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The paradox of high R&D input and low innovation output: Sweden

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Abstract

This chapter takes its point of departure in the so-called Swedish paradox, according to which the Swedish NSI is plagued by low pay-off in relation to very high investments in R&D and innovation efforts. Using new data, we show that this paradox is still in operation, i.e. the productivity or efficiency of the Swedish NSI remains low. We also specify the paradox in several respects. By focussing upon nine activities in the NSI, we attempt to explain why and how the paradox operates. The paradox is also related to the moderate growth of labour productivity in Sweden. Further, we show that the paradox is linked to globalization: internationalization of production by Swedish firms has proceeded further than the internationalization of R&D. On the basis of this analysis, we identify strengths and weaknesses of the Swedish NSI – many of which are related to the Swedish paradox. We take account of the history of innovation policy in Sweden and – on the basis of the analysis as a whole -- we identify future policy initiatives that might help to mitigate the Swedish paradox.

Keywords: : Innovation, innovation system, Swedish national system of innovation, Swedish paradox

The paradox of high R&D input and low innovation output: Sweden[1]

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1 Introduction

The notion of a 'Swedish paradox' has been central to recent innovation policy discussions in Sweden. When first formulated, it was as a reflection of a high research and development (R&D) intensity in Sweden coupled with a low share of high-tech (R&D intensive) products in manufacturing as compared to the OECD (organization for economic co-operation and development countries. It was seen as a paradox between a high input and a low output measured by these specific indicators (Edquist and McKelvey, 1998).[2] In other words, it pointed to a low productivity of the Swedish national system of innovation (NSI) in this specific sense. Subsequently, the expression has been used widely, but often formulated as a general relation between inputs and outputs – e.g. that the investments in R&D in Sweden are very large, but that the 'pay-off' (in terms, e.g., of growth and competitiveness) is not particularly impressive (e.g. Andersson et al., 2002, Chapter 2). Due to varying uses of the concept, and since many formulations have been based on rather partial data, it is not yet clear to what extent there exists a paradox or where the gap between input and output resides. In this chapter, we will discuss the Swedish paradox in terms of a relation between inputs of R&D and innovation efforts and outputs of innovations of different kinds.

Those studies that propose that there exists a paradox have also formulated a number of different hypotheses to explain it. (1) One proposition is that the knowledge resulting from R&D remains in the R&D sphere - e.g. in universities or corporate research units - and hence is not transformed into innovations. (2) Another is that the paradox can be explained by the sectoral allocation of R&D investments. (3) A third is that the internationalization of production has proceeded further than that of R&D, so that R&D carried out in Sweden bears fruit, as innovations, elsewhere, sometimes in the subsidiaries of Swedish multinational enterprises (MNEs) (Edquist, 2002, Sections 4.6 and 4.3). However, we still lack a thorough discussion of the validity of these propositions or of the relations among them.

Against this background, we aim to analyse the Swedish NSI. In doing so, we follow the structure and model table of contents presented in the introduction to this book. Among many other things, we scrutinize whether there is support for the paradox, and if so how it may be explained. Specifically related to the paradox, we revisit and reformulate the paradox in Section 3 through an analysis of detailed and comparative data from the 2nd and 3rd Community Innovation Surveys (CIS2/3). To assess the grounds for competing explanations of the paradox, a detailed analysis of activities possibly influencing innovation processes in Sweden - also presented in the introductory chapter - follows in Section 4.

2 Main historical trends

Two main traits characterise the evolution of the Swedish NSI. First, the natural resource base in Sweden - i.e. forests and minerals – and the economic history of Sweden from the industrial revolution and onwards have both strongly influenced the present anatomy of the Swedish NSI. Second, the general pattern of economic development can be summarized in terms of ‘the combination of exports based on refined and processed materials on the one hand and the multinational engineering firms on the other’ (Edquist and Lundvall, 1993, p. 272). As for the resulting character of the NSI, attention should be drawn to the decisive role played by a ‘small number of multinational firms in the engineering industry’ (Edquist and Lundvall, 1993, p. 272).[3]

In the latter half of the 19th century, Sweden was primarily agrarian. Its exports were dominated by products from agriculture and the mining and forest industries (iron and sawn lumber). After the mid-19th century, though, new production processes allowed the export of more refined products from these industries – machinery products and pulp and paper, respectively. The engineering industry subsequently expanded significantly in terms of both employment and export shares, rising from 3 per cent of total exports in 1880 to 10.5 per cent in 1910-1911, and reaching over 20 per cent in 1950. Among OECD countries, the share of manufacturing exports held by engineering industries in Sweden during the 1950s was surpassed only by USA (ibid., p. 271).

Sweden was thus a late but rapidly industrialising country, developing a strong specialisation in mechanical engineering technologies related to the extraction and processing of raw materials. Significantly, its major innovations in machinery products during the late 19th century were ‘all closely related to the export-oriented process industries’ (ibid., p. 271). Later product innovations that became the basis of multinational firms were also concentrated in engineering firms, although the base widened to include both mechanical and electro-mechanical technologies.

The Swedish economy has historically been strongly specialized in low-growth sectors (Jacobsson and Philipsson, 1996). Prior to the 1990s, the more knowledge-intensive growth sectors, often referred to as high-technology (i.e. R&D intensive) production sectors were relatively underdeveloped (Ohlsson and Vinell, 1987). A study of Sweden’s production structure in manufacturing for the period from 1975 to 1991 showed that Sweden actually had a declining proportion of production in the R&D intensive growth industries – from 100 per cent of the OECD average in 1975 to 76 per cent in 1991 (Edquist and Texier, 1996, p. 110). One consequence of this negative specialisation in growth sectors was an exceptionally strong decline of employment in manufacturing (Edquist and Texier, 1996, p. 113-117).

Sweden joined the EU in 1995 in the hope that increased exposure to international demand would lead to diversification and renewed growth, recognising that the 'home market' could no longer provide a sufficient basis for growth and the development of new technologies and industries (Benner, 1997, p. 187-188). Initially, this strategy of exploiting the economies of scale offered by international markets did not bring about diversification, but instead tended to consolidate the pre-existing production structure and established technological trajectories (Carlsson, 1996).

The 1990s witnessed some positive changes in Sweden's sectoral production structure. The general increase in service sector employment, relative to manufacturing employment during 1980-1994 was marked by a modest increase in the share of employment held by knowledge-intensive service industries (Nutek, 2000, p. 41-43). Also, from 1980 to 1996 and especially in the latter part of the period, Sweden significantly increased its export specialisation in high-technology manufacturing, while losing market shares in medium-high-technology manufacturing (ibid., p. 47-52).

In 1997, a statistical study of the Swedish NSI, based on a comparison of seven countries (Finland, Germany, Japan, Netherlands, Sweden, the UK and USA), found that Sweden ranked fourth in terms of the share of manufacturing employment held by high-technology sectors. Furthermore Sweden ranked fifth in terms of the share of the total labour force employed in high-technology manufacturing (Nutek, 1998, Figure 3.8). Swedish production of high-technology products had also increased from 8.8 per cent of all manufacturing production in 1993 to 12.5 per cent in 1996, owing largely to rapid growth in two high-technology sectors in which Sweden was already specialized – telecommunications equipment and pharmaceutical products (ibid., Table 3.2).These developments improved Sweden's international ranking as a high-technology exporter (Braunerhjelm and Thulin, 2004, Table 1).

To the extent that Sweden's high-technology manufacturing industries expanded their exports of domestically produced goods, international demand acted as a spur to continued technological development, not only within the exporting firms, but also among their domestic suppliers. However, Swedish MNEs – and particularly those specialised in high-technology – were simultaneously pursuing a strategy of exploiting international economies of scale through foreign direct investment (FDI), partly in order to avoid high domestic production costs (Braunerhjelm, 2004, p.18, Figure 16).

3 Innovation intensity

Introduction

The Swedish paradox refers to a mismatch between very high values on indicators of inputs into innovation and low values on output indicators. Here we revisit the alleged paradox and try to reformulate it in more specific terms, based on CIS data and using a comparative research design.[4] First, we identify the strengths and weaknesses of the NSI via comparisons with other countries. We focus on some of the small open European economies included in this book, i.e. the other Nordic countries, the Netherlands and Ireland. Second, to capture the dynamics, we compare the indicators over time for Sweden, using CIS data from two periods, i.e. 1994-1996 (CIS2) and 1998- 2000 (CIS3).[5] Third, we compare different sectors (manufacturing, knowledge intensive business sectors (KIBS), finance, trade) and size classes (large firms versus small and medium sized enterprises (SMEs)).

The Swedish paradox revisited

Revisiting the validity of the paradox in the light of new data presented in a separate paper (Bitard et al., 2005), we can confirm that R&D intensity and innovation intensity (as input measures) of Swedish firms is very high compared to the other small industrialized, European countries (Denmark, Finland, Ireland, the Netherlands and Norway). In 1994-96 Swedish firms invested 4.0 per cent of their turnover in R&D, compared to the group average of 2.3 per cent. Sweden ranked first and none of the other countries invested above average. Intriguingly, the Swedish figure was 38 per cent higher than the figure for the country ranked second (i.e. Denmark).

A complementary but wider input indicator is innovation intensity.[6] For this indicator, too, Sweden ranks first. The Swedish figure in 1994-1996 was 6.7 per cent compared to the average of 4.1 per cent, and it was similarly high during 1998-2000.[7] This pattern holds not only for all firms, but also for the manufacturing sector, which is of specific interest.

We conclude that the input component of the Swedish paradox can be extended to all innovation expenditures, and not only to R&D expenditures. Indeed, the difference between Sweden and the other countries was even larger for innovation intensity than for R&D intensity.

At a disaggregated level, however, there is an interesting exception to this overall picture. For SMEs, Sweden ranks only second with regard to innovation intensity, far surpassed by Denmark: Swedish SMEs spent 2.7 per cent of their turnover on innovation, whereas the Danish ones spent 4.9 per cent – i.e. the Danish firms spent 81 per cent more. While in most countries SMEs spend less on innovation than large firms, Sweden had the largest difference in this respect. This difference was 3 times larger than that in Finland, with the second-largest gap, where large firms spent 2.5 times more than SMEs.

On the output side, we revisit the paradox by analyzing the proportion of innovating firms, the share of all firms that have introduced new processes, and the share of firms having introduced product innovations.

First, the proportion of innovating firms measures the share of firms that have introduced either a product or a process innovation. For this indicator, Sweden (all Swedish firms) ranked only 4th for both periods with a performance only slightly above average. Sweden was followed by Norway and Finland for the 1994-1996 period, and by Norway only in the 1998-2000 period. However, when the data is disaggregated into manufacturing, KIBS, finance and trade, Swedish firms perform much better in the service sectors of finance and trade than in manufacturing.

Second, focusing on the share of all firms that have introduced new processes during a three year period, Sweden's performance was 14 per cent below the average, and Sweden was ranked 4th (out of 6) for the first period, and 5th (out of 5) in the second period.[8] Hence, Sweden is at the bottom in comparison, even though differences among the five countries were rather small. Worryingly, the Swedish position deteriorated over time between the two periods. However, Swedish firms performed somewhat better in services than in manufacturing. It is interesting that previous studies have shown that in the past Sweden – at least Swedish engineering industry – has been very advanced with regard to the introduction of new process innovations (Edquist and Jacobsson, 1988).[9] However, judging from the CIS data, this no longer seems to be true.

Third, we have analyzed four indicators related to product innovations. The indicator introduction of new to the firm products measures the share of firms that during a three-year period introduced products that were new to them (but not to the 'world'). On this indicator, Sweden ranked 4th (out of 6) for 1994-1996 and 4th (out of 5) for 1998-2000.

As a contrast, the indicator introduction of new to the market products measures the share of firms that during a three-year period introduced products that were new to the market (i.e., new to the 'world'). On this indicator, Sweden ranked 4th (out of 5), with only Norway behind. Interestingly, on both indicators Swedish firms performed better in comparison to other countries in services, but poorly in comparison to other countries in manufacturing.

The indicator turnover due to new to the firm products is the turnover due to new-to-the-firm products introduced during a certain period, divided by total turnover at the end of the period. On this indicator, Sweden performs very well, ranking first among the 5 countries compared. Hence the performance is much better in this respect than with regard to the proportion of all firms that innovate in new-to-the-firm products.

The indicator turnover due to new to the market products is the ratio of turnover due to new products or significantly improved products (goods or services) introduced during the period 1998-2000, divided by the total turnover in 2000. On this indicator, Sweden is somewhat below the average, ranking 3rd (out of four). Thus, Swedish firms perform relatively worse with regard to creation than to imitation.

It is also interesting that the performance on this indicator is much better for small firms than for large ones, i.e. small firms are much more creative than large ones, as compared to the other countries. Hence the overall performance of all firms – which is, on the average, worse with regard to creation than to imitation – can be explained by the domination of large firms in the Swedish NSI.

Conclusions

Comparatively speaking the input indicators for Swedish firms are very high. On the output side all indicators are quite low compared to the other countries – with only one exception: turnover due to new to the firm product.[10]

The comparison made here has been with 4-5 other small industrialized countries in Europe and the result should be tested through further comparisons with more countries. Even so, we have reformulated the paradox in more specific terms than previously discussed in research and policy literature. Our overall conclusion is that the Swedish NSI is not as capable as some other small industrialized countries of transforming the very large resources invested in R&D and innovation activities on the input side into correspondingly large outputs of product and process innovations on the output side. The productivity (or efficiency) of the Swedish NSI is, in this sense, simply not high. Hence the existence of the Swedish paradox is confirmed on the basis of the different, broader and more detailed indicators based on CIS2 and CIS3.[11] More specifically, the results suggest that the underlying problem may reside with the large firms that dominate the NSI, and their under-performance in innovation outputs.

The conclusions of the analysis in section 3 will be discussed in considerably more detail in Section 7.1.

4 Activities that influence innovation

Having confirmed, extended and specified the Swedish paradox in the previous section, we will now conduct a detailed analysis of the activities possibly influencing innovation processes. Among other things, this will contribute to assess the validity of the three hypotheses that have been advanced to explain the paradox (see the Introduction to this chapter). We follow a set of authors who have stressed the need to go beyond the structural components of an NSI and concentrate on the activities or functions of the system (Johnson, 1998; Rickne, 2000; Liu and White, 2001; Johnson and Jacobsson, 2003; Edquist, 2005; Bergek et al., 2006; Bergek et al., 2007).

In this book we take the specific approach of activities. Edquist (2005) has compiled a general set of activities that may serve as a starting point for our analysis. These activities were presented in Box 2 of the introductory chapter of this book. This list is only ‘provisional’. Thus, our analysis does not claim to analyse all vital activities – or all aspects of these activities. Further, it does not rank the activities in importance, or reveal a master plan for redesigning the Swedish NSI. We hope simply to reflect tentatively on the extent to which innovation patterns in Sweden - and specifically the paradox - can be related to the activities of the system.

4.1 Knowledge inputs to innovation

4.1.1 R&D activities[12]

Measuring the volume of R&D input by national R&D expenditures as a proportion of gross domestic product (GDP), Sweden figures in the very top among OECD countries together with Israel, spending more than 1.8 times the OECD average and more than twice the EU average on R&D (Jacobsson and Rickne, 2004). Sweden and Finland are the only European countries that have displayed a catch-up vis-à-vis the USA on this indicator since 1991 (European Commission, 2003). Sweden has strongly increased its R&D spending, from a level of 2.3 per cent of GDP in 1981 to 4.3 per cent in 2001 (Marklund et al., 2004).[13] Noteworthy though, even though the growth rate is clearly positive with 2.2 per cent average annual growth from 1995 and on, several other countries have a stronger growth rate (e.g. Greece, Finland, Portugal) (European Commission, 2003, Figure 2.1.8).

Sweden's scientific output, as measured by publication, is high, accounting for 1.75 per cent of world publications, and placing it at rank 14 in spite of being a small country (ibid.). In addition, the citation rate, indicating quality, is relatively high, though it has recently declined in some biotechnology-related fields (Sandström et al., 2003). Sweden's scientific productivity[14] is not above that of many other OECD countries. (ibid.). However, the technological output as measured by patents is well above the EU average, vis-à-vis both actual numbers (rating as number 8) and growth rate, and Sweden is listed among the five fastest growing EU countries as regards patenting in the EU. As to the world's share of US patents, Sweden ranks 7th but shows a moderate growth compared to other European countries (ibid., Table 1.6)..

Sweden's relative scientific specialisation resembles that of Finland and Denmark, and lies within life sciences, food science and agriculture, environmental sciences, civil engineering and materials science (European Commission, 2003). In most of these fields the citation impact is above average, being especially strong within pharmacology and clinical medicine. The scientific profile is dominated by bio-medically related fields, where clinical medicine and health science, biomedicine and pharmacology and basic life science account for 56 per cent of the publications. Only the UK, the Netherlands and the USA have a comparable focus on these fields. Notable in comparison with other OECD countries is also a relatively small focus on chemistry as well as on physics and astronomy. As 'the 'age of the atom' is being overtaken by the 'age of the molecule' and, more recently, the gene' (ibid., 2003, p. 290), this may mean that Sweden is taking a promising direction. However, the fields of computer science, mathematics and statistics together account for only 3.2 per cent of the publications in this period (ibid., Figures 5.2.12-13).

In contrast, Sweden's technological specialisation (as measured by patenting across major technology fields) lies in general in mechanics and process industries with relative strengths in pharmaceuticals, telecom, materials and analysis-control, and weaknesses in biotechnology, audio-visual, IT and semiconductors. Notably, patenting growth rates are well above average in all fields except biotechnology and materials (ibid.). Even considering the time lag issue, this mismatch between the scientific and technological profiles may partly explain the low innovation output discussed in Section 3.

The Swedish organisation of R&D, whereby the business sector accounts for a major share of the activity, is different from many other OECD countries where firms are less prominent in R&D, but similar to that of the USA, Ireland, Belgium, Korea and Japan (Jacobsson and Rickne, 2004). The business sector has strengthened its dominance over the last two decades, driving the growth of R&D activity. In contrast, expenditure on R&D in the higher educational sector has remained fairly constant since the beginning of the 1980s and the government sector had only a slow increase until the end of the 1990s. Within the business enterprise sector, the large firms - with 500 employees or more - account for 83 per cent of R&D.[15] While the contribution of the service sector to R&D was still relatively small in 2001, it was above the EU average and its growth exceeded that of manufacturing. In non-business R&D, the higher education sector assumes a major role, while government research bodies and private non-profit organisations are relatively small actors compared to other countries. As regards sources of R&D financing, the share from corporate sources is large – considerably above the EU average

- and comes second only to Japan. Interestingly, it has increased over time, at the expense of public sector financing,[16] and was 72 per cent of the total financing in 2001 (Jacobsson and Rickne, 2004).

In brief, Sweden has clear strengths regarding both input and output of R&D. As pointed out in Section 3, Sweden's innovative firms are now increasingly located in services, and we have seen in this section that Swedish R&D is also characterised by strong dominance of the business enterprise sector – particularly by large firms – and relatively high rates of growth within the service sector. Coupled with these positive traits concerns are, however, raised regarding a potential mismatch between the scientific profile and the technological profile, potentially explaining that there is a problem in transferring scientific knowledge into industrial needs in Sweden.

4.1.2 Competence building

In 1994, total Swedish spending on education as a proportion of GDP was the highest in the world (OECD, 1998, p. 37), and in 1999 Sweden remained one of the leading OECD countries, with a share of 6.7 per cent just slightly below the leader, Korea, at 6.8 per cent, and well above the average of 5.8 per cent. (OECD, 2002, p. 170, Table B2.1a) Sweden also allocates a comparatively high proportion of educational expenditure to tertiary education. In 1999, Sweden spent 2.1 per cent of GDP on tertiary education, compared to an OECD average of 1.2 per cent (ibid., p. 78, Table B3.1). In 2003, this level of expenditure remained essentially unchanged, and Sweden ranked fifth among 25 OECD countries (Högskoleverket, 2003, p. 22).

Consequently, the Swedish labour force has a comparatively high level of educational attainment, with a rate of university graduation above the OECD average (OECD, 2002, p. 54, Table A31b). About 30 per cent of an age cohort graduates from higher education (Högskoleverket, 2003, p. 28). An OECD comparison of the EU-15, along with the USA, New Zealand, Australia, and Canada, ranked Sweden third in terms of the proportion of the adult population participating in education and training in 2001. The Swedish participation rate of about 55 per cent in 2001 was surpassed only by Finland (about 56 per cent) and Denmark (around 58 per cent). (OECD, 2002, p. 249, Chart C4.2) In another EU-15 comparison of workplace-based education in 2000, Sweden ranked fifth, with a participation rate of 42 per cent – well above the average of roughly 33 per cent. (Aspgren, 2002, pp.105-106, Figure 5.7).

Recently, Sweden has expanded its higher education system, developing towards a mass rather than an elite system, predominantly academic rather than vocational in orientation (Sohlman, 1996; 1999). The engineering shortages of the past have been overcome, with graduation rates of natural scientists and engineers (NSEs) becoming comparable to those of competitor countries (Aspgren, 2002, p. 102; Jacobsson et al., 2001; Sohlman, 1996, p. 71). A recent international comparison of the proportion of NSEs within the total population holding tertiary qualifications shows Sweden in third place, surpassed by only Germany and Korea (Marklund et al., 2004, p. 47, Chart 13.2, c.f. OECD 2003). The Swedish educational system remains entirely under Swedish control, and is still largely dominated by the public sector (although private schools are currently growing rapidly). Swedish higher education, however, has strengthened its internationalization since joining the EU in 1995. There is now a fairly even balance between foreign students at Swedish universities and Swedish students abroad (Högskoleverket, 2003, p.13-14).

Henrekson and Rosenberg (2001) address some rigidities of teaching in their critique of Swedish higher education. Such rigidities include barriers to competition among universities for both faculty and students, and barriers to competition among faculty within universities, both rendering universities unresponsive to shifting market demands. Historically, low remuneration paid to teaching faculty for high performance in specialisations under strong demand, separation of undergraduate teaching and research, and fixed programmes of study providing students with little latitude for choosing courses have all combined to make the Swedish system of tertiary education rather slow to respond to changing markets (ibid., pp. 223-226).

There has been considerable improvement in these areas since the early 1990s, which ushered in decentralisation reforms in both tertiary and non-tertiary education (Bauer et al., 1999; Lundahl, 2002). In tertiary education, these reforms were meant to make the system more market responsive and enhance international competitiveness. Although decentralisation has been achieved, it is still unclear whether it has translated into greater competitiveness. Arguably, the reforms have enhanced systemic flexibility at the level of competition among universities, but not yet sufficiently stimulated competition within universities. At the same time, it appears that many Swedish universities and colleges have not yet re-organised themselves to take full advantage of greater freedoms in internal decision-making (Alskling, 2001).

To summarise, the Swedish education system scores high in international comparisons of both inputs and outputs, and has improved its flexibility. The fact that most graduates now work in knowledge intensive services, rather than manufacturing (Marklund et al., 2004, p. 17), may help to explain why many of Sweden's innovative firms are now located in services, rather than manufacturing.

4.2 Demand side factors

Historically, several new industries and technologies in Sweden have been closely tied to new domestic demand, with national procurement initiatives providing initial markets for several 'state-sponsored development blocs' (Glimstedt, 2000, p. 207). Public technology procurement (PTP) has, in earlier times, been an important innovation policy instrument (Edquist and Hommen, 2000).

However, since Sweden joined the EU in 1995, its public agencies have faced greater institutional obstacles in undertaking PTP initiatives under the EC Directives on Public Procurement (Edquist, Hommen and Tsipouri, 2000). Sweden's accession to the EU was accompanied by a wave of liberalisation reforms that resulted in the dismantling of many state agencies and the privatization of many state-owned companies. There is still some scope for the use of PTP as a demand-side instrument for innovation policy, using the Swedish public sector's comparatively large size and high quality standards as points of leverage (Marklund et al., 2004, p. 9). However, most PTP projects now under way are mainly characterised by incremental innovation within existing industries. The 24SJU (24SEVEN) project of the Swedish Agency for Administrative Development, in which public administrations will procure information and communication technology solutions to make basic services available 24 hours per day, 7 days per week, provides one example (Karlberg, 2004; Kleja, 2004).

Product market regulation has shaped several important Swedish industries (Glimstedt, 2000, pp. 184-202). Among ‘institutions specific for each technological system’ (Carlsson and Jacobsson, 1997, p. 288), standards have been particularly important in, e.g., mobile telecommunications (ibid., 284-289; Glimstedt, 2001, p. 49). Standard-setting contributed to Ericsson’s (and Nokia’s) current leadership in mobile telecommunications equipment through ‘early identification of new technological opportunities (Carlsson and Jacobsson, 1997, p. 284-289). However, standard-setting has become increasingly internationalized, and private actors, especially producers, have become dominant in influencing the development of standards (Hommen and Manninen, 2003; Hommen, 2003).

Recent Swedish innovation policy has replaced purely demand-side measures with public-private partnerships (PPP) combining demand-and supply-side measures. For instance, the Swedish Agency for Economics and Regional Growth (NUTEK) programme ‘Design for Environment in SMEs’ was based on ‘networks of firms involving research institutes, universities, and in some cases customers of the participating SMEs, based on industry-specific supply chains, or on specific product development’ (Fukasaku, 1998, p. 124).

In summary, Sweden’s accession to the EU led to a shift in Swedish innovation policy, from a strategy of utilising domestic demand to one of relying upon international demand to stimulate industrial and technological development. Positive effects include gains in high-technology exports and new opportunities for MNEs (see Section 2). However, PTP and standard-setting have decreased in importance. These observations may help explain why the Swedish NSI currently performs better in turnover due to products ‘new to the firm’ rather than products ‘new to the market’.

4.3 Provision of constituents

4.3.1 Provision of organisations[17]

The birth rate of new firms is comparatively low in Sweden. This observation is worrying, since new firms are an important mechanism of industrial renewal. Even though 60 000-75 000 firms were established yearly during the 1990s, the population of new firms was still only 7.4 per cent of all companies in 2001.[18] In a large international survey, Sweden ranked only 33rd out of 41 countries in terms of the share of individuals engaging in firm formation (GEM, 2003). But in a study of new technology-based firms (NTBFs) established between 1975 and 1998 the accumulated population numbered almost 1 400 in 1998 (Rickne and Jacobsson, 1999), [19] and their relative share has increased over time. Although firm formation has maintained a constant level during the last decade, there has been a steady increase in science or technology-based spin-offs from universities and companies.

An unusually high proportion of new firms endure: The three-year survival rate was an impressive 55 per cent in 1998 (ITPS, 2003a). Regarding stability, one study showed that 63 per cent of the high-tech spin-offs established in 1996 passed the 4-year survival limit, comparing favourably with other Nordic countries (Nås et al., 2004). However, two thirds of the new firms are one-person companies (ITPS, 2002), and most other firms also remain small (OECD, 2004, p. 101). One study reveals that out of firms surviving three years (1998-2001), 40 per cent show some growth (ITPS, 2003a) but only a few grow substantially. Also, less than a third of the spin-off firms created in 1996 had created any employment expansion in the following 4 years.

Although many large, international companies have been created in Sweden, few of them were created during the last three decades. Among the newer established firms that do grow, some grow on their own account, but growth frequently seems to be enhanced by becoming part of a larger corporate structure through acquisition (Lindholm, 1994). Through mechanisms such as sub-contracting components and subsystems, acquisitions and spin-offs, large companies play an important role in creating and developing innovative new firms.

On balance, Sweden lags in creation of new firms and their contribution to industrial renewal. High survival rates are enlarging the population of firms and the formation rate of high-tech firms is increasing. However, the relative lack of growth may partly explain Sweden's lack of innovation as discussed in Section 3. The shift towards more service firms can be linked to the finding that Sweden's innovative firms are now increasingly located in services rather than manufacturing, and that the highest rates of 'new to the market' product innovation occur in knowledge intensive services.

4.3.2 Networking, interactive learning and knowledge integration

Empirical data indicates that innovative collaboration and networking seems to develop organically among Swedish actors and between Swedish and foreign actors. Swedish research often involves collaborations between researchers in firms and in universities or institutes, (private or public research organisations) resulting, for example, in joint publications or patents (Sandström et al., 2003). Out of all Swedish publications, 27 per cent are co-published with a national partner and 39 per cent with a foreign partner (EC, 2003, Figure 5.4.2) The importance of spatial closeness is stressed where there is a preference for Nordic partners, but there are many non-Nordic foreign partnerships. Sweden's rate of university participation in research joint ventures with US actors is – despite Sweden's relative smallness – among the 6 highest in Europe (EC, 2003, Figure 3.3.11). Naturally, patterns of R&D collaboration vary by sector, and science-based sectors such as biotechnology display very high intensities.

University-industry relations are frequent and important in some sectors. One study showed that 93 per cent of the Swedish biotech firms reported university cooperation (Vinnova, 2001). However, Swedish industrial actors finance fewer activities in universities or research institutes than do firms in other EU countries (EC, 2003, Figures 3.1.4-5). Also, a need for improved technology transfer is stressed by the finding that in East Gothia the main partners of firms pursuing product innovations are other firms (suppliers and customers), not universities (Edquist et al., 2000).

Swedish firms frequently enter into licensing, joint development, marketing or distribution, outsourcing agreements, etc. A survey of collaboration in product development, covering all manufacturing firms in East Gothia found that 70 per cent of all product innovating firms relied on partnerships (Edquist et al., 2000). This tendency can be illustrated by e.g. the field of biocompatible materials, where innovating firms rely heavily on other actors, and a large variety of partners – national and foreign – supply technological competencies, financing, market guidance, etc. (Rickne, 2000). Types of partners and resource exchanges vary substantially across sectors – with, for example, biotech entailing mainly technology development but also market-oriented relations (Alm, 2004).

These findings contrast starkly with evidence from CIS3,[20] where the proportion of cooperating enterprises was shown to be rather low in Sweden (around 30 per cent in 1998-2000) compared to other European countries.[21] The consistent pattern across countries was that a much higher share of large firms cooperate for innovation. In Sweden, 2/3 of large firms cooperated, but only 1/3 of SMEs. Comparatively, Swedish firms displayed low cooperation in all sectors except KIBS.

These competing observations, based on different data, each find support in the character of the Swedish system. The rather high degree of vertical integration in Sweden implies a lower degree of cooperation and fewer market-based sourcing solutions, as indicated by CIS. But the history and ownership structure of Swedish industry, as well as path dependencies involving technological trajectories, resource inertia, and variety creation (Glete, 1989; Rickne, 2000; Waluszewski, 2004) point to a system with extensive networking, as in the East Gothia study. Even so, there is a need to enhance collaboration and learning over organisational borders. Today, private initiatives such as industry associations and bridging organisations, as well as government schemes of various kinds – for example the Innovation Bridge Foundations and VINNOVA –

continue to provide arenas for meetings, coordinate suppliers, or spur university-industry relations by making such cooperation a prerequisite for financing.

4.3.3 Provision of institutions

Here we focus on institutions such as science and technology (S&T) employment rules, corporatist arrangments, intellectual property rights (IPR) laws, competition rules and trade agreements.

Andersson et al. (2002) and Henrekson and Rosenberg (2001) point to insufficient incentives for academic entrepreneurship, with consequently poor performance in commercialising research results via NTBFs (Lindholm-Dahlstrand, 1997a; 1997b; Rickne and Jacobsson, 1999) including university-based start-ups (Olofsson and Wahlbin, 1993; Rickne and Jacobsson, 1996; Marklund, 2001). The Swedish labour market featured low returns on human capital from the 1960s to the 1980s (Edin and Topel, 1997; Fredriksson, 1997). In 1995, Sweden had the lowest wages for experienced teachers among leading OECD countries (OECD, 1995). Rigid pay scales and poor remuneration for high performance and specialisation in areas of high demand persist in academia (Etzkowitz et al., 2000; Stankiewicz ,1986, p. 90).

Sweden’s post-war social-democratic welfare state was favouring large firms and strong trade unions (Esping-Andersen, 1990). Sweden also developed corporatist economic policy-making based on tripartite co-operation (Ruin, 1974). Initially, the ‘core institution’ governing economic growth and industrial change was ‘labour market regulation’ (Benner, 1997, p. 202). Later, public companies, investment planning and

R&D policy assumed more importance, and by the 1990s policy aimed at low inflation and labour market flexibility (ibid., pp. 205-213). However, corporatist arrangements remained intact (Edquist and Lundvall, 1993, p. 291). Unions were thus rewarded for co-operation with employers, supporting production-based learning within firms and collaborative learning within industries (Glimstedt, 1995; 2000). However, extensive social security has been confined to large manufacturing firms and the public sector, encouraging a lock-in that can lower the impact of public investments in R&D and education (Andersson et al., 2002, pp. 45-46).

Since 1949, the ‘university teachers’ exemption’ has granted faculty at Swedish universities complete ownership to research results. Arguments for the university teachers’ exemption stress that it minimizes bureaucracy and does not preclude voluntary agreements between universities and their employed scientists (Sellenthin, 2004). An alternative arrangement with university involvement would also require more effective technology transfer services (Rosenberg and Hagen, 2003, p. 25-26).Critics argue that this law does not mitigate costs, uncertainties and risks of commercialization (Brulin et al., 2000). Critics also point to a weak incentive structure with negative effects on both universities (Henrekson and Rosenberg, 2001, p. 225) and faculty (Etzkowitz et al., 2002). There is also evidence of ‘anti-entrepreneurial peer pressure’ within university departments (SOU, 1996, p. 70). These conditions may have contributed to the underdevelopment of NTBFs in Sweden and may help to explain the low innovation intensity of SMEs. Some Swedish universities have therefore recently introduced extensive infrastructures for enhancing commercialization.

Sweden's EU accession in 1995 implied liberalization and internationalization Deregulation of the capital market had already occurred in the 1980s. In the 1990s followed sweeping reforms in telecommunications (1993), electricity (1996), banking, finance, postal services (1993) and domestic air travel (1992). A central aim was to create new entrepreneurial arenas and innovation opportunities, in both Sweden and the EU. Since Sweden joined the EU, moreover, the ownership of Swedish MNEs has become increasingly internationalized (Andersson et al., 2002, pp. 28-29).

To sum up, EU membership made it difficult to pursue 'demand side' innovation policy (Edquist, 2002, pp. 40-42), as argued in Section 4.2. Liberalization also spelled an end to 'state-sponsored development blocs' (Glimstedt, 2000, p. 207). Both S&T employment relations and IPR law and legislation can be linked to Sweden's continuing underproduction of NTBFs – and, hence, the relatively low innovation intensity of Swedish SMEs. Conversely, aspects of both corporatist arrangements and competition and trade policy seem to have perpetuated the dominance of large firms and reinforced established technological trajectories. These factors help to account for the much higher innovation intensity of large firms, relative to SMEs, and Sweden's generally poor performance with regard to the introduction of new to the market products.

4.4 Support services for innovating firms

4.4.1 Incubating activities

Sweden’s division of labour in initiating, financing and operating science parks and incubators varies greatly and includes government supported non-profit units, university-driven units, PPPs, and private initiatives in corporate incubators.[22] Incubation is seen as a potent policy tool, and university-related incubators have most often been initiated and financed by public money. Recently, a national technology-based incubator programme aiming to operate on a long-term basis and include financial support services has been designed on the initiative of government actors.

Following the example of US and UK science park establishments in the 1970s, Sweden’s incubation activities commenced in 1983, with the Ideon Science Park in Lund (Bengtsson, 2003) and an additional 15 parks were established between 1983 and 1989. However, the positive results were not as strong or direct as anticipated (Ferguson, 1998; Lindelöf and Löfsten, 1999; Löfsten and Lindelöf, 2002). This led to a systematic review, in which science parks were highlighted as only one instrument in an innovation environment (Vinnova, 2002). Today, some incubators are stable and successful, while many still struggle.

The Swedish universities have incorporated ‘technology transfer offices’ similar to those at Stanford University or Massachusetts Institute of Technology only since the mid-1990s. Today, most large universities have some form of unit for handling patent and licensing issues, and promoting entrepreneurial and cooperative activities. Searches for entrepreneurial opportunities are undertaken through e.g. venture competitions or innovation prizes. However, there is much more to be done. In 1998, Sweden officially assigned universities a ‘third mission’ of diffusing knowledge for societal use, but few means are devoted to it by governmental or other bodies. Academic researchers own the right to their inventions, but other supports for commercial activity – i.e., incentives, suitable career structure, time, financial resources, role models and experience – are often missing.

While deficiencies in incubation may help to explain the relatively low innovation intensity of Swedish SMEs, there have been dramatic enhancements since the beginning of the 1990s. Policy actors and the bridging organisations they have formed, as well as universities and private firms have played important roles.

4.4.2 Financing

Since the joint effort by government and a merchant bank to create the first venture capital (VC) firm in 1973, the Swedish VC industry has experienced waves of increase and decline (Berggren, 2002; Isaksson et al., 2004).[23] In the early 1980s a promising stock market and the formation of the OTC-list in Sweden encouraged both private actors and government funds to enter the industry. However, a shakeout followed, due to high interest rates, a weakening stock market and a promising real estate market. This resulted in a shift to majority investments and late stage financing. The 1990s saw a moderate growth, and the valuable experience cultivated by the long-term surviving VC firms was important when the situation evolved into a significant expansion of the industry in the latter part of the decade. This was a response to the increase of the number of high-tech firms, the growth in the stock market and input from both private savings and pension funds (Vinnova, 2002), and was consistent with European patterns. However, the global downturn affected the Swedish VC market in 2000 and a severe decline has followed.

Based on the description above, Sweden has often been pointed out as having an impressive level of VC activity. It is indeed true that there are an increasing number of actors on the VC market, and that the percentage of GDP devoted to VC is well above the EU average (Eurostat, 2003). In fact, the number of actors tripled (from 50 to 150 firms) between 1998 and 2002, at the same time as the funds managed quadrupled (from 45 to SEK 190 billion). However, as Sweden started from a low figure, she is still in somewhat of a catch-up situation. In fact, many developed EU countries have been ahead of Sweden for many years and Sweden has yet to develop a fully competent capital market with experienced actors and sufficient institutional support (Karaömerlioglu and Jacobsson, 2000; European Commission, 2003). While an upsurge has certainly put Sweden on the map and been important for firm formation and growth, the industry can still be characterized as relatively immature, in terms of institutional structure, phase of financing and sectoral focus.

Thus, first, there are some misgivings about the institutional structure underlying the VC market. In effect, in a comparative study analysing the regulatory environment for VC, Sweden was ranked below average in Europe (EVAC, 2004). Positive features mentioned are the fund structure, the company tax rate, the ease of registering a new company and the regulation for reorganization and bankruptcy of a company. More negative aspects include the strict regulation of mergers, the lack of a special tax rate for SMEs, the income and capital gain taxes for individuals, the lack of tax incentives for individuals, and the lack of fiscal incentives for inter-firm cooperation (see also SVCA, 2002).

Second, as regards the phases of development which are VC financed, a relatively large share of the funds has been allocated over time to late stage development. Indeed, surveys show that 30-50 per cent of the funds managed by Swedish VC firms are invested in any of the phases from seed to expansion, and the rest in buyouts (EVAC, 2001). In fact, while the heavy lagging seed financing has displayed an upsurge since 1998, later figures have disputed this trend (Nutek, 2004). Interestingly, although the government aimed to increase the volume of seed capital through the establishment of two large investment organizations in 1992 (Atle and Bure), these bodies subsequently refocused on later stage financing (Isaksson and Cornelius, 1998). While the lack of early stage financing to some extent seems to be handled by the entrepreneur's own sources, bank loans are mainly an option for more mature buyouts and neither source is sufficient (Nutek, 2004).

Third, another worry concerns the sectoral focus, where only 28 per cent of the total equity capital in Sweden is allocated to high-tech sectors, as compared to the EU average of 38 per cent and the astonishing US figure of 79 per cent (European Commission, 2003).

All-in-all, even though several EU countries have long been ahead, Sweden does have a good situation with growing financial options for firm formation and expansion. However, there is clearly a quandary in Sweden as regards maturity of the VC market and the involvement of all the types of actors necessary for a smooth sequence of financing and the provision of resources to high-technology firms. Much has been done towards the development of the VC industry in Sweden, but it still requires much improvement, and its current state may help to explain why the innovation intensity of Swedish SMEs is not exceptionally high. Especially, the fact that there is a relative shortage of seed and early stage financing and the lack of high-tech focus may possibly contribute to explaining the Swedish paradox. A positive sign is a visible internationalization of the VC market. In fact, although domestic actors dominate the financing of innovation and VC firms located in Sweden invest mostly in Swedish firms (82 per cent) or in other Nordic companies (13 per cent) (Nutek, 2004), foreign organisations are nevertheless involved in every fifth investment and the financing process has become more internationalized.

4.4.3 Provision of consultancy services

Nearly all Sweden's private consultancies are located in the KIBS sector.[24] VINNOVA's recent comparison of nine countries – Austria, Germany, Denmark, Finland, France, Italy, Norway, Sweden and the USA (Marklund et al., 2004, Figure 4.4) shows that Sweden's KIBS sector is not especially large. Sweden ranks seventh in the proportion of total services belonging to KIBS, sixth in the percentage of the total labour force employed in KIBS, and sixth in the per centage of total population employed in KIBS (ibid.). The sector has recently expanded rapidly, with high employment growth from 1981 to 1991, returning to more moderate rates in 1991-2000 (ibid., Table 5.4). This development was part of a more general change in sectoral employment patterns, whereby increasing employment in knowledge-intensive services, combined with stable employment in other services, contributed to a net increase in private sector services until 1985, after which private sector employment in knowledge-intensive services continued to increase, while other private sector services, as well as public sector services, stagnated (ibid., p. 17).

KIBS has clearly become important for innovation processes, due to the reorganisation of other sectors. Thus, KIBS has for some time accounted for a very large share of the employment of all Sweden's qualified NSEs. In 1996, 41 per cent of all NSEs employed in private or public organisations were employed by manufacturing firms, and nearly as many were employed by firms in KIBS (Nutek, 1998, p. 133).[25] Moreover, a majority of the NSEs employed in KIBS were employed in small firms, bolstering the innovation capacity of SMEs. In manufacturing, especially in high-technology and medium-high-technology industries, there has been (and remains) a strong positive association between firm size and NSE employment. Large firms in these industries accounted for two-thirds of the net increase in NSE employment in manufacturing over the period 1993-1996 (ibid., p. 137). In services, though, a different pattern prevails. In KIBS, 63 per cent of the net increase in NSE employment took place in SMEs, and was fairly evenly divided between small firms and medium-sized firms, with 34 and 29 percentage points respectively (ibid.).

Sweden's KIBS sector also exhibits a high level of innovative activity itself. An analysis of CIS2 data for Sweden has shown that a high proportion of all innovating firms, well above the service sector average of 36 per cent, were found in the Financial Intermediation and KIBS sectors, where the shares of innovating firms were 59 per cent and 51 per cent, respectively (Nählinder and Hommen, 2002, p. 11, Table 2). KIBS firms were also especially strong investors in human resource development related to innovation, with the proportion of all innovative KIBs firms investing in innovation-related training standing at 67 per cent – far more than in any other of the service sectors covered by the CIS2 survey (ibid. p. 12). A more recent analysis of independent survey data has confirmed these findings and provided a more detailed profile of innovation in Sweden's KIBS sector (Nählinder, 2003). According to this survey's results, 82 per cent of Swedish KIBS firms exhibit a high level of knowledge intensity in terms of the employment of qualified personnel (ibid., p. 14), and some 82 per cent of this population of firms engaged in some form of innovation during the period from 2000 to 2002 (ibid., p. 15). This figure is much higher than the corresponding figure of 51 per cent arrived at by the Swedish CIS2 survey, and is arguably more reliable, given that the CIS2 survey in Sweden provided poor and uneven coverage of the service sectors.

To summarise, the recent expansion of Sweden's KIBS sector, together with the centrality of KIBS firms to many innovation processes, and their typically high levels of knowledge intensity, may help to explain why Swedish firms are currently more innovative in some service sectors, particularly, finance and trade, as compared to manufacturing. These observations may also help to explain why the Swedish NSI also performs well in new to the market products within such service sectors.

4.5 Summary of the main activities influencing innovation

In our discussion of the nine activities influencing innovation processes we have, at times, related the arguments to the Swedish paradox. In the introduction, we mentioned three hypothetical explanations to the paradox: 1) there are obstacles to technology transfer from the R&D sphere to the commercial sphere; 2) sectoral allocation of R&D is problematic; and 3) internationalization of production means that the results of Swedish R&D is increasingly exploited abroad. We have found support for the first hypothesis under Section 4.1 (Knowledge inputs to innovation), Section 4.3 (Provision of constituents), and Section 4.4 (Support services for innovating firms). We have also found some support for the second hypothesis under Section 4.3 (Provision of constituents). However, we have found no support for the third hypothesis, which will be revisited in Section 6.

5 Consequences of innovation

In this section, we address the consequences of innovation. We focus on productivity at the micro, meso and macro levels. First, we assess the relation between innovation expenditure and turnover growth. Subsequently, we examine the relation between turnover and growth of value-added. Then, we consider evolution of labour productivity and sectoral changes in value-added. Finally, we assess changes in sectoral value-added.

Micro level

On the micro-level, we find a weak[26] but significant[27] association for manufacturing firms between turnover increases of at least 10 per cent and engagement in innovation (as indicated by the level of innovation expenditure), for both the 1994-1996 and 1998-2000 periods. Thus, the most successful firms (as measured by turnover increases) are likely to be those who have invested in innovation. However, it is problematic to identify causality here. It might be that the most successful firms are more likely to invest in innovation.

Turning to the sectoral level, we hypothesize that sectors with the highest shares of turnover due to new products during the 1998-2000 period were also those with the highest growth of value-added in the following year. Changes in labour productivity between 2000 and 2001 derived from the STAN dataset show how productively labour is used to generate value-added (OECD, 2001). We couple this measure with the share of turnover due to new products during 1998-2000 according to CIS3.[28]

The result of the correlation test indicates a negative and significant correlation between the two variables.[29] This result suggests that, in a given sector, the higher the share of turnover due to new products during 1998-2000, the lower the growth of value-added was likely to be between 2000 and 2001.

This result rests on a small sample and must be regarded with caution. It may be partially explained by the spectacular drop in value-added of the ‘machinery and equipment’ sector between 2000 and 2001.[30] However, it could also be evidence that ‘successful’ innovative sectors - as measured by the share of turnover due to new products - also experience the smallest increases in value-added. This is counter-intuitive since, statistically, innovation’s impact on value-added seems to be negative.

Meso level

To assess structural changes, we examine the last decade. We assess the <u>average share</u> of sectoral value-added as related to value-added created by the whole economy, as well as the variation of these shares relative to the grand total between 1991 and 2001 (see Table 1).[31]

There were significant structural changes during the period. The weight of the manufacturing sectors increased relative to service sectors in the Swedish economy, representing an average share of 21 per cent versus. 69 per cent respectively of the total value-added between 1991 and 2001. 'total manufacturing' grew by 9.17 per cent whereas 'total services' grew only by 3.2 per cent. However, 'computer and related activities' experienced a spectacular 192 per cent increase, its relative share in the total value-added standing at 1.65 per cent. There was a concurrent decline of traditional low-tech sectors. Both 'construction', and 'cgriculture, hunting, forestry and fishing' dropped by about 34 percentage points. The latter represented an average proportion of total value-added of 2.40 per cent, and the former an average share of 4.71 per cent.

Comparing these sectoral differences in value-added with R&D expenditures between 1993-2001, we note that the sector with the most dramatic growth in value-added – i.e. 'computer and related activities' - has also undergone the strongest growth in R&D expenditures (from index 20 in 1995 to nearly index 120 in 2001). It experienced a 100 percentage point growth of R&D investment (see Figure 2).

Macro level

Comparing evolution of labour productivity, measured as GDP per hour worked between 1979 and 2001 (see Figure 1) with other countries, Sweden neither catches up with nor lags behind USA. Sweden has remained at a high level, slightly above 80 per cent of

USA level of labour productivity. Compared to the other countries, Sweden remained at fourth ranking almost all through the period, despite remarkable catching-up in most of the other countries. By 1997, Ireland had over-taken Sweden, and has performed better ever since, reaching the third rank and approaching becoming second-best (replacing the Netherlands). At this macro level, it is difficult to investigate clear relations between different kinds of innovations and performance; therefore we have to rely more on lower levels of aggregation for these purposes.

Conclusions

In summary, the most successful Swedish firms are likely to be those investing most in innovation. However, the most innovative sectors are also those experiencing the smallest increases in value-added. Sweden has had moderate success in evolution of labour productivity. However, the example of ‘Computer and related activities’ illustrates innovation’s positive impact on firms’ value-added.

6 Globalization

MNEs have played a central role in the Swedish NSI, accounting for as much as 70 per cent of the total private-sector R&D in the later 20th century (Braunerhjelm, 1998). As shown in Section 4, the dominance of domestic MNEs has contributed to the Swedish paradox by diminishing commercialization of research results and maintaining a disproportionately high allocation of R&D resources to low-and medium-technology sectors with little potential for growth. Many of Sweden's large firms have long been highly internationalized in production and sales; more recently, ownership has also been internationalized (Edquist and Lundvall, 1993, p. 291-292). Foreign ownership and relocation of head offices has created great concern (Andersson, 1998) and off-shoring of more sophisticated forms of production threatens the innovative capacity of supplier industries (Metall, 1998). As suggested in Section 2, the latter trend may also eventually undermine the increases in high-technology manufacturing exports that Sweden achieved during the 1990s.

In the mid-1990s, Sweden's high-technology manufacturing MNEs had not yet begun to make the majority of their R&D investments abroad, and they are not likely to do so within the near future (Nutek, 1998, p. 113-118, Figures 6.11 and 6.13). Moreover, foreign subsidiaries still rely strongly upon exports from Sweden, and Sweden continues to have a positive trade balance in high-technology products (Marklund et al., 2003, pp. 13 and 32, Figure 9.3). However, Swedish high-tech MNEs have begun to substitute outward FDI for exports based on domestic production (Braunerhjelm, 2004). Further, although these firms continue to invest strongly in R&D within Sweden, an increasing share of their production is located abroad (ITPS, 2003), and their contribution to GDP continues to decline (Marklund et al., 2003, p. 13). It is clear that the internationalization of production in Sweden has proceeded further than the internationalization of R&D, and that 'multinational industrial groups find Sweden considerably more attractive for R&D activities than for production' (ibid., p. 32). Thus, there is substantial support for the hypothesis that the Swedish paradox can be at least partly explained by globalization, in the sense that R&D carried out in Sweden increasingly bears fruit in terms of innovations in other countries.

7 Strengths and weaknesses of the system and innovation policies

Section 7 is based on our previous analysis. In Section 7.1, we concentrate on the strengths and weaknesses of the NSI and in Section 7.2 we focus on policies recently pursued. In Section 7.3, we address innovation policy implications for the future, based on the preceding discussion.

7.1 Strengths and weaknesses

From Section 3, we conclude that the Swedish NSI is <u>strong</u> on the <u>input side</u> and rather <u>weak</u> on the <u>output side</u>, i.e. the Swedish paradox is confirmed. One exception to the overall pattern of strength on the <u>input</u> side is that innovation expenditures of SMEs were not exceptionally high. Sweden has the greatest difference between large firms and SMEs in this respect. If high innovation expenditures is considered to be a weakness, we have thus also identified a weakness at the input end of the paradox. However, if a high innovation output can be achieved with a low input, it can also be considered to be a strength (see the discussion of small firms' performance below).

Transferring to the output side, Swedish firms were not particularly innovative according to an indicator measuring process and product innovation combined. However, they were more innovative in some service sectors than in manufacturing; manufacturing is weaker than some other parts of the system in this respect.

Performance was poorer for process innovations than for new (to the firm) product innovations. This weakness is surprising in the light of previous studies, covering earlier periods. Judging from the CIS data, a new weakness in process innovations seems to have emerged during the 1990s.

In introduction of new to the firm products, Sweden performed badly by one measure (proportion of firms carrying out product innovations) and well by another (turnover due to new to the firm products).[32] On the output side, the latter is the only indicator for which the Swedish NSI performs well. Hence the two indicators on new to the firm products point in different directions. However, with Sweden's very high R&D and innovation intensities, this performance should have been better. On both indicators, Swedish firms performed somewhat better in some service sectors than in manufacturing.

For new to the market products, Sweden performed very badly on both available indicators (proportion of all firms carrying out new to the market product innovations and proportion of turnover due to new to the market products). The paradox is certainly strong in this respect.

It can also be noted that the performance on this indicator (new to the market product innovations) is much better for small firms than for large ones, i.e. small firms are much more ‘creative’ than large ones in comparison with the other countries in the sample. Hence, the overall performance of all firms – which is, on the average, worse with regard to creation than to imitation – can be explained by the domination of large firms in the Swedish NSI. We have above seen that small firms spend considerably less than large ones on innovation, and that (as expected) they perform rather badly with regard to number of innovative firms, but that they perform well above the average with regard to turnover due to new (to the market) products. This is a great strength of small firms within the Swedish NSI.

Taken together, the results on the four last indicators discussed can be interpreted in the following way. As compared to input efforts, Swedish firms performed well with regard to one of the indicators capturing new to the firm products, but badly on the other one. Swedish firms performed badly with regard to both indicators capturing new to the market products. More specifically, Swedish firms are reasonably good at imitating products that have already been introduced elsewhere by other firms, but they are very bad at innovations that are brand new (new to the world). In broader terms, this means that the Swedish NSI is not creative in a profound way. It is locked into producing products that are not unique.

Turning to the activities - or determinants of innovation processes - analysed in Section 4, Sweden is strong with regard to R&D and competence-building. However, the generation of organizations causes concern. The volume of new firm formation is simply too low. Connected to this is a VC market whose growth has finally taken off, but which has not yet supported early stages and high-tech ventures sufficiently.

Other support services for innovating firms have been weak in the past but are now improving. Incubation support has been established in recent decades, through diverse actors and initiatives, and is now better coordinated. With the rapid expansion of KIBS, consultancy services are plentiful.

As regards networking, a high degree of vertical integration may imply a lower degree of market-based sourcing solutions, as indicated by data from the CIS surveys, but in fact other studies point to a system with extensive networking, even though strengthening is needed in relation to e.g. university-industry collaboration.

Demand side activities, generally, are underdeveloped, having been largely reduced to seeking global markets through internationalization and restructuring domestic markets through liberalization.

Many problems of the Swedish NSI relate to institutions. Rigidities in S&T employment and uncertainties related to IPR legislation may have contributed to low rates of new firm creation. The relative success of large firms has been supported by corporatist organisation and competition and trade rules, but these institutions may also have hindered technological renewal by impeding the creation of new firms.

Large firms remain central to the NSI, and, as shown in Section 6, they have also been the primary agents of globalization through outward FDI. As a result, much of the return on Sweden’s R&D investment is captured abroad, rather than domestically.

7.2 Summary and evaluation of innovation policies pursued

We now address Swedish innovation policies pursued during the last two to three decades. We define innovation policy as all actions by public organizations related to the nine activities discussed in Section 4.[33]

Knowledge inputs to innovation

The total R&D expenditures are high in the Swedish NSI. However, while the business sector is strong in this respect, the public sector is weaker. The public funding has also been distributed more widely among an increased population of higher education organisations whose numbers have been swelled by the creation of many new regional universities and university-colleges. Hence, established research universities have experienced a real decline in public research funding (Sörlin and Thörnqvist, 2000).

Sweden has had a persistent under-production, relative to other economically advanced OECD countries, of university graduates in natural sciences and engineering subjects, particularly in disciplines related to high-technology industries, such as electronics and computer science (IVA, 1986). During the 1990s, therefore, Sweden greatly expanded its higher education system, focusing especially on increasing enrolments in natural sciences and engineering, and eventually reaching a level of NSEs graduation comparable to that of the US (Jacobsson et al., 2001).

Demand side factors

Sweden's relatively poor innovation output may partly be explained by the lack of market formation, where traditional instruments like regulation or PTP have recently had little scope, as compared to earlier decades.

Historically, Sweden's policy of 'armed neutrality' has meant that the military has been an important actor in the development of 'indigenous military technology' (Edquist and Lundvall, 1993, p. 281). After the fall of the Berlin Wall, it no longer plays that role. Other influential public agencies in Sweden have included state owned authorities for infrastructure in areas such as power, transport and communications. During the mid-20th century, procurement contracts between the state power authority, Vattenfall, and ASEA (now merged into Asea Brown Bovery, ABB) led to ASEA's early development of high voltage direct current transmission technology (Fridlund, 2000a). From 1954 to 1980, Televerket, the telecommunications authority, fostered Ericsson as a major supplier of telecommunications equipment, and later facilitated Ericsson's entry into mobile telecommunications (Fridlund, 2000b; Hommen and Manninen, 2003). PTP by the Swedish Railway authority, SJ, supported the development of the X2000 high-speed train during the 1980s by the transport division of ASEA (Edquist, Hammarqvist and Hommen, 2000).

Sweden's accession to the EU has made it awkward to utilize many of the policy instruments formerly used by public organisations to stimulate the development of new technologies from the demand side. PTP is now seldom pursued. Similarly, technological standard setting (see Section 4.2) is now carried out primarily by private sector actors. In addition, large firms have also become less suitable partners for national ‘innovation policy’ due to the effects of globalization.

Provision of Constituents

When it comes to public organisations related to innovation, there have been frequent restructurings. In the late 1960s, there occurred an ‘industrial policy offensive’, characterized by ‘an emphasis on state ownership and public support to industrial renewal’ (Benner, 1997, p. 221). It included large public subsidies to sunset industries such as textiles and shipyards. For example the support to the ship-yard industry amounted to as much as 0.5 per cent of Sweden’s GDP for a ten-year period. It left no surviving results. Hence the industrial policy offensive eventually failed as industrial policy per se (Arvidsson et al., 2007, pp. 36 and 101-102). Failing support to ailing industrial sectors served as a lesson that everyone in Sweden seems to have accepted. No-one now advocates public support for established industries that are not competitive. However, as we will see in Section 7.3, the negative attitude towards public support to specific sectors of production changed in 2004.

However, the industrial policy offensive marked an important turning point for technology policy in another respect. It led to the creation of the Swedish Board for Technical Development – later transformed into NUTEK - and the initiation of a number of large-scale projects involving public and private sector cooperation in the development of new technologies in fields such as nuclear energy, telecommunications and military aircraft (Benner, 1997, pp. 121-123).

In 2001 important changes were made in the organisational set-up of innovation policy in Sweden.[34] NUTEK was divided into two parts, one still named NUTEK and the other one was called The Swedish Agency for Innovation Systems (VINNOVA). VINNOVA's mission is to promote sustainable growth by developing effective systems of innovation and funding problem-oriented research. The name is rather unusual, since national policy organisations are seldom named after an academic theory or approach. Renamings of relevant public activities and organisations from the 1960s to the early years of the 21st century also reflect a changing policy emphasis: from industrial policy, to technology policy and then to innovation policy.

One important institutional measure has been to charge the universities with a third mission, which in 1998 was explicitly stated in the new regulation of universities as the task of engaging with the surrounding society, disseminating research information outside of academia and facilitating societal access to relevant information about research results (SOU, 1998, pp. 128 and 153-154). This reform was largely, though not exclusively, directed towards the commercialization of university-based research, through the promotion of various forms of university-industry collaboration. However, this third task is not regarded as at all as important as the 'original' tasks (teaching and research), e.g., in academic appointments.[35]

Support services for innovating firms

The main policy initiatives taken in recent years to provide support services to innovating firms, particularly NTBFs, have been concerned with academic-industry relations, in areas such as public R&D expenditures, technology transfer initiatives (including the third mission), and public support for the financing of innovation. Higher education reforms (see Section 4.1.2) have figured prominently in this context, as have efforts to develop a VC industry in Sweden.

In addition to the third mission, a number of other reforms in the area of academic-industry relations have been implemented in recent years. From the early 1980s onwards, several Swedish universities have sought to build up an infrastructure for the exploitation of university patents and other research results. Between 1983 and 1997, 17 science parks were established in Sweden with government assistance, and since 1993 universities have been allowed to set up wholly owned companies for the commercialization of their research. (Henrekson and Rosenberg, 2001, p. 212)

Increased public support for the financing of innovation has complemented the above-mentioned reforms of higher education. NUTEK has continued its activities in this area, and since 1994 the Swedish government has also established seven Innovation Bridging Foundations in major university regions. Their mandate is to support the commercialization of (largely university-based) R&D by assisting inventors with patenting and aiding the start-up of SMEs – by, for example, locating appropriate VC financing (Henrekson and Rosenberg, 2001, p. 212).[36]

Numerous government schemes – as many as 140 in 1998 – have been introduced to increase the proportion of Swedish VC investment allocated to seed and early-stage financing for NTBFs, albeit with rather modest success (Landell et al., 1998). Public actors were essential for the formation of the VC industry, establishing the first VC firm, encouraging regional formation, and supplying most of the monetary resources during the

1970s and a significant share in the 1980s. Also, in the surge of VC formation in 1982-1984 many smaller funds were formed by pension funds, insurance companies and real estate companies. Policy changes were crucial to these developments. For example, regulatory reforms allowed government pension funds to make equity investments (Karaomerlioglu and Jacobsson, 2000). In addition, the creation of the OTC-list in 1982 opened up the stock market as an exit route (CEBR, 2001). Recently, the Innovation Bridging Foundations have become an increasingly important tool. As discussed in Section 4.4.2, there is still a relative shortage of seed and early stage financing. However, efforts to increase the overall size of Sweden's VC industry have met with considerable success. During the late 1990s, Sweden became the third ranking EU country in terms of the amount of VC relative to GDP (Isaksson, 1999; Karaomerliogu and Jacobsson, 2000).

7.3 Future innovation policy

We now turn to suggesting policies for the future development of the Swedish NSI. Above, we have identified weaknesses representing problems and unexploited opportunities that should be subject to policy interventions or changes.[37]

We have confirmed the existence of the Swedish paradox, enlarging the input side to cover not only R&D but also all other innovation expenditures. We have also specified it on the demand side. Further, we have found support for all three hypotheses that have been advanced to explain the paradox. (1) In Section 4, on Activities that influence innovation, we found support for the first hypothesis, concerning obstacles to technology transfer from the R&D sphere to the commercial sphere, in relation to Section 4.1

(Knowledge inputs to innovation), Section 4.3 (Provision of constituents) and Section 4.4 (Support services for innovating firms). (2) We also found support for the second hypothesis, which points to a problematic sectoral allocation of R&D, under Section 4.3 (Provision of constituents). (3) The third hypothesis, according to which internationalization of production means that Swedish R&D is increasingly exploited abroad, was supported by our assessment of globalization in Section 6.

The dominance of incumbent large manufacturing firms (MNEs) is a common element in all these explanations. We are therefore persuaded that the underlying problem concerns the apparent inability of these large firms to translate innovation inputs into outputs – at least not in a way that secures that the return on Sweden's R&D investment is captured domestically, rather than abroad.

(1) Regarding obstacles to technology transfer from the R&D to the commercial sphere, most recent policies have concentrated on creating incentives and infrastructures for improving university-to-industry technology transfer. Given that corporate sources account for 72 per cent of R&D funding, it would be logical to address the overwhelming domination of business sector R&D by large firms to a larger extent. This is especially so, since small firms are more efficient innovators than large ones - comparing inputs and outputs, i.e. productivity - and also perform better in product innovation. Innovation expenditures and resources are much lower for SMEs than for large firms. At the same time, large firms are becoming less suitable partners for a national innovation policy, because of ongoing globalization.

Hence, there are strong reasons to increase R&D and innovation expenditures and efforts in SMEs in advanced sectors. The recently started VINNOVA program entitled

Do Research and Grow (Forska och Väx) may be instrumental here. Regional clusters and collaboration in strategic R&D and innovation including SMEs should also be strengthened. One thing that could be done is to facilitate the spin-off of new firms from large firms, in cases where the latter are not commercialising results from R&D and innovation efforts to a sufficient extent. These instruments would lead to the establishment of more new innovation-based firms.

(2) With respect to the problematic sectoral allocation of R&D, policy-makers have generally ignored the institutionally induced lock in of R&D resources and results to large firms in traditional sectors. Public agencies have even supported R&D in traditional sectors to a large extent, such as research in relation to forest-based industries, and provided direct subsidies to the textile and shipyard industries mentioned before. Further, many of the reforms introduced in recent decades have actually exacerbated this problem, reinforcing existing sectoral and technological specialization patterns. Therefore, there are reasons to stimulate the development of new knowledge-intensive industries, by encouraging large firms to diversify into them, by assisting the birth and growth of new innovation-based firms in new sectors and by attracting foreign firms in advanced sectors of production. One infrastructural mode of doing so would be to make more strategic use of public funding for R&D (Edquist, 2002, pp. 53-54).[38]

In 2004 the Swedish Ministry of Industry abandonded the dogmatic resistance to formulating policies at – and providing public support to - a sectoral level. This was actually a crucial paradigm shift in Swedish innovation policy which replaced the dogmatic rejection of sector-oriented policies based on the failures in textiles and ship-yards mentioned in Section 7. The Ministry formulated 6 sectoral policy initiatives for the following sectors: Aerospace, Motor vehicles, Metals, Information Technology/Telecom, Forest and wood and Pharmaceuticals/biotech/medical technology.

It is a major step forward that the policy is formulated at the sectoral level. However, it is (still) a problem that the list of sectors includes a large part of industry – and, accordingly also established and traditional sectors that can be expected to finance their own future development. Less policy effort and fewer public resources should be allocated to well-established, 'traditional' sectors, and stronger, more focussed interventions should be pursued in radically new areas of technical development (Edquist ,2002, pp. 53-54; Arvidsson et al., 2007, pp. 9-18). In other words, public R&D and innovation efforts should be more effectively targeted to sectors of production that are new and where uncertainty is large.[39] Such a strategy can be seen as an attempt to balance previous policy measures – or, rather, mistakes – in Sweden. These mistakes have contributed to a lock-in effect that has actually supported the maintenance of the existing production structure. Examples are substantial support to ailing industries through subsidies, currency devaluations in the 1970s and 1980s and public R&D support to traditional industries.

Complementary measures could be developed on the largely neglected demand-side of innovation policy by, e.g., following the EU's recent 'rediscovery' of PTP as a policy instrument for stimulating private sector innovation. Sweden's current lack of attention to the demand-side is reflected by the country's poor performance in new to the market product innovations, with the exception of a few service sectors. These exceptions should provide models for new thinking on, and initiatives in, demand side policies, including new forms of PPS and new combinations of supply and demand side measures.

(3) Regarding the internationalization of production by MNEs and the resulting failure to capture returns on R&D investment within the domestic economy, Sweden faces a quandary. On one hand, outward FDI has meant declining benefits from Sweden's historical specialisation in low-tech and medium-tech sectors and industries dominated by very large and increasingly internationalized firms. On the other, it has also meant the development of Sweden into a global centre for R&D activities and services – a potential source of comparative advantage which, however, remains under-utilized. Public policy cannot intervene very much in the internal affairs of large firms in order to exploit this source of opportunity. Instead, it should try to build upon and complement their valuable contributions to the NSI, including the creation of a strong labour market for NSEs and other R&D personnel and expression of sophisticated, 'leading edge' demand in relation to domestic supplier industries.

These innovation policies should include elements of 'attraction policies'. These are a matter of how MNEs can be influenced to locate high productivity activities (such as R&D) within the borders of Sweden (Arvidsson et al., Chapter 8). However, there are certainly dilemmas associated with pursuing such policies in the present era of globalization. It can be questioned that the state in a small country, for example, subsidises R&D activities of large, foreign-owned MNEs. At the same time, public support to (R&D in) Swedish innovation-based SMEs can also means that the pay-offs for Sweden disappears – if the firms move early to other countries, maybe because they get larger subsidies there (Borrás et al., 2007).

What should be addressed is the industrial ecology surrounding the large international firms, in an effort to replicate the virtuous relationships between KIBS firms and the large service sector firms whose unbundling created them (Nählinder, 2005). Much could be done towards achieving such a balance. For instance, supplier firms that already benefit from collaboration with MNEs should be encouraged to interact with a broader range of customers. Inter-firm networks of innovation in Sweden have a strong ‘vertical’ character, due to domination and control by a few large firms, and could be greatly enhanced by measures to support collaboration and learning over organisational borders. Increasing collaboration with customers through diversification should markedly improve Swedish firms’ poor performance with respect to product innovations – both those that are new to the market and those that are new to the firm.

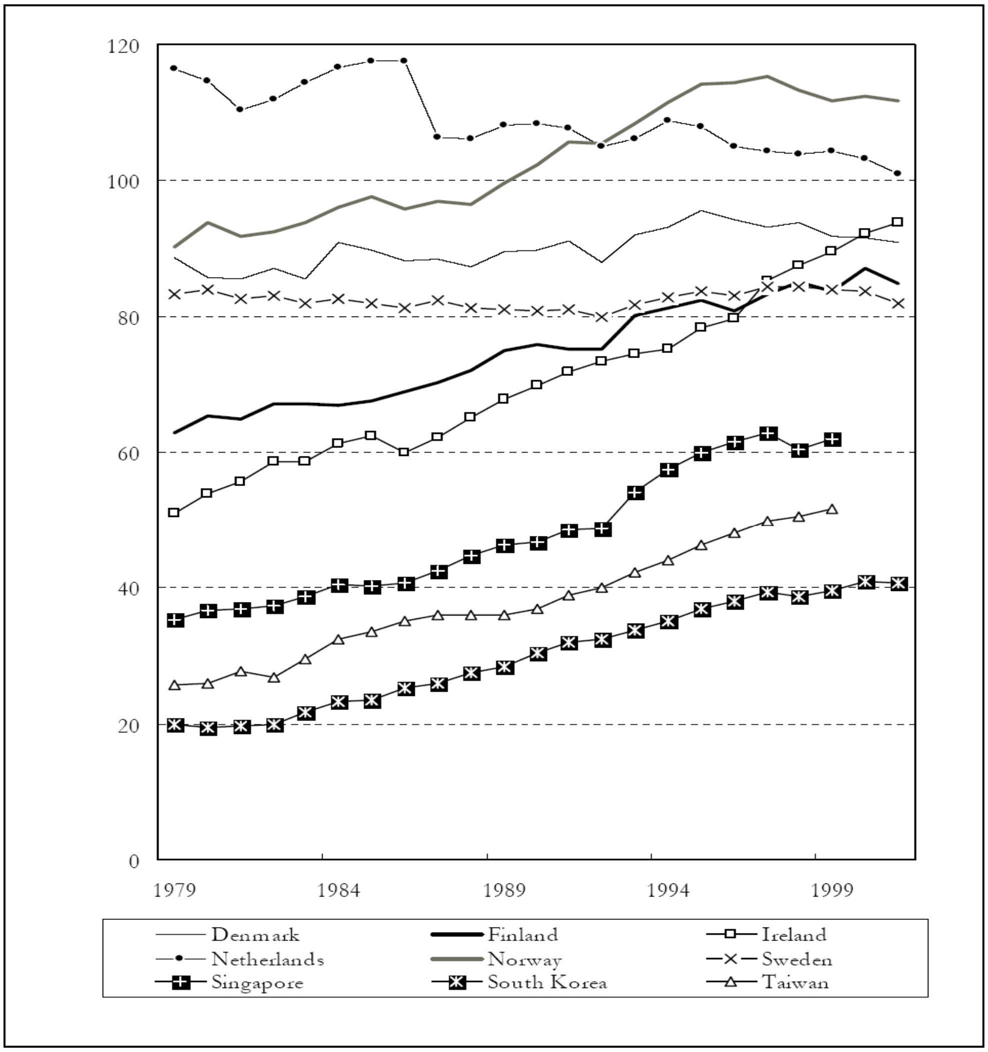
In addition to indicating some new policy directions, sketched above, our analysis also recommends continued support for some initiatives already under way. Efforts to stimulate translation of research results from universities into innovations in firms should be strengthened, by pushing the third mission, and improving both financing and additional support services for innovating firms, particularly those formed to exploit academic research results. Increasing the presence of this type of firm should help to ameliorate low innovation expenditures by SMEs in Sweden. The innovation gap between Sweden and other countries is greatest in manufacturing, and calls for more policy efforts targeted towards manufacturing. For instance, policy should try to make process innovation a preferable alternative to relocating production abroad.

However, there is still also a general need to stimulate product innovation, since such innovation is the main engine of renewing the production structure of any NSI. Here, newer and smaller firms seem to be more creative than older and larger ones and should therefore be the main focus. Efforts to alter the production structure towards stronger representation of high-technology sectors should also be continued, with emphasis on entry into new knowledge fields and creation of new sectoral innovation systems. A shift towards a more knowledge-intensive structure of production would increase productivity, economic growth and employment. However, it can only be achieved by combining many of the policy measures discussed here.

With regard to practically all the issues addressed in this chapter, much more data could – and should – be created and collected and the analysis should be made much more profound in many respects. This chapter has only scratched the surface and calls for more profound analysis of many issues. In addition, the NSI’s strengths and weaknesses will also change over time, and policies will have to be adjusted. This task requires continuous and in-depth analyses, to which considerable resources should be committed. Therefore, our most important policy proposal is that a collective analytical effort is needed to create a knowledge basis for innovation policy. Learning for policy and through policy is crucial

Table and figures

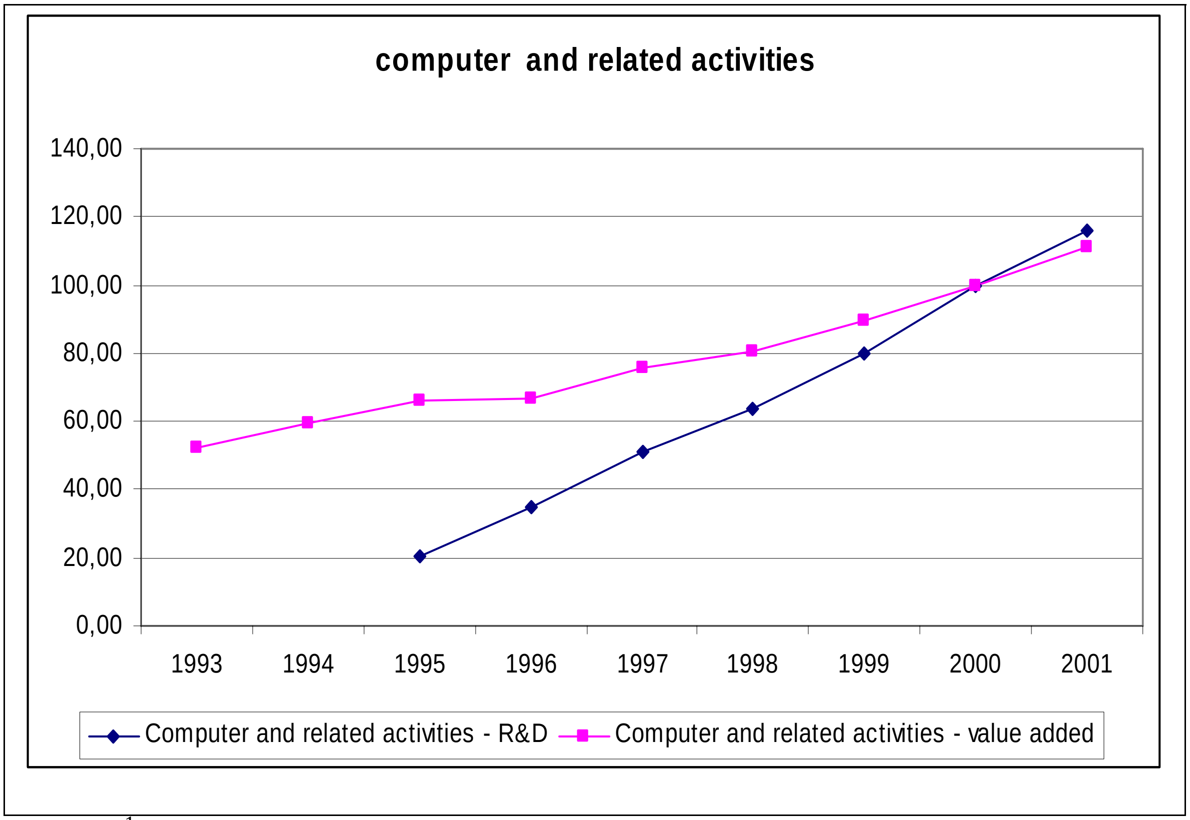
Figure 7.1: GDP per hour worked, in 1990 PPP US$, USA=100, 1979-2001



Notes: The Geary-Khamis method is used when benchmarking PPP's for GDP. It is used as an aggregation method used to weight and sum the commodity-group parities to arrive at PPP's for each category of expenditure up to the level of GDP.

Source: Appendix 1: Statistical bases of comparison for ten 'small country' NSIs,

Figure 7.2: R&D expenditure[1] and value added[2] for the sector Computer and related activities in Sweden (year 2000=100)



Source: [1] Own calculations ANBERD - R&D Expenditure in Industry (ISIC Rev.3) Vol. 2003 release 01

[2] using the STAN database for Industrial Analysis Vol. 2004 release 04

Table 7.1: Industrial structure of Sweden – Average share of the value-added of the different sectors in the grand total (%) and variation of the share in the grand total (%) from 1991 to 2001

Sectors	Average share 1991-2001 (%)	Variation 1991 - 2001 (%)
AGRICULTURE, HUNTING, FORESTRY AND FISHING	2,40	-34,26
MINING AND QUARRYING	0,31	-30,99
TOTAL MANUFACTURING	20,79	9,17
Food products, beverages and tobacco	1,83	-4,51
Textiles, textile products, leather and footwear	0,29	-21,13
Wood and products of wood and cork	0,93	-11,93
Pulp, paper, paper products, printing and publishing	3,30	18,04
Chemical, rubber, plastics and fuel products	2,77	33,72
Other non-metallic mineral products	0,51	-18,85
Basic metals and fabricated metal products	2,76	10,99
Machinery and equipment	5,15	-3,62
Transport equipment	2,70	25,80
Manufacturing n.e.c.	0,55	15,31
CONSTRUCTION	4,71	-33,84
TOTAL SERVICES	68,79	3,20
WHOLESALE AND RETAIL TRADE; RESTAURANTS AND HOTELS	12,15	0,75
FINANCE, INSURANCE, REAL ESTATE AND BUSINESS SERVICES	23,60	14,38
Financial intermediation	4,03	-25,96
Computer and related activities	1,65	191,83

Source: Own calculation and presentation based on STAN database for Industrial Analysis (OECD Organisation for Economic Co-operation and Development, 2004:06).

NOTES

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[2] This publication of 1998 was written in 1994, was internally published in 1996 and was based on a publication from 1992 – which, in its turn, was a translation of a chapter in an appendix to the final study of the Swedish Productivity Delegation from 1991 (Edquist and McKelvey, 1991).

[3] See further Sections 6 and 7 about the dominance of large firms in the Swedish NSI.

[4] The CIS data referred to here are presented in Section 4 of the Appendix 1: Statistical bases of comparison for ten 'small country' NSIs in this volume. A series of 15 tables provides detailed comparative data on the countries mentioned here.

[5] This also means that we will give priority to indicators that are available for both periods.

[6] This indicator includes not only R&D but also acquisition of machinery, equipment and knowledge,

training, market introduction of innovations, design and other preparations for production or distribution.

[7] In Bitard et al. (2005), Section 1, Footnote 1, we pointed out, however, that the data seems to be uncertain for innovation intensity 1998-2000.

[8] Our data measured mainly technological process innovations and did not include organisational process innovations.

[9] There it was shown that Swedish manufacturing firms were among the world leaders in the 1970s and 1980s with regard to the diffusion of computer-controlled process technologies (numerically controlled machine tools, industrial robots and flexible manufacturing systems) in the engineering industry.

[10] This could indicate that the new (to the firm) products innovated, on average, account for large volumes of sales, which is certainly a great strength of the Swedish NSI.

[11] In addition, the input component of the Swedish paradox can be extended to all innovation expenditures, which does not only include R&D expenditures. Further, the difference between Sweden and the other countries with regard to this indicator was even larger for innovation intensity than for R&D intensity. In other words, the paradox can be reformulated along these lines: on the input side we could use innovation intensity instead of R&D intensity – or both.

[12] The analysis in this section partly supplements the discussion in Section 3. There the discussion was focused upon R&D performed by firms. Here both private and public R&D is discussed. The sources used are also different between Section 3 and Section 4.1.1.

[13] While we have no reason to doubt the high R&D expenditure in the business sector (accounting for approximately 75 per cent of the R&D expenditure), a recent study shows that there are some measurement problems involved in assessing non-business R&D, making this part of the R&D volume somewhat overestimated (Jacobsson and Rickne, 2004). This means that although Sweden does have a very high R&D expenditure, the figure of 4.3 per cent may be somewhat overestimated.

[14] As measured by the number of publications per input unit (e.g. the number of R&D personnel or researchers).

[15] Although this may not appear much higher than the EU average (77.9 per cent), there are large differences across countries (Finland. 71.8 per cent; Denmark, 60.6 per cent).

[16] The common trend of reduction of defense budgets in the beginning of the 1990s has naturally had a strong influence on public R&D expenditures.

[17] This sub-section focuses on new firms. Other organisations, especially those that support innovation, will be discussed in Sections 4.4 and 7.

[18] There is a relatively large stock of small firms in Sweden, but not a high formation rate of new firms.

[19] NTBFs, or high-tech firms, are those with a clear scientifically or technologically innovative character (Rickne, 1999).

[20] CIS asked whether or not the firm had cooperated on innovation activities, and if so with what kind of partner.

[21] Note the study by Edquist et al. (2000) relates to product innovations only, while the CIS study also refers to process innovations.

[22] Science parks and incubators are, of course, two different things. In Sweden, however, most science parks have deliberately incorporated incubator functions, either formally or informally, and very few incubators are found outside of science parks.

[23] The venture capital and private equity industry (here termed the VC industry) involves the support of unlisted companies, both economically and with active owner involvement.

[24] The following discussion focuses on private consultancy services, and therefore on the KIBS sector. Public consultancy services have been addressed in Section 4.4.1 and will also be dealt with in Section 7.

[25] This source defines KIBS as including 'business service firms, R&D firms and firms engaged in wholesale trade with machinery and equipment' (NUTEK 1998: 133).

[26] Phi and Cramer's V was equal to 0.115 in the first period and 0.148 in the second period. The values range between 0 (no correlation) and 1 (perfect correlation).

[27] At the 5 per cent level of confidence.

[28] A 10-sector decomposition was chosen, including the following sectors: Food products, beverages and tobacco; Textiles, textile products, leather and footwear; Wood and products of wood and cork; Chemical, rubber, plastics and fuel products; Other non-metallic mineral products; Machinery and equipment; Transport equipment; Manufacturing n.e.c. (not elsewhere classified); Financial intermediation and

Computer and related activities.

[29] cf. Pearson coefficient= -0,673, significant at the 5 per cent confidence level.

[30] At the same time, the volume of hours worked in this sector remained constant.

[31] Based on STAN database for Industrial Analysis (OECD, 2004, 06).

[32] As mentioned in Section 3, this could indicate that the new (to the firm) product innovations, on average, account for large volumes of sales, which is certainly a great strength of the Swedish NSI.

[33] The discussion here is structured according to the areas of activity discussed in section 4. It will concentrate on outlining broad, general trends in policy, since it is beyond the scope and possibility of this sub-section to mention all of the specific policy measures that have been taken. Instances of specific policy measures will only be referred to as examples used for illustration and explanation.

[34] With regard to the provision of organisations, public efforts to encourage the formation of new firms was be discussed under Section 4.4 (Support services to innovating firms) below.

[35] Institutional reforms, such as deregulation and privatization measures have been mentioned under Section 4.2 (Demand side factors). The same is true for policies for supporting networking and collaboration between organisations.

[36] In late 2004, the seven Innovation Bridge Foundations were reorganised into one national organisation with regional branches.

[37] We have also identified ‘strengths’. These should not be subject to policy or policy changes (since private actors or prevailing policies already secure a good performance).

[38] Anyone reflecting on this realizes that most policies – including publicly funded R&D – are problem-oriented and selective rather than neutral. Of course, also firm strategies are a matter of selection between alternatives. For both public and private actors such choices are extremely difficult, but cannot be avoided. (These arguments are developed in the concluding chapter in this book.)

[39] As shown in the concluding chapter of this book, such policies have been pursued in many of the ten countries addressed.

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