelated economic factors. However, some general observations can be made. Firstly, the substantial macroeconomic imbalances in the Swedish economy that were generated in the 1980s and which had roots dating back to the 1970s, had a major influence on overall Swedish economic activities both in the 1980s and in the 1990s. Secondly, a major feature of the macroeconomic situation in the 1980s was one of increasing public debts and subsequent devaluations of the currency to improve industrial competitiveness. Thirdly, a severe economic crisis in the early 1990s cleared out many of the least productive production units in the Swedish economy. Finally, a purposeful and efficient Swedish public budget policy in the 1990s has strengthened the Governmental budget and contributed to low inflation and interest rates.[64]

From these observations, a few hypotheses can be raised regarding the incentive impacts of these macroeconomic developments on innovation and economic renewal patterns in Sweden. Firstly, it is likely that different industrial policy and macroeconomic stimulations in the 1980s, such as sectoral subsidies, currency depreciation and increased public spending contributed to a slowdown of innovation rates and economic renewal in Sweden. Secondly, the long-term instability of the macroeconomic situation may have tended to favour and encourage entrepreneurship in financial activities and industrial restructuring rather than entrepreneurial activities that focused on generating new value through innovation activities.

Finally, the radically improved macroeconomic situation in Sweden in the late 1990s and the early 2000s has been an important step towards building a strong platform for a successful innovation and growth policy in Sweden.[65]

Company taxes and regulations

Swedish tax structures have been particularly favourable to large-firm capital accumulation and growth in Sweden. Company taxes have been low in international comparison, which was based on a policy aiming to generate strong incentives to re-invest capital in the firms, in order to stimulate further innovation and growth in established firms. In line with this policy, taxes

on dividends to shareholders have been high, as have personal income taxes,[66] figures 16.4 and 16.5

Moreover, taxes related to new firm start-ups and the initial stages of small firm development should have generated considerable disincentives to start-up ventures. Swedish tax rules related to closely-held firms are particularly unfavourable to fast-growing firms.[67] Despite some recent improvements, the risk reward for starting and growing new firms in Sweden is still relatively unfavourable to such entrepreneurial ventures. On the other hand, bankruptcy rules have been modified and now involve considerably lower personal risks.

Still, general attitudes in Sweden seem to be the most sceptical in Europe towards risk-taking and the most critical to entrepreneurs who have failed.[68] The problems with taxes related to start-ups and early stages of SME growth are now widely recognised and proposed to change. Some measures have also been taken towards such changes,[69] although no new comprehensive tax structure design has yet been presented for and discussed in the Parliament.

As a result, the general Swedish tax incentive structures should have favoured capital accumulation in large established firms, rather than capital investments in start-ups and new ventures. While this should have been an efficient method of promoting growth in the existing industry, it should have generated tendencies of technological and industrial lock-in effects, which may be hampering to radical innovation and industrial renewal.

There is reason to believe that the incentive structures generated by this tax system were adequate and efficient in periods with relatively slow renewal and structural change, but that it might be less adequate for a situation which requires greater innovation rates and structural renewal in which start-ups and SME growth should become more important.[70]

Further, the Swedish regulation structures have probably generated relatively weak incentives for start-ups and SME growth, although considerable improvements have been achieved in recent years.[71] Given that large firms have much larger administrative resources than SMEs, the Swedish regulation structures should not have generated particular disincentives for large firm industrial activities in Sweden.[72]

Labour market incentives

Another important incentive structure in the Swedish national innovation system has been the relatively high low-wage profile and low salary spread on the Swedish labour market. As a consequence of the breakdown of the central salary negotiations in 1983, the salary spread has increased considerably in Sweden. However, the Swedish salary structure is still highly concentrated in international comparison.[73]

This has been the result of a long-standing principle, based on the Rhen-Meidner model for salary development, established in the 1960s, which has since been adopted as a basic profile of labour market agreements between employer organisations and labour unions. This model was particularly important in the first half of the period, but also continued to influence Swedish labour market negotiations in the later part of the period.[74]

A condition for the application of this model was centrally co-ordinated salary negotiations. Sweden has a tradition of an exceptionally high degree of union participation among both blue-collar employees and white-collar staff, as well as a high degree of employer membership in the central employer organisation. Therefore, the labour market organisations have not only had a vested interest in, but also to a large extent been carriers of, the Swedish labour market, which thus have been characterised by a high degree of corporativism.[75]

As a consequence of these labour market structures, the incentives to focus on high rates of process innovations have generally been strong in Swedish industry. As a result, Swedish manufacturing industry has been characterised by high labour productivity, based on highly competitive production processes and organisation. This kind of restructuring pressure on Swedish industry was also intended by the architects of this wage policy. While it has been highly effective in generating an efficient flow of manufacturing process innovations, it may not have been as efficient in stimulating product innovation investments in Swedish industry.[76]

Innovation investment incentives

Direct R&D-related incentives in terms of tax credits for R&D costs have not been present in the Swedish national innovation system since 1983, when such a system was abolished. The reason for the abolition of this system was that international evaluations indicated a very low impact on real net R&D investments in businesses.[77] Also, since the tax credit could only be claimed by firms with a taxable income, the system discriminated against new start-up firms. Despite the absence of a direct tax credit, tax deductions are in any case possible in firms with large turnover and significant total investments, which to a certain extent permit tax deduction.

Another important set of incentive structures in the Swedish national innovation system relates to university research. Swedish universities are supposed to be the dominating research base for both scientific development and for the benefits of the Swedish industry and public sector. According to the Swedish research policy doctrine, universities are supposed to perform functions in relation to society as a whole that in most other countries are carried out by R&D institutes. However,

this "third mission" of the universities was not explicitly stipulated by law until the late 1990s.[78]

Despite the expectations on interactions between universities and society at large, the general incentive structures in the publicly funded and university-based Swedish research system have not provided strong incentives for knowledge interaction and learning between university researchers and businesses or public sector services.[79] Even the incentives for interaction between different university departments, within or between different universities, are not particularly strong, since the main principle for research resource allocations relates to well-established scientific fields.[80] A consequence of this structure is that more radical renewal within the research system may be hampered.

16.1 Gross government deficits in relation to GDP in different countries 1980–2002

No.	Country	1980–1989	Country	1990–1994	Country	1995–1999	Country	2000–2002
1	Finland	17	Norway	33	Norway	29	Norway	27
2	Iceland	30	Finland	41	Iceland	53	Iceland	45
3	Norway	34	Germany	43	Portugal	59	UK	51
4	France	36	France	46	UK	60	Finland	51
5	Germany	39	Iceland	47	Germany	61	Denmark	53
6	Spain	40	UK	50	Finland	63	Netherlands	54
7	Greece	43	Spain	57	France	67	Portugal	56
8	Austria	48	Portugal	59	Austria	67	USA	60
9	Portugal	50	Austria	60	USA	70	Germany	61
10	UK	54	**Sweden**	**67**	Netherlands	70	**Sweden**	**62**
11	USA	56	Japan	71	Denmark	72	France	66
12	**Sweden**	**61**	USA	72	Spain	79	Austria	67
13	Canada	62	Netherlands	77	**Sweden**	**80**	Spain	69
14	Netherlands	64	Denmark	78	Canada	97	Canada	82
15	Japan	68	Canada	88	Japan	103	Greece	106
16	Denmark	71	Greece	94	Greece	108	Belgium	108
17	Italy	84	Italy	124	Belgium	125	Italy	122
18	Belgium	111	Belgium	133	Italy	133	Japan	141

Source: OECD, MEI, 2003

16.2 Inflation rates in different countries 1971–2002, per cent

No.	Country	1971–1980	Country	1981–1990	Country	1991–1995	Country	1996–2000	Country	2001–2002
1	Switzerland	5.0	Japan	2.1	Japan	1.4	Japan	0.3	Japan	-0.8
2	Germany	5.1	Netherlands	2.5	Denmark	2.0	**Sweden**	**0.7**	Switzerland	0.8
3	Austria	6.2	Germany	2.6	New Zealand	2.1	Switzerland	0.7	Germany	1.7
4	Luxembourg	6.7	Switzerland	3.4	France	2.2	France	1.2	UK	1.7
5	Netherlands	7.3	Austria	3.5	Finland	2.3	Germany	1.3	France	1.8
6	Belgium	7.4	Luxembourg	4.5	Canada	2.3	Austria	1.3	Belgium	2.1
7	USA	7.9	Belgium	4.6	Norway	2.4	New Zealand	1.4	Netherlands	2.1
8	Canada	8.1	USA	4.7	Belgium	2.5	Finland	1.5	Finland	2.1
9	Norway	8.4	Denmark	5.9	Australia	2.5	Luxembourg	1.6	Norway	2.2
10	Japan	9.1	Canada	6.0	Ireland	2.5	Belgium	1.7	USA	2.2
11	**Sweden**	**9.2**	France	6.4	Netherlands	2.7	Canada	1.7	Austria	2.2
12	France	9.7	UK	6.6	Luxembourg	2.8	Australia	1.9	Luxembourg	2.4
13	Denmark	9.9	Finland	6.6	USA	3.1	Netherlands	2.1	Denmark	2.4
14	Australia	10.4	**Sweden**	**7.7**	Switzerland	3.2	Norway	2.3	Canada	2.4
15	Finland	11.2	Norway	7.7	Austria	3.2	Denmark	2.3	**Sweden**	**2.5**
16	New Zealand	12.5	Ireland	7.9	UK	3.4	Italy	2.4	Italy	2.6
17	Ireland	13.7	Australia	8.1	Germany	3.6	USA	2.5	New Zealand	2.7
18	UK	13.8	Italy	9.7	**Sweden**	**4.5**	Ireland	2.6	Australia	3.7
19	Italy	14.0	New Zealand	10.8	Italy	5.1	UK	2.7	Ireland	4.8

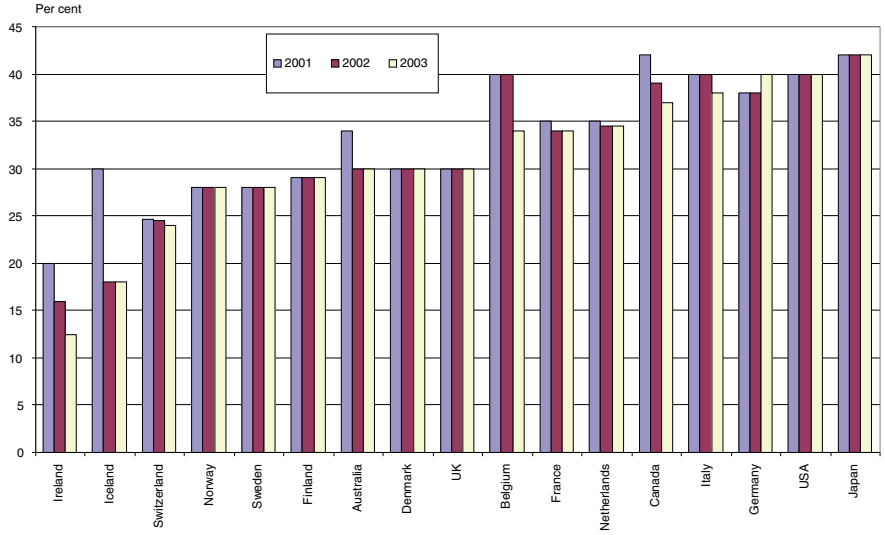
Source: OECD, MEI, 2003

16.3 Real interest rate in different countries 1971-2002, per cent

No.	Country	1971-1975	Country	1976-1980	Country	1981-1985	Country	1986-1990	Country	1991-1995	Country	1996-2000	Country	2001-2002
1	Denmark	3.8	Denmark	7.3	Denmark	8.5	Ireland	7.0	Finland	7.8	New Zealand	5.5	Norway	4.0
2	Germany	2.9	Austria	3.5	USA	6.7	Belgium	6.6	Italy	7.0	**Sweden**	**5.2**	New Zealand	3.8
3	Austria	1.2	Germany	3.4	Australia	5.8	Denmark	6.4	Australia	6.6	Australia	4.6	UK	3.2
4	France	0.4	Belgium	3.3	Belgium	5.4	Netherlands	6.3	Denmark	6.4	Canada	4.3	Germany	3.1
5	Canada	0.2	Netherlands	2.7	Canada	5.3	Italy	6.2	New Zealand	6.1	Austria	4.1	France	3.1
6	USA	0.2	Switzerland	1.8	UK	5.0	France	6.1	Canada	6.0	France	4.1	Canada	3.0
7	**Sweden**	**0.0**	Japan	1.3	Japan	4.9	Norway	6.0	Ireland	6.0	Finland	4.1	Netherlands	2.9
8	Luxembourg	0.0	Canada	0.9	France	4.8	Germany	5.6	Norway	5.9	Germany	4.0	Belgium	2.9
9	Ireland	0.0	France	0.8	Netherlands	4.8	Finland	5.5	France	5.6	Luxembourg	3.8	Finland	2.9
10	Netherlands	-0.3	**Sweden**	**0.0**	Germany	4.7	Canada	5.3	Belgium	5.6	Italy	3.8	Austria	2.8
11	Belgium	-0.6	Luxembourg	0.0	**Sweden**	**4.1**	**Sweden**	**5.3**	**Sweden**	**5.3**	Belgium	3.7	Denmark	2.7
12	Norway	-1.7	Ireland	0.0	Austria	4.0	Austria	5.2	UK	5.2	Norway	3.7	**Sweden**	**2.7**
13	Switzerland	-1.8	Norway	0.0	Italy	3.6	Australia	5.1	Netherlands	4.7	Denmark	3.5	USA	2.6
14	UK	-2.4	USA	-0.1	Norway	3.5	New Zealand	4.7	Austria	4.3	USA	3.5	Switzerland	2.5
15	Australia	-2.6	Australia	-0.5	Finland	2.6	USA	4.4	Germany	3.7	UK	3.5	Italy	2.5
16	Finland	-3.1	Finland	-0.5	Ireland	1.5	UK	4.3	USA	3.7	Ireland	3.1	Luxembourg	2.4
17	Italy	-3.5	UK	-1.5	New Zealand	1.5	Japan	4.0	Japan	3.4	Netherlands	3.1	Australia	2.1
18	Japan	-4.0	Italy	-2.6	Switzerland	0.4	Switzerland	2.3	Switzerland	2.2	Switzerland	2.7	Japan	2.1
19	New Zealand	-4.4	New Zealand	-4.2	Luxembourg	0.0	Luxembourg	0.0	Luxembourg	2.1	Japan	1.8	Ireland	0.2

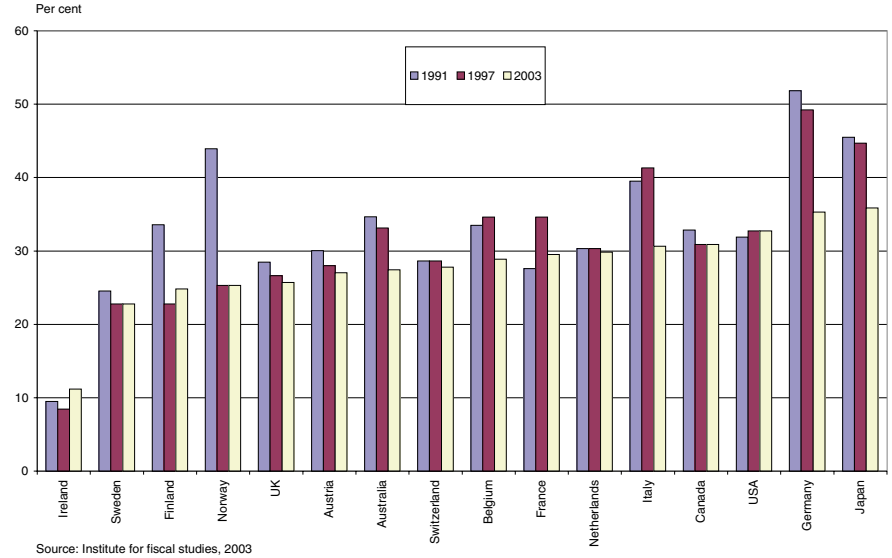
Source: OECD, MEI, 2003

16.4 Corporate rate taxes 2001–2003, per cent



Source: KPMG Corporate tax survey 2002 & 2003

16.5 Effective average corporate tax rates 1991–2003



Source: Institute for fiscal studies, 2003

Notes

1 OECD, *Economic Surveys, Sweden*, 2004, p. 106, OECD, *The Sources of Economic Growth*, 2003, Rosenberg, N., *Exploring the black box – Technology, economics and history*, 1994, p. 9, Schumpeter, J., *The Theory of Economic Development*, 1934

2 OECD, *Science, Technology and Industry Outlook*, 2002, p. 13

3 This is basically in line with the broad definition of innovation suggested by Schumpeter in 1934 and which has been the focus of most innovation related research and analysis since then.

4 This is basically in line with the different variations of innovation system definitions adopted by different researchers and the OECD. However, it explicitly contains individuals and it explicitly includes the economic impact of innovation systems. None of these aspects are generally explicitly included in innovation system definitions used in the research literature. A more action-oriented innovation system concept is used by VINNOVA as a tool for innovation policy programmes where the aim is to promote efficient interplay between different agents in innovation systems. Innovation systems is then understood as: "Agents within research, business and politics whom in interplay generate, exchange and use new technology and new knowledge for sustainable economic growth through new goods, services and processes."

5 The dependency ratio is the ratio between number of people in a population that are outside the labour force and the number of people in the same population that generate net value to the national income.

6 OECD, *Economic Surveys, Sweden,* 2004, p. 15

7 OECD, *The Sources of Economic Growth*, 2003, pp. 35–39

8 OECD, *Economic Surveys, Sweden*, 2004, p. 18

9 Sörlin, S. and Törnqvist, G., *Kunskap för välstånd – Universiteten och omvandlingen av Sverige*, 2000, pp. 91–92

10 For a methodological discussion on productivity measures, see OECD, *The Sources of Economic Growth*, 2003

11 OECD, *Economic Surveys, Sweden*, 2004, p. 16

12 Ibid, pp. 93–95

13 Ibid, pp. 28–29

14 Ibid, pp. 21, 33–34

15 Multi-factor productivity growth calculates the relationship between value added and the total value of all inputs required to produce the value added. The main problem with multi-factor productivity data is problems in getting access to high-quality and comparable data on capital costs.

16 OECD, *The Sources of Economic Growth*, 2003, pp. 49–51

17 Since labour costs are easier to calculate and compare between sectors and countries, labour productivity data are often the only ones available for comparative analysis. In analysing innovation competitiveness, labour productivity data have one important weakness. Since it hides capital costs in production, it is not possible to know whether a productivity growth is generated through increased capital or labour intensity.

18 Eurostat, *Community Innovation Survey III*

19 This pattern is supported by the internationally high levels of investments in new technology in Sweden. OECD, *Economic Surveys, Sweden,* 2004, p. 22, see also chapter 9 and 11 for investments in new technology and ICT investments.

20 OECD, *Economic Surveys, Sweden*, 2004, p. 101

21 Global Entrepreneurship Monitor (GEM), *Global report 2003*, 2003

22 Nås, S.O., Sandven, T., Eriksson, T., Andersson, J., Tegsjö, B., Lehtoranta, O. and Virtaharju, M., *High-Tech Spin-Offs in the Nordic Countries,* STEP Report 22-2003, SINTEF, 2004

23 Schumpeter, J., *The Theory of Economic Development,* 1934

24 Nås, S.O., Sandven, T., Eriksson, T., Andersson, J., Tegsjö, B., Lehtoranta, O. and Virtaharju, M., *High-Tech Spin-Offs in the Nordic Countries*, STEP Report 22–2003, SINTEF, 2004

25 Delmar, F. & Wiklund, J., *The involvement in self-employment among the Swedish science and technology labour force between 1990 and 2000*, ITPS A2003:017, 2003

26 Patenting in the USA is often used to compare patenting between different countries, since the US market is important for most countries and to be technologically competitive it should generally be important to patent in the USA.

27 It should be noted though, that the US figures are overestimated, since it is patenting in the US patent system that has been used as the basis of this analysis.

28 Persson, O., *Scientific articles from the Swedish companies*, unpublished special study for VINNOVA, 2004

29 Baumol, W. J., *The Free-Market Innovation Machine – analyzing the growth miracle of capitalism*, 2002

30 Coe, D. and Helpman, E., *International R&D spillovers*, European Economic Review, 1995, 39(5), pp. 859–887, Guellec, D. and Van Pottelsberghe de la Potterie, B., *R&D and productivity growth: panel data analysis of 16 OECD countries*, STI Working Papers, No. 2001/3, 2001, OECD, *Links between policy and growth: cross-country evidence,* OECD Economic Outlook no 68, 2000, pp. 133–154, Bassanini, A., Scarpetta, S. and Hemmings, P., *Economic growth: the role of policies and institutions. Panel data evidence from OECD countries,* OECD, Economic Department Working Papers, No. 283, 2001

31 Baumol, W. J., *The Free-Market Innovation Machine – analyzing the growth miracle of capitalism*, 2002, pp. 134–135, Wolff, E.N., *Spillovers, Linkages and Technical Change*, Economic Systems Research 9, 1997, pp. 9–2, Nadiri, M.I., *Innovations and Technological Spillovers,* NBER Working Paper No. 4423, 1993, Mohnen, P., *The Relationship between R&D and Productivity Growth in Canada and Other Industrial Countries*, 1992

32 Mohnen, P., *R&D externalities and productivity growth*, STI Review, No. 18, 1996, pp. 39-66

33 Eurostat, *Community Innovation Survey II and III*

34 OECD, *National innovation systems: Analytical findings,* DSTI/STP/TIP(98)6, 1998, p. 33

35 Krugman, P., *Increasing returns and economic geography*, Journal of Political Economy, Vol. 99, No. 3, 1991, pp. 483-499

36 Technopolis and INNO, *Benchmarking Technology R&D*, draft version of forthcoming study for VINNOVA, 2004

37 Ibid.

38 Data problems with existing R&D statistics are considerable, particularly in terms of international comparability. One important problem is the uncertain and almost certainly varying relationships between data on R&D expenditure and R&D man-years. Another important issue concerns the problems of making international comparisons of R&D institutes between different countries.

39 See for example the *Community Innovation Surveys* (CIS I and CIS II), conducted by Eurostat.

40 Williamson, O., *The Economic Institutions of Capitalism*, New York, 1985, Baumol, W.J., *The Free-Market Innovation Machine – analyzing the growth miracle of capitalism,* 2002.

41 Baumol, W.J., *The Free-Market Innovation Machine – analyzing the growth miracle of capitalism*, 2002, p. 94

42 Lundvall, B-Å., *Product Innovation and User-Producer Interaction,* 1985.

43 Von Hippel, E., *The Dominant Role of Users in the Scientific Instrument Innovation Process, Research Policy*, Vol. 5, No. 3, 1976 and Von Hippel, E., *The Dominant Role of the User in Semiconductor and Electronic Subassembly Process Innovation,* IEEE Transaction on Engineering Management, Vol. EM-24, No. 2, 1977

44 See for example the *Community Innovation Surveys* (CIS I and CIS II), conducted by Eurostat, and Norgren, L., *Innovative activities in firms – Sources of knowledge, protection of innovations and government policies,* 1995

45 IVA, *Teknikutveckling på avreglerade marknader,* Executive Summary from IVA project "Samverkan för tillväxt", IVA, Stockholm, 2003, and Sörlin, S. and Törnqvist, G., *Kunskap för välstånd – Universiteten och omvandlingen av Sverige*, 2000

46 Ibid.

47 Boden, M. and Miles, I. (eds), *Services and the Knowledge-Based Economy*, 2000, and the *Community Innovation Surveys* (CIS I and CIS II), conducted by Eurostat.

48 Hertog den, P. and Bilderbeek, R., *The New Knowledge Infrastructure: The Role of Technology-Based Knowledge-Intensive Business Services in National Innovation Systems*, in Boden, M. and Miles, I. (eds), *Services and the Knowledge-Based Economy,* London, 2000

49 Booz Allen Hamilton, *The Competitiveness of Europe´s ICT Markets – the Crisis Amid the Growth,* 2000

50 Tellis, G., *The International Takeoff of New Products: The Role of Economic, Culture and Country Innovativeness*, 2002

51 Technopolis and INNO, *Benchmarking Technology R&D*, draft version of forthcoming study for VINNOVA, 2004

52 OECD, *Science, Technology and Industry Outlook,* 2002, p. 42 and p.70

53 OECD, *Science, Technology and Industry Outlook*, 2002, pp. 73–81

54 Marklund, G., Modig, S. and Backlund A., *The Swedish National Innovation System – A Quantitative Study,* 1998

55 KIBS industries have been defined as business service firms, R&D firms and firms in wholesale trade with machinery and equipment.

56 OECD, *Economic Outlook,* 1999

57 OECD, *Economic Surveys, Sweden*, 2004, p. 97

58 Ibid.

59 Special data analysis at VINNOVA based on material from *Statistics Sweden,* 2004

60 Sörlin, S. and Törnqvist, G., *Kunskap för välstånd – Universiteten och omvandlingen av Sverige*, 2000, p. 88

61 VINNOVA, *Nationellt Inkubatorprogram*, VINNOVA policy VP 2002:2, 2002, pp. 9–11

62 Deiaco, E., Giertz, E., Reitberger, G. And Rogberg, A., *Teknikparkernas roll i det svenska innovationssystemet – historien om kommersialisering av forskningsresultat*, 2002

63 Eklund, K., *Vår Ekonomi*, Gnesta, 1996

64 Eklund, K., *Vår Ekonomi*, Gnesta, 1996 and OECD, Economic Surveys, Sweden, 2004, pp. 50-51

65 Eklund, K., *Vår Ekonomi*, 1996 and OECD, Economic Surveys, Sweden, 2004

66 Eklund, K., *Vår Ekonomi,* 1996, p. 351

67 Firms are considered to be closely-held if four or less individuals hold at least half of the voting rights.

68 OECD, *Economic Surveys, Sweden*, 2004, pp. 104–105

69 SOU 1998:94, Johansson, M., *Förslagskatalog – Småföretagar-delegationens rapport 7*, 1998

70 Eklund, K., *Vår Ekonomi*, 1996, and SOU 1998:94, Johansson, M., *Förslagskatalog – Småföretagardelegationens rapport 7*, 1998

71 Wall Street Journal, *Index of Economic Freedom Rankings*, 2003. (Available at www.heritage.org)

72 Nicoletti, G., Scarpetta, S. and Boyland, O., *Summary of Indicators of Product Market Regulation with an Extension to Employment Protection Legislation*, OECD, Economics Department, Working Paper, No. 226, 2000

73 Björklund, A., *Arbetsmarknaden*, 2000, pp. 148-151

74 The model was based on four main ingredients: 1) A strict finance policy in order to limit profit-margins and inflationary pressures. 2) Selective measures to increase employment, whenever finance policy would tend to generate increased unemployment. 3) Measures to increase the mobility of the labour force to competitive firms in order to limit bottle-necks and stimulate expansive industries, without generating rapid salary increases. 4) A basic principle of equal salary for the same job, a principle labelled, a "solidaric salary policy". Eklund, K., *Vår Ekonomi,* 1996, p. 287 and Björklund, A., *Arbetsmarknaden*, pp. 336–340

75 Danielsson, A., *Arbetsmarknadsboken*, Stockholm, 1997, p. 37

76 SOU 1998:94, Johansson, M., *Förslagskatalog – Småföretagar-delegationens rapport 7*, 1998, p. 16

77 Sandgren, P., *Skattestimulans eller skattesubvention?*, unpublished, VINNOVA

78 Sörlin, S. and Törnqvist, G., *Kunskap för välstånd – Universiteten och omvandlingen av Sverige,* Stockholm, 2000, p. 84

79 Nybom, T., *Kunskap, politik, samhälle: Essäer om kunskapssyn, universitet och forskningspolitik 1990–2000*, Hjalmar & Jörgen Bokförlag, Stockholm, 1997, p. 24

80 Technopolis and INNO, *Benchmarking Technology R&D*, draft version of forthcoming study for VINNOVA, 2004

Bibliography

Andersson, T., *Globalisering och teknisk utveckling förändrar politikens roll,* in *Politik och utvecklingskraft i kunskapssamhället,* Swedish Ministry for Industry and Trade, Stockholm 1997

Andersson, T., Asplund, O. and Henrekson, M., *Betydelsen av innovationssystem – utmaningar för samhället och för politiken,* VINNOVA Forum, VFI 2002:1, Stockholm, 2002

Bannock, G., Baxter, R.E. and Rees, R., *The Penguin Dictionary of Economics*, London, 1981

Bassanini, A., Scarpetta, S. and Hemmings, P., *Economic growth: the role of policies and institutions. Panel data evidence from OECD countries*, OECD, Economic Department Working Papers, No. 283, Paris, 2001

Baumol, W.J., *The Free-Market Innovation Machine – analyzing the growth miracle of capitalism*, Princeton University Press, New Jersey, 2003

Boden, M. and Miles, I. (eds), *Services and the Knowledge-Based Economy,* Continuum, London, 2000

Booz Allen Hamilton, *The Competitiveness of Europe's ICT Markets – the Crisis Amid the Growth*, Ministry of Economic Affairs, Noordwijk, 2000

Brooks, H., *Applied Science and Technological Progress*, Science Vol. 156, June 1967

Coe and Helpman, *International R&D spillovers*, European Economic Review, 1995

Dahmén, E., *Svensk industriell företagarverksamhet 1919–1939*, Industrins utredningsinstitut, Stockholm, 1950

Danielsson, A., *Arbetsmarknadsboken*, Allde & Skytt, Stockholm, 1997

Deiaco, E., Giertz, E., Reitberger, G. and Rogberg, A., *Teknikparkernas roll i det svenska innovationssystemet – historien om kommersialisering av forskningsresultat*, VINNOVA Forum, VFI 2002:3, Stockholm, 2002

Delmar, F., Sjöberg, K. and Wiklund, J., *The involvement in self-employment among the Swedish science and technology labour force between 1990 and 2000*, ITPS A2003:017, Stockholm, 2003.

Donselaar, P., Erken, H. and Klomp, L., *Innovation and productivity – A study at the macro, meso and micro level*, Ministry of Economic Affairs, 2003

Dosi, G., *Institutions and Markets in a Dynamic World,* The Manchester School, Vol. LVI, No. 2, June 1988

Dosi, G., *The Nature of the Innovation Process*, in Dosi, G., et. al. (eds) *Technical Change and Economic Theory,* London, 1988

Dosi, G. et al., *Technical Change and Economic Theory,* Printer, London, 1988

Dosi, G., *Technical Change and Industrial Transformation – The Theory and Application to the Semiconductor Industry,* Macmillan, London, 1984

Ds 2003:62, *Benchmarking av näringspolitiken 2003 – Sverige i ett internationellt perspektiv*, Stockholm, 2003

Eklund, K., *Vår Ekonomi,* Prisma, Gnesta, 1996.

Eliasson, P., Umeå university, in Sörlin, S. and Törnqvist, G., *Kunskap för välstånd – Universiteten och omvandlingen av Sverige,* Stockholm, 2000

Eurostat, *Community Innovation Survey II and III*, 1998 and 2002

Eurostat, *New Cronos*, 2003

Fi-stencil 1967:11 p.16, Elzinga, A., *Forskningspolitik i Sverige*, in Ambjörnsson, R., Andersson, G. and Elzinga, A., *Forskning och politik i Sverige, Sovjet och USA*, Bonniers, Lund, 1969

Global Entrepreneurship Monitor (GEM), *Global report 2003.* (Available at www.gemconsortium.org)

Government bill 1942:282

Government bill 1968:68

Greenwald, D., *The McGraw-Hill Dictionary of Modern Economics,* New York, 1965

Gribbin, J., *Science – A History 1543–2001*, Allen Lane, London, 2003

Guellec, D. and Van Pottelsberghe de la Potterie, B., *R&D and productivity growth: panel data analysis of 16 OECD countries,* OECD, STI Working Papers, No. 2001/3, Paris, 2001

Guellec, D. et al., *Does Government Support Stimulate Private R&D*, OECD Economic Studies No. 29, 1997/II

Guellec, D. et al., *The Impact of Public R&D Expenditure on Business R&D*, OECD STI, Paris, 2001

Hall, B., *Effectiveness of research and development and experiment tax credits,* University of California at Berkeley, 1995

Hall, B., *How effective are fiscal incentives for R&D? A review of the evidence*, National Bureau of Economic Research, Working Paper No. 7098, 1999

Hodgson, G.M., *Economics and Institutions*, Oxford, 1988

IMD, *World Competitiveness Yearbook,* Lausanne, 2002

Karlsson, C., *Creation of new businesses in large established organizations*, chapter 11 in Technovation, No. 5, 1986

Kealey T., *Economic laws of Scientific Research*, St Martins Press, New York, 1996

KPMG, *Corporate tax survey 2002 and 2003,* (Available at www.kpmg.com.sg/publications), 2004

Krugman, P., *Increasing Returns and Economic Geography*, Journal of Political Economy, Vol. 99, No. 3, pp. 483–499, 1991

Krupp, H., *Public promotion of Innovation – Disappointments and Hopes,* Fraunhofer Institute, Berlin, 1985

Leslie, S.W., *The Cold War and American Science*, MIT Press, Cambridge, Mass., 1994

Lundvall, B-Å., *Product Innovation and User-Producer Interaction*, Aalborg University Press, Aalborg, 1985

LU 1995, NUTEK, *Svenskt näringslivs teknologiska specialisering,* Appendix 11 to Långtidsutredningen (Long-term investigation) 1995, Stockholm, 1995

LU 2003, Gustavsson, P. and Kokko, A., *Sveriges konkurrensfördelar för export och multinationell produktion*, Appendix 6 to Långtidsutredningen (Long-term investigation) 2003, Stockholm, 2003

Manigart, S. and Beuselinck, C., *Supply of Venture Capital by European Governments*, Universiteit Gent, August 2001

Mansfield, E., quoted in The NEA Higher Education Journal. (Available at www.nea.org/he/heta00/f00p09.pdf)

Marklund, G., Modig, S. and Backlund A., *The Swedish National Innovation System – A Quantitative Study*, NUTEK, Stockholm, 1998

Mohnen, P., *The Relationship between R&D and Productivity Growth in Canada and Other Industrial Countries,* Canada Communications Group, Ottawa, 1992

Mohnen, P., *R&D externalities and productivity growth*, OECD, STI Review, No. 18, 1996

Nadiri, M.I., *Innovations and Technological Spillovers,* NBER Working Paper No. 4423, Cambridge Mass., National Bureau of Economic Research, August, 1993

National Science Indicator database, 2003

Nelson, R., *What is Public and Private about Technology?*, Working Paper No. 90–9, Columbia University, 1990

Nicoletti, G., Scarpetta, S. and Boyland, O., *Summary of Indicators of Product Market Regulation with an Extension to Employment Protection Legislation,* OECD, Economics Department, Working Paper, No. 226, Paris, 2000

Norgren, L., *Innovative activities in firms – Sources of knowledge, protection of innovations and government policies,* NUTEK, Stockholm, 1995

North, D. and Thomas, R., *The Rise of the Western World – A New Economic History*, Cambridge University Press, Cambridge, 1973

NUTEK Working paper, *De tekniska kompetensföretagens roll i näringslivets teknologi- och produktutveckling – teknologiska resurser och kundrelationer i tekniska konsultföretag*, *FoU-bolag och partihandelsföretag 1985–1992*, Stockholm, September 1995

Nybom, T., *Bernalism och forskningsorganisation*, in Daedalus, 1986

Nybom, T., *Kunskap, politik, samhälle: Essäer om kunskapssyn, universitet och forskningspolitik 1990-2000*, Hjalmar & Jörgen Bokförlag, Stockholm, 1997

Nås, S.O., *Formal competencies in the innovation systems of the Nordic countries: An analysis based on register data*, STEP Report R-06 1998, Oslo, 1998

Nås, S.O., Sandven, T., Eriksson, T., Andersson, J., Tegsjö, B., Lehtoranta, O. and Virtaharju, M., *High-Tech Spin-Offs in the Nordic Countries,* STEP Report 22–2003, SINTEF, Oslo, 2004

OECD databases (Available at www.sourceoecd.org), 2003
AFA (Activities of foreign affiliates database)
ANBERD (Analytical business enterprise research and development database)
MEI (Main economic indicators database)
MSTI (Main science and technology indicators database)
STAN (Structural analysis database)
Telecommunications database

OECD, *Economic Surveys, Sweden*, Paris, February 2004

OECD, *Education at a glance 2003*, Paris, 2003

OECD, *Globalisation of Industry – Overview and sector reports*, Paris, 1996

OECD, *Links between policy and growth: cross-country evidence*, OECD Economic Outlook No. 68, Paris, 2000

OECD, *National innovation systems: Analytical findings,* DSTI/STP/TIP(98)6, Paris, June 1998

OECD, *Public support to industry,* Paris, 1996

OECD, *Science Technology and Industry Scoreboard 2001*, Paris, 2001

OECD, *Science Technology and Industry Scoreboard 2003*, Paris, 2003

OECD, *Special Issue of New Science and Technology Indicators,* STI Review No. 27, Paris, 2002

OECD, *Tax incentives for Research and Development, Trends and Issues,* OECD DSTI/IND/STP(2002)1/REV1, Paris, 2002

OECD, *Tax incentives for Research and Development, Trends and Issues,* OECD DSTI/IND/STP(2002)1/REV1, Paris, 2002

OECD, *Technology, Productivity and Job Creation*, Paris, 1998

OECD, *The Sources of Economic Growth*, Paris, 2003

Olofsson, C. and Wahlbin, C., *Firms started by university researchers in Sweden – roots, roles, relations, and growth patterns*, in Frontiers of Entrepreneurship Research, Babson, Houston, 1993

Persson, O., *Scientific articles from the Swedish companies,* unpublished special study for VINNOVA, January 2004

Rosegger, J., *The Theory of Economic Development,* Oxford, 1985

Rosenberg, N., *Exploring the black box – Technology, economics and history,* Cambridge University Press, New York, 1994

Rosenberg, N., *Inside the black box – Technology, economics and history,* Cambridge University Press, New York, 1994

Rosenberg, N. and Birdzell, L., *How the West Grew Rich – The Economic Transformation of the Industrial World,* Basic Books, New York, 1986

Sandgren, P., *Skattestimulans eller skattesubvention? Till frågan om den svenska förändringen om särskilt forskningsavdrag vid taxering till statlig inkomstskatt (1973:421) under perioden 1973-1984,* unpublished, VINNOVA

Scarpetta, S., Hemmings, P., Tressel, T. and Woo, J., *The role of policy and institutions for productivity and firm dynamics: evidence from micro and industry data,* OECD, Economics Department Working Papers, No. 329, Paris, 2002

Schumpeter, J., *The Theory of Economic Development,* Cambridge Mass., Harvard University Press, 1934

SOU 1998:94, Johansson, M., *Förslagskatalog – Småföretagardelegationens rapport 7,* Stockholm, 1998

SOU 2003:90, Gidlund, J.E. et al., *Innovativa processer,* Stockholm, 2003

SOU 2003:57, Lundberg, A. and Murray, R., *Alternativ finansiering av offentliga tjänster,* Appendix 7 to Långtidsutredningen (Long-term investigation), Stockholm, 2003

Statistics Sweden, *Official statistics*, 2003 (Available at www.scb.se)

Stenberg, L., Gustafsson, E., Marklund, G., *Use of human resource data for analysis of the structure and dynamics of the Swedish innovation system,* Research evaluation, vol. 6, No. 2, August 1996

Stokes, D.E., *Pasteur's Quadrant – Basic Research and Technological Innovation,* Washington, 1997

Sundin, B., *Ingenjörsvetenskapens tidevarv: Ingenjörsvetenskapsakademin, Pappersmassekontoret, Metallografiska institutet och den teknologiska forskningen i början av 1900-talet*, Acta universitatis umensis 42, Umeå, 1981

Sörlin, S. and Törnqvist, G., *Kunskap för välstånd – Universiteten och omvandlingen av Sverige*, SNS, Stockholm, 2000

Technopolis and INNO, *Benchmarking Technology R&D,* draft version of forthcoming study for VINNOVA, Brighton and Stockholm, February 2004

Tellis, G., Stremersch, S. and Yin, E., *The International Takeoff of New Products: The Role of Economic, Culture and Country Innovativeness,* Marketing Science Institute, Cambridge, 2002

Wall Street Journal & Heritage 2003, *Index of Economic Freedom Rankings 1995–2003,* 2003 (Available at www.heritage.org)

Williamson, O., *The Economic Institutions of Capitalism*, Free Press, New York, 1985

Wolff, E.N., *Spillovers, Linkages and Technical Change*, Economic Systems Research 9, pp. 9–2, 1997

VINNOVA, *Nationellt Inkubatorprogram,* VINNOVA Policy VP 2002:2, Stockholm, 2002

Von Hippel, E., *The Dominant Role of Users in the Scientific Instrument Innovation Process*, Research Policy, Vol. 5, No. 3, July 1976

Von Hippel, E., *The Dominant Role of the User in Semiconductor and Electronic Subassembly Process Innovation*, IEEE Transaction on Engineering Management, Vol. EM-24, No. 2, 1977

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