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Comparing the Danish and Swedish Systems of Innovation

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SIMILARITIES AND DIFFERENCES BETWEEN DENMARK AND SWEDEN[1]

Most comparative work on national systems supporting technical change has focused on the differences between the United States and Japan. Such comparisons may be very useful as first approximations; they demonstrate, lucidly, how differences in national economic structures and institutional setups are reflected in differences in the rate and direction of technical change. In this chapter Sweden and Denmark, i.e., countries that are much more similar, are compared.

From a non-European perspective, Sweden and Denmark might seem almost identical.[2] But the closer the observer gets the more visible the differences become. In this chapter it is proposed that the Danish and the Swedish systems of innovation have quite different characteristics. It is argued that these characteristics are embedded in the economic structure and in the socioinstitutional setup and that they have strong and deep roots in the economic history of the two countries.[3]

Proximity and Common Characteristics

The distant observer is certainly right in perceiving striking similarities between Denmark and Sweden. It takes less than half an hour to cross the Sound between them, and on arrival in the neighboring state you can read its newspapers and, with a minor effort, take part in conversation with its citizens. There are few legal difficulties limiting movements across the borders. You do not have to show your passport, and you have the same right as the indigenous population to enter the labor market.

The living standard, life-style, and consumption pattern do not seem to vary much between the two societies. In both countries the public sector is in charge of systems for education and health service, which are of a comparably high quality. This is reflected in high tax rates and generally, of course, in a large public sector. Important factors behind the expansion of the public sector have been the strong Social Democratic presence in politics and the strong trade unions.

Looking back in history, we find important parallels that might partly explain the similarities of today. Both countries were industrial latecomers. In 1979 the two countries were ranked among the 10 countries having the highest GNP/capita (Sweden as number 6 and Denmark as 8). Apparently, both countries have been successful in exploiting technology to stimulate economic growth. Thus, it is easy to understand why a distant observer would tend to speak about these two small and rich countries as reflecting one single Scandinavian, or Nordic, model. One point to be made in this chapter is that such similarities in overall aggregate performance might coexist with—and even conceal—radical differences between national systems of innovation. Also, it implies that quite different institutional setups may be effective in exploiting technological opportunities. One question, however, is whether the Nordic systems of innovation, so successful historically, will remain so in the present and prospective global context.[4]

Conspicuous Differences in Indicators on Innovative Activities

Although the long-term growth records look rather similar, the most up-to-date indicators on innovative activities put Denmark and Sweden into two different leagues. We can see from Table 8.1 that Sweden is a country investing heavily in R&D whereas Denmark is characterized by an internationally very modest R&D effort. Turning to output indicators we find that Sweden is one of the countries with the highest numbers of patents per capita in the United States, whereas Denmark has a very weak record in this respect.[5]

What is the background for these dramatic differences between the two countries? We shall argue that they reflect qualitative differences in the national systems of innovation and that these differences can be understood only if we take into account specificities of the historical process of industrialization in the two countries.

We will also propose that one important, contemporary, factor behind the observed differences in registered innovative activities is the degree of economic concentration, and the related role of domestically based multinational capital in the two economies.

Table 8.1. Comparison of R&D Intensity (1985) and Number of United States Patents Per Million Inhabitants in Denmark, Sweden, United Kingdom, United States, and Japan, Annual Averages 1980–1985

Innovation Indicators	R&D Expenditures/GDP (%)	United States Patents Per Million Inhabitants 1980–1985
Denmark	1.25	27
Sweden	2.78	89
United Kingdom	2.33	41
United States	2.78	158
Japan	2.81	79

Source: R&D expenditures from OECD (1988a, p. 13). United States patents for Denmark (the average for 1980–1982) from Mjöset (1986, p. 81) and for the other countries from Patel and Pavitt (1989, p. 20).

Again, the two countries present themselves as very different as shown in Table 8.2. In Denmark the small and medium-sized enterprises dominate in manufacturing and only a few internationally small multinational firms have their home base in Denmark. In Sweden the degree of concentration in terms of ownership and control is very high, even in international terms, and the amount of capital abroad controlled by Swedish firms is large, relatively speaking.

The Structure of This Chapter as Reflecting Conceptual Matters

The rest of this chapter is divided into four main sections. The first gives a brief historical sketch of the processes of industrialization in Denmark and Sweden. The second describes the anatomy of the two systems of innovation in terms of the socioinstitutional setup, the structure of production, and the R&D system. The performance of the systems is discussed in the next section. Finally some prospective problems are addressed. This structure reflects our understanding of what constitutes a national system of innovation, as outlined below.

The national system of innovation[6] is constituted by the institutions and economic structures affecting the rate and direction of technological change in the society. Obviously, the national system of innovation is larger than the R&D system. It must, for example, include not only the system of technology diffusion and the R&D system but also institutions and factors determining how new technology affects productivity and economic growth. At the same time, the system of technological change is, of course, less comprehensive than the economy/society as a whole.[7]

We assume that technical competence is built in a cumulative process. This is the reason why we find it useful to give a brief historical sketch of the industrialization process. The cumulative character of the process of technical change reflects that interactive learning is at the center of the process of technical change. Individual agents and organizations increase their knowledge in technical matters, not in isolation from each other, but in a process of interaction, involving learning from each other as well as producing new knowledge and innovations in cooperation.[8]

We also assume learning to be a process strongly based in routine economic activities. At the firm level, it involves workers and technicians (engaged in production routines), marketing people (engaged in selling to the ordinary customers), as well as laboratory personel (engaged in routine experiments). One result from learning is that new problems are registered, and entered on the agenda of organizations. But it also

Table 8.2. Indicators of Economic Concentration and of Domestically Based Multinational Firms

	Share of Value Added in Manufacturing by the 10 Biggest Firms, 1982 (%)	Foreign Employment in Domestic Large Firms, 1984 (Absolute Number)
Denmark	14	51,000
Sweden	33	256,000

Source: Data on value added from Nordic Growth (1984, p. 185) and on foreign employment from Industriökonomisk Institut (1986, p. 61).

produces important inputs to the process of solving the problems faced by organizations engaged in searching (R&D departments, etc.).

This is the general background for the section on the anatomy of the national system of innovation. The socioinstitutional setup focuses on corporative arrangements forming a framework for interactive learning. The development blocks define areas of specialization giving such processes their content and direction. The R&D efforts, representing attempts to expand knowledge through searching rather than learning, will, as well as technology policies, be rooted partly in the production system.

Having stressed interactivity and learning, it is analytically useful to make certain distinctions with regard to the process of technical change. In the section on performance, two such distinctions are used. First, it is fruitful to distinguish between product technologies and production technologies (or process technologies) in the sphere of production. Product technologies are or are included in products (goods or services) and production technologies are used in the process of production to produce goods and services.

Second, it is also useful to make an analytical distinction between development of technologies and their diffusion.[9] The development of technology involves the production of technically feasible prototypes (inventions) and their modification and development into economically feasible technologies (innovations).[10] A breakthrough innovation is here assumed to be made only once in time and space. Everything else is diffusion, which includes absorption or assimilation of technologies developed in other countries.[11] Diffusion also includes adaptations and incremental innovations. In other words, technologies are gradually modified and changed during the whole process of technical change (i.e., also during the process of diffusion).[12]

It may sometimes be difficult empirically to make a clearcut distinction between development and diffusion. And the same artifact may sometimes be a product technology and sometimes a process technology.[13] Sometimes, but not always, a radically new product technology will also involve a need for new process technology; they may mutually condition each other. But at the same time, the distinctions prove to be very useful, as analytical tools, when it comes to analyze and characterize the performance of national systems of innovation.

The fact that a country is strong in the development of new technology, for example, does not rule out that it has great difficulty in terms of diffusion—reflecting a weak ability to absorb new technologies (products or processes) into its production system. And the fact that a country is extremely strong in terms of the diffusion of process technology does not rule out that it has great weaknesses in the diffusion of new product technologies—reflecting a weak ability to take up the production of new products, characterized by strong growth, and developed abroad. As we will see, there are examples of both these kinds.

In the section on performance, Denmark and Sweden are compared regarding their capacity to develop new technologies. We then focus on the diffusion of new process technologies and, finally, we look at the diffusion of new product technologies. The analyses demonstrate that the capability profiles of Sweden and Denmark differ in these dimensions—which confirms the usefulness of the distinctions made.

The understanding of technical change as a cumulative process based on interactive learning implies that national systems tend to be geared to follow specific trajectories. The close relation between learning and searching is crucial when it comes to moving rapidly ahead along given technological trajectories. However, the close relation might also result in locking the system of innovation into a specific trajectory in a period characterized by a change in technology paradigm. In the long run, this may cause problems in terms of stagnation, especially as it may involve a weakness in relation to the diffusion of product technologies (i.e., a weak capability to absorb new product technologies developed abroad). This problem is discussed briefly with regard to the two Nordic systems of innovation in the final section on structural and institutional problems.

There are several important elements of the national systems of innovation which we have not included in this analysis of Sweden and Denmark. Examples are the financial system and the institutional characteristics of the R&D system. It is especially true for the education and training system and the work organization.[14] We believe that the interface between technology and the development of human resources is critical for the prospective survival and growth of national systems of innovation but this perspective will have to be elaborated elsewhere.

HISTORY: THE PROCESSES OF INDUSTRIALIZATION IN SWEDEN AND DENMARK

The present profile of the two systems of innovation illustrates the cumulative character of processes of technical change and the stubborness of historically established institutional setups and economic structures. The two economies have taken part in a rapid, and far-reaching, process of internationalization. Nevertheless, it is to an important extent possible to trace their present patterns of specialization and current specific strengths and weaknesses in their systems of innovation back to how their respective economies were industrialized.

From Grain to Butter and Meat: The Establishment of the Danish Agroindustrial Complex

In the 1870s, the Danish economy was predominantly agrarian and linked to the world economy mainly through its grain exports to the United Kingdom. In this decade new competitive grain producers (Russia and the United States) entered the British market. The Danish response to the resulting dramatic fall in grain prices (40% price reduction 1880–1890), and to the ensuing crisis in Danish agriculture, was a reorientation of production from grain to pigs and cattle and, also, gradually toward more processed products.[15]

It is interesting to note that the cream separator (a continuous centrifuge), which was to play a crucial role in making the dairy industry a modern process industry, was invented almost simultaneously in Sweden and Denmark in the 1870s.[16] The rapid diffusion of this technical innovation through the Danish economy in the following decades was combined with an important social innovation—the introduction of cooperatively organized ownership of dairies. This form of organization proved to be an efficient framework for the modernization of both primary agriculture and the secondary industries refining milk and cattle into butter and meat; by 1910 90% of total exports were processed agricultural products such as bacon, butter, and cheese.[17]

In the wake of the modernization of agriculture and as farmer's income level rose, the domestic market for industrial products expanded. In the 1890s, and again in the 1930s, new home market industries developed, but it was not until the 1960s that an increasingly export-oriented manufacturing sector developed. As late as 1958, 61% of commodity exports emanated from agriculture (including agroindustrial products such as butter, cheese, and bacon) and 39% came from manufacturing. In 1968, this had been reversed: 62% came from manufacturing and 38% originated in agriculture (Andersen, 1972, p. 62ff).

As we shall see, the history of the transformation of the agroindustrial complex is reflected both in the pattern of specialization of Danish technical competence and in the organization of innovation. The cooperatively owned agroindustrial sector has been very successful in developing, producing, and marketing food products of a uniform, and high, standard. State-supported development work and quality control have interacted with the efforts of the cooperatives aiming at a high and stable quality. The success is reflected even in the present export specialization of Denmark. Butter, cheese, ham, and bacon are still dominating export products earning an important part of foreign currency. The export specialization indices presented in Table 8.3 illustrate this fact.

One strength of cooperative ownership has been its stimulation of rapid technology diffusion. A weakness has been the one-sided focus of innovative activities on process technologies.[18] The R&D efforts have generally been small in the Danish agroindustrial sector[19] and this is especially true for R&D aiming at new product technologies.

Table 8.3. Export Specialization for Main Product Groups and for Some Dominating Natural Resource-Based Export Commodities in Denmark 1973–1987[a]

Product[b] and SITC Number	1973	1979	1987
Products based on natural resources	1.3	1.5	1.6
Bacon, ham, etc. (012.1)	49.4	46.9	30.4
Prepared preserved meat (013.8)	33.6	28.7	28.8
Butter (023.0)	10.3	6.8	4.7
Oil and gas	0.7	0.8	0.8
Chemicals	0.7	0.7	0.8
Engineering	0.7	0.7	0.6
Other industry	1.2	1.1	1.4

[a]The export specialization figures in Tables 8.3, 8.4, and 8.8 are calculated as "revealed comparative advantage" indices:

$$R_{ij} = \frac{X_{ij}/X_i}{X_j/X}$$

where R_{ij} is the export specialization index of country i in commodity j, X_{ij} is exports from country i of commodity j, X_i is total exports from country i, X_j is total OECD exports of commodity j, and X are total OECD exports (Dalum et al., 1988, p. 134). If the value is 1.0 there is no specialization. The more the values deviate from 1.0, the stronger is the specialization. If the value is larger than 1.0 there is a large export of the product (group) in question. If the value is below 1.0, this is a reflexion of a small export of the relevant product.

[b]The exact content of the product groups is specified in Dalum (1989, Appendix 1).

Source: IKE database (Bent Dalum).

From Agriculture, Forestry, and Mining toward Engineering in Sweden

Sweden was, of course, also a predominantly agrarian country in the latter half of the nineteenth century. Agricultural products were also exported. From about 1830 Sweden began exporting oats to England.[20] During some years in the late 1870s, oats was the second largest export product (after wood). The export of oats decreased sharply after 1880, but was immediately replaced by a large butter export.

However, in contrast to Denmark, a large part of Swedish exports had its origin in forestry and mining rather than agriculture. And this export did not consist of plain raw materials, but of refined products. From the seventeenth century to the mid-nineteenth century iron was the main mining-based export product.[21] During the latter half of the nineteenth century new processes made possible production of cheap steel—also from the phosphor-rich iron ore abundant in Sweden. Somewhat later iron and steel began to be transformed into machinery products before export. The forestry-based export commodities were from the mid-nineteenth century "plank and boards"—processed by the sawmill industry—as opposed to timber. Later, wood was further refined and exported as pulp and paper.[22]

The fact that the export products emanating from mining and forestry were already refined products created, in the case of iron and steel, an important metallurgical capability. Hence, an important part of the nineteenth-century transformation in Sweden took place outside agriculture. In particular, the engineering industry became—and still is—a strategic sector for the modernization of the Swedish economy around the turn of the century. Employment in the engineering industry increased from 23,000 in 1890 to 63,000 in 1912, while employment in mining and iron works decreased from 35,000 to 32,000 during the same period (Gårdlund 1942, p. 279).

This expansion of the engineering industry was gradually reflected in exports. In 1880 it constituted 3% of total exports, growing to 10.5% in 1911–1913 (Senghaas, 1982, p. 131). In the interwar period the proportion of machinery and transport equipment kept growing and in 1950 its share of total export had passed 20% (Svennilson, 1954, p. 180ff). Its share of manufacturing exports was now getting close to 50% and only in the United States was this share higher among OECD countries.

The development of the Swedish engineering industries reflected a small number of specific technical innovations introduced by Swedish inventors and entrepreneurs. Among early important Swedish technical innovations we find an automatic machine for cutting matches (Lagerman invented it around 1860), the separator already mentioned above (invented in the 1870s), and new methods for processing pulp (developed by Ekman in the beginning of the 1870s). It is important to note that these three early inventions were all closely related to the export-oriented process industries.

Several important Swedish innovations in mechanical and electromechanical systems took place around the turn of the century. Several of the largest Swedish multinational firms may, actually, be regarded as originally based on single product innovations. This is certainly true for Ericsson (innovations exploiting low current technology by Lars-Magnus Ericsson), SKF (the development of ball bearing technology by Wingquist), ASEA (the development of a three-phased motor by Wenström), and Alfa Laval (the separator). The focus on single inventions and inventors might be misleading to a certain degree. All of these technological breakthroughs were, obviously, cumulative in the sense that they were built on a competence reflecting several decades of experience with metal working and with technical development in engineering.

In Sweden, an important outcome of the process of industrialization was the combination of exports based on refined and processed raw materials on the one hand and the multinational engineering firms on the other. The Swedish system of innovation still reflects this combination both in its institutional setup and in its pattern of specialization—as indicated by the export specialization indices presented in Table 8.4. In particular, it is the small number of multinational firms in the engineering industry that plays a decisive role in this system.[23]

ANATOMY: THE TWO NATIONAL SYSTEMS OF INNOVATION

Introduction

In this section we will discuss the anatomy of the Swedish and Danish systems of technological change. We begin with a discussion of the socioinstitutional setups in the two countries. The focus is on the corporative interaction between the labor unions, the welfare state, and private capital.

We then take a closer look at the patterns of specialization and the production structure in the two countries. Among other things, we point out a few strategic development blocks in each country.

Finally, we address the R&D systems and the role of the state in relation to technological change (i.e., technology policy). We end by briefly characterizing the two systems of innovation.

Social and Political Similarities and Differences

Both Denmark and Sweden are modern welfare states. The size of the public sector and, especially, of the parts engaged in social security, health care, and education put them in a class by themselves. And, since the 1930s, both countries have been char-

Table 8.4. Export Specialization for Main Product Groups and for Some Dominating Natural Resource-Based Export Commodities for Sweden 1973–1987[a]

Products[b] and SITC Number	1973	1979	1987
Product based on natural resources	1.1	1.1	1.1
Mechanical wood pulp (251.2)	20.0	31.0	20.5
Kraft paper (641.3)	18.5	24.6	24.9
Iron and steel powder (671.3)	14.8	16.9	16.7
Oil and gas	0.2	0.5	0.7
Chemicals	0.5	0.5	0.6
Engineering	1.1	1.1	1.0
Other industry	0.9	0.9	0.9

[a]For definition of export specialization index, see note *a* in Table 8.3.

[b]The exact content of the product groups is specified in Dalum (1989, Appendix 1).

Source: IKE database (Bent Dalum)

acterized by strong trade unions and by a strong political presence of Social Democratic parties.

However, there are also important differences of a social and political character between the two countries. In Sweden a stable modernist social liberal norm system dominates the political culture and institutions while political culture is less homogeneous and stable in Denmark. For example, the room for political deviations to the left and right has been greater in Denmark than in Sweden. The Social Democratic dominance of the political scene and inside the trade unions has been less continuous and hegemonic in Denmark than in Sweden.

Differences in the structure and institutions of private economic power, rooted in the history of industrialization, are also important influences on the differences in political culture in the two countries. As we have seen in Table 8.2, a small number of private firms dominate Swedish manufacturing. Also ownership and financial control are much more concentrated in Sweden than in Denmark. In Denmark the farmers' movement and the small owners have played a much more important role. The Swedish corporative interaction between big capital and labor has contributed to the stability of political development while it has been more difficult to establish long-term and corporatist social compromises in Denmark because none of the parties has been strong enough to guarantee the fulfillment of such a contract.[24]

The Labor Market

The more "modern" character of the Swedish system and its more stable context for corporatist cooperation are reflected in the institutions around the labor market. In Denmark the influence of preindustrial organizational forms is reflected in the trade union structure, as well as in the systems for training workers. The trade unions in Sweden are centralized and organized along industry lines, while the Danish unions are organized according to profession and competence. The training system in Denmark is a dual system where one of its elements may be regarded as a remnant from preindustrial artisan training.

Labor market conditions differ greatly between the two countries. In Sweden the registered unemployment rate has never in the postwar period reached 4%, while it has reached and permanently stayed above 8% in Denmark since the 1973 oil crisis. In 1990 it is about 1.5 and 10%, respectively.[25] The very low level of unemployment in Sweden means that most sectors and regions experience a severe shortage of labor. Both countries spend considerable amounts of money on labor market policy. In Sweden most of the money is used to retrain or to reemploy hit or threatened workers. In Denmark almost all of the expenditures go to cash payments to the many unemployed workers.

The Swedish Model and Its Impact on the Process of Technical Change

In Sweden a fundamental historical compromise on rationalization and technical change was established in the 1920s and 1930s. In the late 1920s and early 1930s, the leadership of the trade union movement changed its attitude to the introduction of new technology, and to rationalization of the labor process, into a much more positive one.

Originally, the trade unions had been extremely negative to Taylorism and rationalization, regarding them as threatening the workers with technological unemployment. One of the reasons for the change in attitudes was the belief—rightly or wrongly—that the Social Democratic government, established in 1933, could guarantee that new production technology would not result in widespread unemployment. Another reason was their belief that unions would be capable of appropriating what they considered their rightful share of the productivity gains. Hence, the very positive attitude toward technical change of the Swedish unions has been around for many decades now. This is one sense in which the term "Swedish model" can be used.

Johansson (1989) shows in detail how agreements between labor and capital—with regard to rationalization, technical change, and related matters—have been reached through a complex process. In the majority of conflicting issues, the unions have, in negotiations with the employers, threatened to use their privileged links with (Social Democratic) state power and to "solve" the problems through legal means. However, this threat has, normally, led to an agreement through negotiations between the labor market partners, without any formal state interference. But, indirectly, the welfare state and its commitment to full employment policies has been an important precondition for the lasting viability of this compromise. Hence, the emergence of the "Swedish model" in this sense has been characterized by an interplay between three parties: (efficient and concentrated) capital, (strong and centralized) trade unions, and the (Social Democratic) state.

The permanent shortage of workers in the postwar period means that firms compete with each other in attracting workers. One means of competition is salary. Another possibility is to make jobs more interesting and stimulating. Firms are pushed to redefine jobs in order to enlarge the scope of tasks allocated to each worker and thereby make the jobs more attractive. This means that the shortage of labor has important consequences for the quality of jobs (Edquist and Glimell, 1989, p. 43).

The shortage of labor may also influence management strategies and work organization ideas and thereby the sociotechnical and organizational design of new factories. One example, although atypical in its radicalism, is the Volvo Uddevalla factory. The shortage of labor, combined with inferior working conditions in traditional automobile assembly, has contributed to a high turnover of workers and to absenteeism—which means large costs for the employer. This has been one of the reasons why Volvo has recently designed the factory in Uddevalla according to new principles. In Uddevalla there is no moving assembly line at all. Instead a small group of workers "builds" (which is the new word for assemble) the whole car in a 2-hour cycle[26] (Edquist and Glimell, 1989, pp. 43–44).

The term "Swedish model" can also be used to denote the Swedish model for economic policy, including union-managed solidaristic wage policy, which developed after World War II. One important aspect of the Swedish model, in this sense, was acceptance of and even active support of structural change of the trade unions. If an industrial sector was ailing it was assumed to reflect low relative productivity and/or stagnating demand. General economic policies pursued by the state (through investment funds and labor market policies) and by the centralized trade unions (through solidarity wage policies, securing the largest wage increases for the lowest paid worker) combined forces in stimulating a transfer of resources from the ailing sectors to growth industries with better long-run prospects. Gösta Rehn and Rudolf Meidner were the architects behind the Swedish model of wage formation.

The Danish Model and Its Impact on the Process of Technical Change

The dominance of small scale production, and the historical importance of the cooperative movement in agriculture, has limited the influence of big capital in Denmark. One important consequence of the success of the cooperative movement in gaining control in the dominating export sectors was that it closed these strategic sectors to private capital. This is reflected in the weak position of financial capital in relation to the Danish production system.

The survival of small scale and artisan-like production has fostered a kind of corporatism, very different from the Swedish. Small, independent, entrepreneurs in Denmark will often be quite negative to central trade union power, but at the same time, often willing to cooperate, locally, with their workers and their representatives. They will often be driven by incentives less oriented toward firm growth and more toward the maintenance of an independent, and reasonably comfortable, life-style.

This small-scale corporatist model often involving a flexible use of reasonably advanced production equipment and a continuous development of incremental product innovations has its strength in flexible adaptation. But a great weakness seems to be that it does not give enough incentives to use and develop human resources inside firms. In the 1980s Danish firms have invested heavily in advanced process technologies and the disappointing outcome in terms of poor productivity performance reflects, primarily, problems with labor organization and skill development (Gjerding et al., 1990).

The workers' attitude to rationalization seems to be different in Denmark than in Sweden. Some years ago, a questionnaire sent to a representative sample of Danish citizens asked about attitudes toward "new technology." Two-thirds of the respondents expected mainly a negative impact on employment, as well as on work satisfaction. The negative expectations were strongest among the unskilled workers but, even among small owners, the negative expectations dominated (Petersen et al., 1983).

Economic policies at the national level reflect the fact that the corporative parties are weak and heterogeneous. Although incomes policies, at least until recently, was a trade union responsibility in Sweden it is the state in Denmark that has repeatedly tried to regulate incomes and wages. It has proved difficult to make incomes policies efficient without a high level of unemployment, however.

On the Structure of Production as Reflected in Development Blocks

When comparing the structure of production in Sweden and Denmark, it is useful to isolate a small number of *development blocks,* in each of the two countries. This concept was developed by the Swedish economist Erik Dahmén. Dahmén's interest is in the *transformation* of industry and trade. Therefore he focuses on changes over time within and between microentities. According to Dahmén such changes are the essence of industrial dynamics. They imply disequilibria, which should not, however, be regarded as disturbances because they are essential in transformation processes (Dahmén, 1970, 1988, p. 4).

A *development block* is a sequence of complementarities—between technological, economic, and other related factors—which by way of a series of disequilibria (or structural tensions) may result in a balanced situation.[27] Dahmén talks about development blocks and structural tensions at different levels of aggregation—from the factory floor over the interplay between enterprises to a broader socioeconomic context. We will here use the concept at a level of aggregation lower than the national economy but still not focusing on distribution of production and employment only at the level of industrial sectors.[28]

A development block will, typically, involve several domestic sectors, coupled by strong quantitative and qualitative linkages. We assume that development blocks form frameworks for interactive learning and that the specific combination of such blocks at the national level will have an important impact on the direction of processes of technological change.

Development Blocks in the Danish Economy

In the historical review we saw how an export-oriented development block had already formed around the agroindustrial activities at the beginning of this century. Still, at the end of the 1970s slightly more than 42% of total nonservice employment and nonservice exports emanated from this block (Lundvall et al., 1984, p. 23). Its present importance is also reflected in the export specialization figures for the postwar period presented in Table 8.3. The successful transformation of the Danish agriculture in the last part of the nineteenth century is still strongly reflected in the pattern of export specialization.

Actually, the block encompasses two different modes of development and two different modes of innovation. The dominating one has at its center the farmer-owned cooperative process industries. The other mode is dominated by a few large (according to a Danish standard) private food-producing firms. Some of these firms are, or have been, semipublic firms, started as licensed monopolistic producers of, for example, liquor or sugar and several of them are controlled by the old merchant and shipping firm ØK.

We have already commented on the strengths and the weaknesses of the cooperative model. The one-sided focus on standardization and rationalization of the labor process in slaughteries and dairies combined with the neglect of product innovation reflects the mode of competition and ownership in the cooperative sector. With prices given through EC regulations the competition between the different cooperative companies has been directed toward gaining access to a maximum amount of raw materials (milk, pigs, or cattle). This competition has put strong upward pressure on input prices, and the individual owners of the cooperatives have not had any strong incentives to engage in costly and uncertain long-term projects. Actually the cooperative movement has been so successful that it has eliminated most private Danish slaughter firms and dairies. Also, the process of concentration of production in the cooperative process industries has gone much further than in the privately owned sector. Now, more than two-thirds of all milk is passing through one dairy company and at present strong efforts are being made to join the last handful of cooperative slaughter firms into a single one.

Among the private companies involved in food processing, we find some of the technically most advanced Danish firms. These firms are often conglomerates, with activities in related fields of chemical production or engineering. For example, the sugar refining company developed advanced know-how in filter technology to support its main line of business. This technology was later applied by affiliated engineering firms, first to refine milk, and later to wastewater treatment, and was built into environment technology. By international standards these firms are not big, however, and they operate, typically, in specialized niches.

Until the beginning of the 1970s, two other development blocks played an important role in stimulating the growth of the economy. One was oriented toward shipping and ship-building and the other toward construction. With the international crisis in shipping, following in the wake of the oil crisis, this development block became a structural problem in Denmark as in many other countries.

The same was true for the development block oriented toward domestic construction. This block had expanded very rapidly, especially in the 1960s, and it involved not only construction as such but also the cement industry. Again we find a strong Danish technological position in cement processing machinery and production systems (F.L. Schmidt). With the oil crisis a drastic reduction in the activities inside this block took place.

Of course, not all parts of Danish production are integrated in such development blocks. In the export-oriented industrial growth, in the 1960s, a number of technically rather advanced firms in electronics expanded and became internationalized. Several of them had developed their basic, and original, competence in an interaction with domestic users—often to be found inside the public sector—but gradually they developed into enclaves.[29] These firms are engaged in medical technologies, scientific instruments, and measurement, for example.

Another, much larger group of Danish firms, in the engineering sector, produces traditional machinery or components for engineering products for larger Danish or foreign firms. The production takes place on the basis of skilled workmanship often with the help of computer-controlled machinery. It is often very flexible in terms of the products, while the connection to R&D and science is quite weak.

Development Blocks in the Swedish Economy

As in Denmark, it is possible to locate Swedish development blocks around the basic export commodities (e.g., iron and steel and wood, pulp, and paper). In these areas there has developed an infrastructure of smaller firms, service organizations, equipment producers, and research organizations, according to Stenberg (1987). In particular, the relations between specific raw material sectors and suppliers of equipment are sometimes quite important. Examples could be paper pulp producers and paper pulp machine producers or mining and mining equipment producers. This argument means, of course, clustering together specific parts of the engineering industry with its customers, implying that the relations between producers and users of various products may constitute an important relation of interactive learning.

Another development block, discussed in Stenberg (1987), is one grouped around production technology for the engineering sector. However, the engineering industry as a whole would be a very large and heterogeneous block, and it would therefore be useful to divide it into subsectors. Such an analysis might reflect the interaction between (groups of) engineering firms and their suppliers and/or customers. Such a division of the engineering industry into subblocks would be motivated also by the fact that the suppliers and customers mentioned are also, often, firms in the engineering industry.

Such an analysis would result in a number of development blocks centered around the large Swedish engineering firms or parts of them. Examples could be an electricity block (ABB Electricity, Vattenfall, etc.), an automobile block (Volvo and SAAB automobile production and their subcontractors), a telecommunication block (Ericsson, Televerket, etc.) and an aereoplane block (SAAB aeroplane production, its suppliers and the Swedish defense procurement). The Swedish development blocks might, because of the dominant role of a single or a few large firms, work differently than the Danish ones.

The relative strength of these blocks can be indicated through figures on export specialization. In Table 8.4 we have given these numbers for products based on domestic natural resources (agricultural products, wood, pulp, paper, textiles and iron and steel), oil and gas, chemicals, engineering, electronics, and transport equipment, and other industrial products. Table 8.4 illustrates the strong position still held by the sectors based on the domestic raw materials wood and iron. It also points to a relatively strong position in engineering and to a very weak position in chemicals.[30] Actually, one might argue that engineering, historically, and in a complex manner, has grown out of the raw material development block and, of course, especially the part oriented toward iron and steel. This perspective is supported by the fact that Swedish competence and R&D activity in nonferrous metals are quite weak, while it is strong both in engineering and in iron and steel (IVA, 1979a, p. 52).

The R&D System and Technology Policy

We will not try to give a detailed description of the institutions and their activities in the field of R&D and public technology policy in Sweden and Denmark in this section. For detailed presentations we refer to various national sources as well as to the OECD Reviews of National Science and Technology Policies for Sweden (OECD, 1987) and for Denmark (OECD, 1988a). Instead we will make an effort to bring forward the most characteristic aspects in a comparative perspective.

The R&D Effort

In the introduction we noted that Sweden is a big spender on R&D (2.8% of GDP) and that Denmark spends much less (1.3% of GDP).[31] Business enterprise expenditure on R&D was in 1985 1.05% of domestic product of industry in Denmark and 3.02% in Sweden—Sweden having the highest figure of all OECD countries (OECD, 1988b, Table 17). Sweden is like the large economic powers and Denmark is at a low level also compared to her fellow small countries in this respect.

Another difference is that in 1985 46.5% of all R&D was financed by public sources in Denmark but only 34.0% in Sweden. Hence more than 65% of the R&D was funded by the private sector in Sweden (OECD, 1988b Table 5). To the extent that a high proportion of private funding of R&D is an indicator of technological "maturity," Sweden is more advanced, in this respect, than Denmark. The Swedish firms have transformed themselves to R&D-based activities to a larger extent than the Danish ones.[32]

It is also important who executes R&D. Roughly a quarter of all Swedish R&D work is performed within the higher education system. The other three-quarters is performed by industry, national authorities, public, private, and cooperative research institutes, and independent consultants. However, the higher education system plays a much more prominent role in the performance of research (R) than in development (D). The basic and applied research (R) in industry is estimated at some 12% and development (D) at 88%. About half of the R&D undertaken by public authorities, institutes, etc., is research (R) and half is development (D) (OECD, 1987, p. 41). Most of the firm-based research (R) in Sweden is carried out by a handful of firms—including the pharmaceutical companies, which dominate in this respect. Most of the other corporations concentrate on more or less qualified development work (D).

The much more modest efforts in R&D in Denmark reflect several factors. To a certain degree, the low rate of investment in R&D in Denmark reflects the fact that small manufacturing firms tend to invest proportionally less in R&D than larger companies. Hence the small size of firms and the limited role of big multinational firms are important. Many of the small and medium sized Danish firms are, however, involved in development activities. For example, two-thirds of a sample of small and medium sized firms reported that they had introduced at least one new product in the market 1984–1989. However, most of these activities are not separated clearly from routine activities and do not get registered in R&D statistics.

In addition, the production structure of Danish manufacturing is a crucial determinant behind the low R&D expenditures. Several of the strategic export sectors have weak connections to a science base, and limited technological opportunities (e.g., in terms of prospects of development of radically new products such as furniture and food products). For example, in relation to value added the Danish food, drink, and tobacco industry (ISIC 31) spent 0.6% on R&D in 1987. The corresponding figure for Finland and Sweden was 1.6 and 1.7%, respectively (Nordisk FoU-statistik, 1987 og 1981–1987, 1990) Hence R&D expenditures in this sector are small in all countries. In this sense, the low overall R&D intensity in Denmark is to a large extent a consequence of the type of specialization of the economy.[33] However, the factors mentioned here cannot fully account for Denmark's limited R&D efforts. As we shall see later there seems to be a different "mode of innovation" in Denmark, based less on formalized R&D efforts.

Technology Policy

Technology policy is often identified with public R&D policy. Here, the term will be given a wider content. Technology policy includes public intervention in the process of technological change as a whole. It embraces both technological development and encouragement of the application of new technology regardless of its origin (i.e., absorption or diffusion). We will here briefly address several elements of technology policy: state support to R&D, national technology programs, support of technology diffusion, and public technology procurement.

Public support for technical R&D in Sweden is channeled through agencies such as STU (The Swedish Board for Technical Development) and is allocated, mostly, in response to initiatives from firms, institutions, and so on. Support measures consist of advisory services, grants or loans, commissions or contracts, and fellowships or prizes (for inventors). When the technology is developed, other agencies exist with the objective of providing support for later stages in the process of commercialization (OECD, 1987).[34]

During the 1980s a new element was added to the instruments of technology policy in Sweden. In late 1983 a decision was taken in Parliament to create a national program on microelectronics components, financed by government and the participating firms jointly.[35] It has later been followed by a similar program on information technology.[36] And in 1990 a decision was taken to launch a national program to give state support to technology development in small and medium sized firms (mainly subcontractors) in the engineering industry.

Danish technology policy reflects the dominance of small and medium-sized enterprises in the economy. Public efforts to promote the application of new technology in industry strongly emphasize two objectives (OECD, 1988a, p. 59). The first is to ensure that enterprises have access to information and advice on the application of new technology. The second objective is to ensure that enterprises can be supplied with solutions in areas where they have neither the personnel nor the equipment to pursue investigations themselves. Such areas may include analyses or testing, experiments or development, investment planning involving the procurement, commissioning, and operation of a new production plant, organizing quality and production control systems, and other specialized activities related to technology (OECD, 1988a, p. 24).

Generally the emphasis has been on technical service organized through a net of public or semipublic technological institutes rather than on support schemes for R&D inside firms. The ambitions regarding industrial policy have been shifting radically during the past decades. Until the middle of the 1980s there were few attempts to intervene besides the technical service net. In the middle of the 1980s began a short period with a rather active policy effort.

In 1984 a technology policy initiative, with special reference to information technology, was initiated as the Technological Development Programme. This was a sizable national technology program under the Ministry of Industries, worth 1500 million Danish crowns, which was to be used over 5 years (1984–1989). The main aim of the program was to promote the use of internationally available information technology in Danish industry as a whole, but it was also intended to stimulate independent Danish development efforts in IT areas where there are special circumstances and prospects (OECD, 1988a, p. 59).

This program was—officially because it had already succeeded in its goals—interrupted before 1989. Thereafter the level of ambition as regards an active technology policy has been reduced. Except for limited programs for new materials and biotechnology, the government has moved to a policy where cost reductions, through tax reductions and restrictive wage policy, are assumed to be sufficient to support industrial development and international competitiveness.

Obviously, Danish technology policy is biased toward diffusion rather than supporting the development of new knowledge and products. This is in sharp contrast to the Swedish technology policy, which is very much a policy of R&D support to the private sector. It seems as if the policy efforts in both countries tend to support the already established mode of technological change rather than trying to correct its weak sides. The interaction between state intervention and the market mechanism is accordingly characterized by duplication rather than by complementarity.[37]

The technology policy initiatives mentioned above work mainly from the supply side. There are also possibilities to intervene from the demand side.[38] One interesting way to influence technical change from the demand side is to use public demand as a means. Public procurement can, of course, influence the choice between existing technologies as well as which new ones are to be developed. Important consequences for technology development might emanate from public demand when no such intentions lie behind the demand.

When analyzing the differences in procurement policies between Denmark and Sweden it is important to take into account their respective roles in international politics. While Denmark, as a member of NATO, can be quite modest in terms of independent military strength the Swedish armed neutrality is partly built on indigenous military technology. The cooperation between the state and the big private firms in ambitious projects, developing large and complex technological systems, was originally developed in areas of military importance. Typical examples were the different generations of military aircraft developed by SAAB; but there were several other large projects where the Ministry of Defense closely cooperated with the largest Swedish firms (Annerstedt, 1976). Denmark has never had any large-scale high-technology development programs in defense, space, or similar areas.

The Swedish nuclear power research program was originally oriented toward a potential Swedish atomic bomb. But when ASEA-ATOM, the development enterprise (which joined ASEA, Uddeholm, and the state) was established in 1969, the responsibility was to develop civil nuclear power. Another development enterprise, LM-Tel, joined the state (Swedish Telecom) with Ericsson in the development of telecommunication technology. In the 1950s, we find other similar cooperative enterprises focusing on, respectively, computer technology, and space technology. In the civilian sphere, public procurement in Sweden has also led to important results in the electricity field (ASEA-Vattenfall) and in railway equipment (ASEA—The State Railway Company).

Such large technology projects have not developed in Denmark. Neither the military demand, the firm structure, nor the strong noninterventionist ideology behind industrial policy has allowed such activities. The Danish state has played a role in technology areas relevant to manufacturing but through more indirect mechanisms. The most important function of the Danish state in this context has been, mostly unintentionally, to support innovation through organizing and financing professional and advanced demand for specific products. Among important examples of products, originally developed for public induced demand but later becoming hi-tech niche products with big international market shares, we find electronic hearing aids, mobile communication technology, medical instruments, and windmill technology.

This implies quite different kinds of relationships between the state and the private sector. In Sweden, a few large firms (e.g., Volvo, ASEA, SAAB, Ericsson, and Bofors) have been involved in quite intimate cooperation with state agencies. Such a close cooperation has contributed to mutual understanding between the state and the most important fraction of private capital in Sweden. In Denmark some small and medium-sized niche firms have profited from the development of an advanced public demand but most of the firms have not been involved in any formalized cooperation with the state.

An important part of technology development in Sweden takes place in a few large multinational corporations, strongly involved in big cooperative activities with professional government agencies. The working of the Danish system is quite different. The process of technical change in Denmark is organized neither by big firms nor by the state. It is quite self-organized. The only reasonably strong coordinating block in the economy has been the export-oriented, and cooperatively organized, agroindustrial sector. This sector has played a certain coordinating role as a demanding user of technologies developed by small and medium-sized firms. Even some of the strategic competencies in the small Danish high technology sector in engineering, pharmaceuticals, and chemicals can be traced back to experiences and learning made in relation to the agroindustrial complex.

The much weaker R&D effort in Denmark reflects the crucial role played by user–producer interaction in product development and the correspondingly weaker links between technical change and science. A recent study of 166 Danish product innovations in manufacturing (Christensen and Valentin, 1989) shows that almost all of the product innovations were based on knowledge already accumulated within the firms rather than on external knowledge sources. Many innovations were stimulated by users and they were also often involved during the process of development.

PERFORMANCE: THE DANISH AND SWEDISH SYSTEMS OF INNOVATION

In this section the performance of the two systems of innovation will be discussed. Performance will be expressed, first, in terms of economic growth and other macroeconomic indicators. Second, the focus is on output indicators relating more directly to the process of technical change and the national systems of innovation.

Macroeconomic Performance

Long-term economic growth rates in Denmark and Sweden were at internationally high levels during the century up to the 1960s. Since the middle of the 1960s the growth rates have become more moderate in relative terms, however. In both countries the average for the 1970s and the 1980s is clearly below the OECD average (Table 8.5). Since 1986 the Danish economy has been characterized by stagnating GNP and, presently, there are many signs pointing toward a period of zero growth also in the Swedish economy. There is also a serious productivity problem in Sweden.

These similarities in long-term trends is somewhat misleading, however. In the last decades the rythm of production and employment growth in manufacturing has been quite different in the two countries (Table 8.6). Immediately after the first oil crisis, the Danish industrial system reacted by dismissing many employees while the firms in Sweden kept their workers, absorbing the crisis in a marked slowdown in productivity growth. In the 1980s, the Danish economy had a brief period of strong growth in production and employment (1984–1987) while productivity growth was extremely slow. In this period employment in manufacturing started to fall more rap-

Table 8.5. GNP growth in Denmark, Sweden, and the OECD Average for 1960–1984

	1960–1964	1965–1969	1970–1974	1975–1979	1980–1984	1985–1986	1987–1989[a]
Denmark	5.6	4.2	2.6	2.5	1.6	3.4	−0.4
Sweden	5.2	3.6	3.4	1.5	1.5	1.8	2.2
OECD growth	5.1	5.0	3.8	3.2	2.0	2.8	2.7

[a]Preliminary figures.

Sources: 1960–1984, Mjöset (1986, p. 329) and after 1984 Dansk Ökonomi (1988).

Table 8.6. Annual Rate of Growth in GNP, Labor Productivity, and Employment in Manufacturing 1973–1985 in Denmark and Sweden

	1973–1979				1979–1985			
	y	z	n	u	y	z	n	u
Denmark	1.6	3.6	−2.0	5	2.8	1.8	1.0	9
Sweden	0.5	1.0	−0.5	2	1.6	3.1	−1.5	3

Sources: production (y), productivity (z), and employment growth (n) from Gjerding et al. (1988, p. 52); unemployment figures, averages for the periods (u) from Kongshöj Madsen (1989, p. 13).

idly in the Swedish economy. And this in spite of the two large devaluations in Sweden 1981 (10%) and 1982 (16%).

Another important difference reflected in Table 8.6 is, of course, the rates of unemployment. The Danish rate is now assumed to stabilize close to 10% while there is an extremely high demand for labor in Sweden in 1990. One result of this constellation is that some of the big Swedish firms now, actively, recruit skilled workers in Denmark. However, there are signs indicating that the Swedish rate of unemployment will increase in the near future.

The aggregate growth rates as indicators of performance imply that the prolonged relative economic success of Denmark and Sweden might now be coming to an end. The slowdown in growth to be observed since the last part of the 1960s has become more serious in the last years. In the following sections we shall look at some performance indicators more narrowly connected to technical innovation and technology diffusion. In this context it will be argued that the slowdown in economic growth, at least to a certain degree, reflects weaknesses in the national systems of technological change. Specifically, we shall look first at the capacity of the two systems to contribute to the global pool of generic technology. But, especially for small countries, the capability to absorb and diffuse new process technology and new product technology developed abroad is crucial.[39]

Development of Technologies

Technology development may involve a scale of technical advances from small incremental innovations to radical innovations and crucial contributions to generic technology. Here the focus will be on radical innovations and generic technology rather than on incremental change.[40]

Taking number of patents in the United States as an indicator of contributions to the common pool of technical knowledge we found (in Table 8.1) the Swedish contribution to be substantial (89 patents per million inhabitants) and the Danish to be very modest (27 patents per million inhabitants).

A closer study, based on Delphi methods, analyzing the specific areas in which Sweden has contributed to the global pool of technical knowledge found that the most important were electrical power, iron ore, special steel, and ship building and that the focus was almost always on developing the process technology (IVA, 1979b, p. 143ff).

In Denmark no such study has been made but it is well known that original contributions have been made in filter technology, extending the use of ultrafiltration to food processing and pharmaceuticals (artificial insulin).

But, generally, Swedish and Danish contributions have been modest and most generic technologies used in the two countries have been developed elsewhere. None of them has, for example, made any substantial contributions to the new engineering process technologies combining mechanical machines and electronics. In none of the main "mechatronic" engineering automation techniques—Computer Numerical Control-machinery (CNC), Industrial Robots, Computer Aided Design (CAD), and Flexible Manufacturing Systems (FMS)—do we find substantial Swedish or Danish innovations. Denmark is not a major producer of any of them and a partly Swedish firm (ABB) is active as a large producer only in one of the four areas—industrial robots. It is especially interesting to note that the Swedish engineering industry, which was characterized by a series of quite distinct and radical innovations almost a century ago and still presents itself as a core sector in the Swedish economy, did not contribute, more substantially, in this area (Edquist, 1989b).

The most important contributions from Denmark and Sweden to the global pool of knowledge might, however, be socioorganizational rather than technical. The cooperative form of agroorganization in Denmark and the technoeconomic system for food production based on it is an example with possible applications in many developing and eastern European countries. There is also a potential for diffusion of social and organizational forms from Sweden to other OECD countries. Some of the most visible and important experiments in this area have been developed by Volvo. Fifteen years ago, a new teamwork organization was introduced at Volvo's factory in Kalmar. And the new Volvo plant in Uddevalla represents another radical step in terms of work design (Edquist and Glimell, 1989).

Diffusion of New Process Technologies

How rapidly can a national system of technological change absorb new process technologies developed abroad? This is an important question because rapid absorption and domestic diffusion would, normally, result in a more productive and competitive national economy. Therefore, the degree of technology diffusion is a very important indicator of the performance of a national system of technological change. In this section we shall use the densities of specific automation techniques (CNC machine tools, industrial robots, CAD, and FMS) in the engineering industry as indicators for the absorption capability regarding process technology. Density is measured as the number of units per million employees in the engineering sector.

According to Table 8.7, Sweden is characterized by the most intensive use of CNC machine tools together with Japan. In industrial robots, it is number two after Japan, while it has the most intensive use of CAD systems. When it comes to the most complex and advanced technology included in the table—FMS—Sweden has a strong lead, as compared to the other countries. Sweden and Japan are well ahead of the United Kingdom, the United States, and West Germany as regards the degree of diffusion of automation technology in the engineering industry. The numbers presented in Table 8.7 refer to the end of December 1984. For industrial robots there are figures for the same set of countries also for 1987. These figures show that Sweden remains second after Japan, in terms of density, but they also indicate that the growth has been more modest in Sweden than in the other countries from 1984 to 1987 (Edquist, 1989b, Table 6).

Table 8.7. Diffusion of Flexible Automation Technologies in the Engineering Industries of Six OECD Countries (Number of Systems and Density at the End of 1984[a])

	CNC—Machine Tools	Robots	CAD	FMS
Denmark				
Stock	3,000	100	1,000	0
Density	19,230	641	6,410	0
Sweden				
Stock	6,010	1,900	1,900	15
Density	22,177	7,011	7,011	55
United States				
Stock	103,308	13,000	59,400	60
Density	11,728	1,475	6,743	7
Japan				
Stock	118,157	64,657	7,300	100
Density	22,399	12,257	1,384	19
West Germany				
Stock	46,435	6,600	11,000	25
Density	11,376	1,617	2,694	6
Great Britain				
Stock	32,566	2,623	9,000	10
Density	10,505	846	2,903	3

[a]Density reflects the total number of systems (end of 1984) divided by million of employees (1980) in the national engineering sector. For all countries except Denmark the source is Edquist and Jacobsson (1988, p. 104). The number of systems in Denmark has been estimated by methods differing from the ones used for the other countries (Kallehauge, 1989). This may imply problems of comparability. For example, the definition of CNC machine tools is wider in the Danish case—which means some overestimation of the Danish figure.

The figures demonstrate that Swedish firms are advanced users of automated engineering techniques—and this in spite of the fact than none of the flexible automation technologies was originally developed in Sweden. Comparative case studies confirm that Swedish firms have been more successful than British firms in introducing FMS systems, the success reflecting close interaction with producers, involvement of workers, and a step-by-step strategy when upgrading the technology (Haywood and Bessant, 1987).

The figures for Denmark have been gathered through many different sources and are quite uncertain, as indicated in the note to Table 8.7. They point to a high density for CNC and CAD but show extremely low values regarding industrial robots and FMS in 1984. In the years after 1984–1986, the use of CNC and CAD expanded radically. This is true also for industrial robots. But in robots the density is much lower than in Sweden and, still in 1990, there is no sophisticated FMS system in Denmark. The Danish figures point to a late, but rapid, absorption of process technology and to a specific weakness when it comes to the most advanced and complex new production systems (as FMS). Recent studies point to great difficulties in Danish firms when introducing new process technology, the difficulties reflecting a lack of technical competence but, especially, problems with qualifications and work organization. Actually, the introduction of new techniques seems, in a number of instances, to affect productivity negatively in the period 1984–1987 (Gjerding and Lundvall, 1990).

The general conclusion with regard to the technological level of process technology (in the engineering industry) is that Sweden is very advanced and that Denmark is weak in the more complex production systems.

Diffusion of New Product Technologies

An economy, or a firm, that continuously absorbs new process technology but neglects adjusting its product program to the change in the market and demand structure will sooner or later run into problems in terms of stagnation.[41] An inability to develop new products or absorb new product technologies developed abroad keeps the firm or country outside the growth sectors and products.[42]

To analyze the capacity to absorb new and advanced product technology from abroad we shall use the relative weight in exports of products with a high ratio between R&D expenditures and sales—so-called R&D-intensive products. We assume that the relative weight of such products in exports reflects the capability to absorb new product technology and to develop a production of new products and product families. One reason for focusing on R&D-intensive products is that the demand grows considerably more rapidly for these products than for other products (Table 8.10).

Table 8.8 shows that both Denmark and Sweden have a weak export specialization in R&D-intensive products. This is, however, true for almost all the small countries represented in the table. Hence, the problem is a small country problem to a certain degree. One of the two exceptions is Ireland—now a host country for multinationals producing microelectronic products but performing only the low-end activities in Ireland. It illustrates how just a few elements of the total production pro-

Table 8.8. Export Specialization Indices[a] for R&D-Intensive Products[b] in 16 OECD Countries 1961–1987

	1961–1965	1973–1979	1983–1987
Denmark	0.4	0.6	0.6
Sweden	0.7	0.9	0.8
United States	1.2	1.4	1.6
Japan	0.9	1.1	1.2
Great Britain	1.4	1.2	1.1
West Germany	1.4	1.1	1.0
Switzerland	1.6	1.8	1.4
Ireland	0.1	0.7	1.2
Netherlands	0.7	0.9	0.8
France	0.9	0.9	1.0
Belgium	0.7	0.6	0.6
Canada	0.3	0.5	0.5
Italy	0.9	0.7	0.7
Finland	0.1	0.3	0.4
Norway	0.3	0.4	0.4
Austria	0.5	0.7	0.9

[a]For definition of export specialization index, see note *a* in Table 8.3.

[b]The R&D-intensive products are inorganic chemicals, pharmaceuticals, plastic materials, power generating machinery, computers and peripherals, semiconductors, telecommunications equipment, machinery for production and distribution of electricity, scientific instruments, photographic supplies, watches, and clocks, and aircraft. The SITC numbers of the product groups are given in Dalum (1989, Appendix).

Source: The IKE databank and Dalum (1989).

Table 8.9. Share of Exports of Engineering Products Emanating from Industries with a High R&D Intensity[a] (%)

	1971	1975	1980	1985	1986
Sweden	23.7	23.8	25.3	29.7	28.1
United States	42.4	37.5	44.9	52.5	55.6
Japan	35.2	29.4	35.9	41.8	42.5
West Germany	24.2	24.4	27.6	30.4	29.3
France	28.7	27.2	30.0	40.1	38.4
United Kingdom	29.7	32.9	39.9	50.9	51.9
Switzerland	45.0	42.5	44.4	45.1	45.2
Netherlands	50.0	44.9	48.6	52.4	51.8
Finland	19.1	18.5	26.1	25.1	27.3
Norway	19.3	13.2	22.0	22.1	23.4
Denmark	27.5	24.4	31.2	35.6	36.3
OECD	31.2	29.5	34.1	39.3	39.1

[a]Industries with a high R&D intensity are ISIC (Rev 2): 3825 (Office machinery and Computers), 383 (Electrical Machinery), 3845 (Aerospace), and 385 (Scientific Instruments).

Source: OECD Industrial Outlook Data Base (January 1989) (COMTAP) and Edquist (1989b, Table 7).

cess may be transferred. The other more genuine exception is Switzerland, successful both in pharmaceutical products and in microelectronic based engineering products. Large countries such as the United States, Japan, the United Kingdom, West Germany and France are relatively specialized in their exports of R&D-intensive products.

Given its importance it is relevant to take a closer look at the engineering sector and its specialization in terms of R&D-intensive products. Table 8.9 demonstrates that the proportion of engineering products exported having a high R&D intensity is low in Sweden (as in West Germany, Finland, and Norway). Denmark has a stronger position in this respect, but is far behind countries such as Japan, the United States, Netherlands, and Switzerland. Accordingly, two of the small countries perform quite well on this indicator.[43]

We find that—on the whole—both Denmark and Sweden have a relatively weak position in R&D-intensive products. Taking into account that the world markets for these products grow considerably more rapidly than for other products (Table 8.10) this constitutes a long-term structural problem for both Denmark and Sweden and may, partially, explain why the growth rates in these countries are becoming low, as compared to the OECD average.

It is not too surprising that Denmark, given its weak R&D effort, has a weak position in R&D-intensive goods. But it is remarkable that Sweden, in spite of its very substantial investments in R&D, its high number of patents per million inhabitants in the United States, and its strong multinationals in engineering, has been so slow in absorbing R&D-intensive products.

PROBLEMS: STRUCTURAL AND INSTITUTIONAL STRAINS ON THE TWO SYSTEMS OF INNOVATION

In the previous section we pointed to one structural problem common to the two systems. This problem refers to the product composition of production and exports. The

Table 8.10. Differences in Annual Growth Rates (%) in the Volume of the OECD Market, in Current Prices

Annual Growth Rates in the OECD Imports	R&D-Intensive Products[a]	Other Products
1961–1973	19.1	15.0
1973–1983	14.0	9.4

[a]For specification of R&D-intensive products, see note *b* in Table 8.8.
Source: Dalum (1989).

internationally most rapidly growing product groups are weakly represented in both economies. Not even Sweden, in spite of its very major efforts in R&D, has succeeded in overcoming this structural problem. But, of course, the problem takes on different forms in the two countries and we shall discuss some of these specificities separately.

The other family of problems refers to the institutional framework of the economy. Again, we find one common problem, reflecting changes in how the relationships between the national and the global economy are regulated. And again, the problem takes on quite different forms in the two economies. We shall end this chapter with a discussion of the character of this institutional problem in the Danish and the Swedish systems of innovation, respectively.[44]

Structural Problems in the Danish System

We want to point to two fundamental structural problems in the Danish economy. The first problem is that demand for the end products of the traditionally strong, development blocks around construction, shipping, and agriculture is falling or stagnating. The new hi-tech product groups in the field of electronics are still small and they have not established anything like the coherence characteristic of the old development blocks. On the contrary, after a period of innovative activities, strongly rooted in the domestic economy, they tend to establish themselves as enclaves, importing at least 90% of their components and exporting at least 90% of their final output.

The agroindustrial and food-industrial sectors are still extremely important for the health of the Danish economy and, at present (1990), a series of mergers are taking place both inside the cooperative part of the economy and in the private sector. It is an open question if this kind of regrouping will give the necessary impetus to a more offensive strategy in terms of innovative behavior. Actually, the cooperative block tends, increasingly, to play a conservative role in the Danish economy and, as long as the cooperative firms can secure acceptable prices and incomes for their owners, the incentives to develop a new strategy are quite weak. For example, we have seen that, relatively speaking, Denmark spends less on R&D in the food industry (in relation to value added) than Finland and Sweden. There might be a potential in biotechnological applications in these product areas and there is, as a matter of fact, a quite strong biotechnological competence in some Danish firms. (NOVO is the best-known example.) But this competence has been oriented mostly toward the pharmaceuticals applications and it might take some strong policy and other efforts to establish the necessary coupling and interaction between the agroindustrial complex and the biotechnology firms.

Table 8.11. The Distribution of Europe's 500 Largest Manufacturing Firms Among a Number of Small Countries

	Number of Firms	Number of Firms/Million Inhabitants
Denmark	2	0.4
Sweden	31	3.7
Norway	4	1.0
Finland	6	1.2
Austria	8	1.1
Belgium	12	1.2
Switzerland	22	3.4
Netherlands	29	2.0

Source: Forum for industriel udvikling (1988, Figure D-5).

The second structural problem is illustrated in Table 8.11. It refers to the fact that the Danish economy is extreme in its dependence on small and medium-sized firms. The two big Danish firms referred to in the table are to be found in, respectively, the dairy industry (Danish Dairy, a cooperative firm) and breweries (Carlsberg, a private firm). Outside the food industry, there are few units large enough to organize scale-intensive R&D activities. This problem is reinforced by the institutional setup of the financial sector, to be discussed in connection with the institutional problems.

It is remarkable that a small country so weak in terms of most traditional technology performance indicators (R&D intensity, process diffusion and product composition) has been able, for so long, to sustain a high level of income per capita. One interpretation might be that these indicators do not catch very well all forms of incremental innovation important to competitiveness. Another, less optimistic, interpretation is that the present stagnation signals the end of success of this model, based on modest incremental indigenous technical change.

Structural Problems in the Swedish System

Also in the case of Sweden, we shall address two structural problems, both of which point toward vulnerability and a risk for secular stagnation. The first relates to the prospective demand for its raw materials and its semimanufactured goods. The exports of wood products, pulp, paper, iron ore, steel, and so on is still very important to the dynamics of the economy. The rapid development in biotechnology and material technology might, however, in the long run result in new materials. The demand for some of the classical Swedish export products might dwindle, and the result might be stagnation and a need for a drastic transformation of the economy. We have pointed to the fact that the engineering industry focuses on the production and export of traditional, mechanical, low-R&D products with a limited growth prospect.

We have seen that the natural resource bases of Sweden and Denmark have shaped the two national systems of innovation to a very important degree.[45] However, Sweden also developed a strong mechanical engineering industry in the early parts of this century. It would, of course, be interesting to find out in detail why this happened in Sweden and not in Denmark—or Canada and Australia. At the same time the Swedish engineering industry is still mainly mechanical. It has not managed to transform itself to also produce electronics products. In this sense Sweden is locked into the mechanical trajectory in the engineering industry and still quite tied to the raw material base in other sectors of industry. Again, it would be very interesting to analyze, in detail, why Sweden did not manage to develop an IT capability (except in the case of Ericsson), while firms in other countries succeeded. In other words, why is Sweden (with a few exceptions) not producing in the new industries, which are not based on raw materials?[46]

Another kind of vulnerability emanates from the concentration in the core sector in the economy—engineering. The five largest engineering firms (Volvo, Electrolux, Ericsson, ASEA, and SKF) produced around one-fifth of the total value added in manufacturing in 1982 (Economic Growth, 1984, p. 193) and in 1976 they organized more than a fourth of total exports (IVA, 1979c, p. 82). The concentration of economic activities is even more extreme than these figures indicate. The large firms have built networks of domestic suppliers directly dependent on the performance of the large firms. And everything points toward increasing ratios of concentration since these data were produced. If these large firms do not succeed in developing efficient production in the new high-growth product areas, the problems of stagnation will become very serious for the Swedish economy. And if one or two of these large firms run into problems, it can have devastating consequences for the whole economy.[47]

A comparative advantage of the Swedish system has been its combination of advanced production methods in traditional product areas on the one hand, and corporatist institutional setups, making it easy to develop and introduce advanced process technology, on the other hand. Paradoxically, this comparative advantage might be an important factor in explaining the rigidities in the product structure. The whole institutional setup, the whole innovation system (including state policy), seems to have become geared toward movement along one trajectory. The ease with which advances have been made in this direction may have weakened the incentives to take on the more difficult task of developing the technological infrastructural basis necessary for radically new product areas.[48]

The average low-R&D character of Swedish production is a severe problem for the Swedish system of technological change. And this problem is certainly not solved spontaneously by the market. Therefore there are reasons to consider whether state intervention could mitigate the problem. A recent evaluation (Edquist, 1989b) of the activitites of The Swedish Board for Technical Change (STU) in the field of engineering technology showed that STU, in the 1980s, spent most of its resources in this field on support to process technology and a smaller—and decreasing—share on product technology. Hence, STU supports an area where Sweden performs extremely well and neglects an area that is a major problem for the Swedish system of innovation. Accordingly, a reallocation of the efforts of STU may be called for. The currently launched national program to give state support to technology in the engineering industry was partly based on the evaluation. In the new program, a more balanced allocation of the state resources between production technologies and product technologies is prescribed (Regeringens Proposition, 1990, p. 107).[49]

Institutional Problems in the Two Systems of Innovation

One fundamental characteristic of the Danish system of innovation is the absence of strong coordinating agencies. Neither the state nor concentrated capital has been powerful enough to take the lead in the process of restructuring the economy. The single strongest organized power has been the cooperative farmer's movement and, for institutional reasons, this movement has become quite myopic in relation to strategies of innovation. In the earlier period of rapid growth in demand, this absence of a coordinating force was not a serious problem. Today, with the increasingly systemic character of technology, the vulnerability of the model becomes more apparent. It is illustrated by the fact that foreign capital now, rapidly, is taking over many of the Danish niche firms characterized by advanced product technology, in, for example, electronics (Aaen, 1986).

Lately, there has been a growing awareness of this vacuum that leaves structural change to market forces and initiatives joining private firms, banks, and pension funds have resulted in a series of mergers, especially in the food industry. At the same time, the trade unions have pointed to wage earner's funds as potential candidates for organizing a more coordinated industrial restructuring. It is an open question if these different efforts will succeed in defending a reasonable degree of coherence in the Danish production and innovations systems. The prospective project of a single European market is regarded by many policy agents as the ultimate response to the structural and institutional problems of Denmark.

In Sweden there is a corresponding growing awareness of a weakening of the foundation for the Swedish model. "The Swedish model" can—as we previously saw—mean different things. If it implies the mode of wage formation developing after World War II, it is clear that it has partly disintegrated during the past 10–15 years. The difference between nominal wage increases and productivity increases has, for a considerable period, been much larger than in competing countries, which has led to a relatively high inflation in Sweden—and several devaluations around 1980. One reason for the high wage increases has been the shortage of labor.[50]

Shortage of labor and large wage increases create incentives for rationalization of production and the introduction of labor-saving process technologies (e.g., automation). And there is widespread acceptance of this in the union movement.[51] If "the Swedish model" is given the other meaning (i.e., a consensus on issues of rationalization and technical change between capital, trade unions, and the state), the model is still alive.

One fundamental problem, in this context, is the fact that the home-based multinational firms are now becoming, increasingly, footloose. ASEA's merger with Brown-Bovery from Switzerland into ABB in 1989 has now been followed up by mergers involving, for example, SAAB (with General Motors), Volvo (with Renault), and several others.[52]

In addition to the fact that the nationality of several of the largest "Swedish" firms can be questioned, the process of internationalization is also proceeding in other spheres. For example, a very important change in the 1980s was the development of a very free flow of capital across borders. This means that the possibility of pursuing an independent monetary policy in a country such as Sweden is severely restricted.[53] Further, the Swedish flow of direct investments abroad is enormous. It has increased from 5 to 55 billion Swedish crowns per year between 1980 and 1989. During the same period the foreign direct investments in Sweden remained around 5 billion per year.[54]

The trend toward internationalization has definitely weakened the structural position of the labor unions—which are still quite national—in Sweden.[55] But it has also weakened the position of the state. And capital has strengthened its position—in particular the internationalized capital. Accordingly, the power relations between the three main parties of the Swedish model have been fundamentally changed.

In other words, the process of internationalization changes, drastically, the basic workings of the Swedish model. The old model was based on the fact that the Social-Democratic state and the large firms were *mutually* dependent. If this dependency goes only one way in the future, the basis for corporatism will erode. This problem is referred to in a report to the 1989 congress of the Swedish Metal Workers Union:

> The problem today is that these multinationals do not any longer need Sweden, but the Swedish economy needs them. The "third way politics" was the last major contribution that the Swedish society could make to big business, and still expecting something in return. (Solidarisk arbetspolitik, 1989, p. 93)[56]

This brings us to an end, pointing to the possibility that the two small national systems of innovation studied here, Denmark and Sweden, are now in a critical phase.

NOTES

1. This chapter has been written within the Columbia University project on National Systems Supporting Technical Advance in Industry. We have greatly profited from discussions at the conferences organized within this project and in particular from Richard Nelson's comments. Swedish and Danish colleagues have also commented on earlier drafts. We have received valuable comments from Esben Sloth Andersen, Boel Berner, Ted Bradshaw, Martin Börjeson, Tarja Cronberg, Erik Dahmén, Bent Dalum, Mark Elam, Hans Glimell, Lars Herlitz, Mikael Hård, Björn Johnson, Maureen McKelvey, Lennart Stenberg, Elisabeth Sundin, Lars Svensson, and Hans Vallentin. The paper was written in 1990 and completed in January 1991. Accordingly it does not cover events and changes occurring thereafter (see also note 56).

2. Comparing countries with many features in common allows us to keep some variables constant. This might be effective when it comes to establishing the most crucial elements and relationships in national systems of technical change. At the same time, this chapter brings into focus some of the specific problems facing *small* national systems of innovation.

3. The comparison presented here confirms that it still is useful to assume that national borders matter when it comes to the workings of the process of technical change. If two distinct and different systems of innovation can be isolated in two countries, so close in terms of culture and space, this should be true, a forteriori, for countries more distant in these respects.

4. This issue will be discussed in the final section on structural and institutional problems.

5. Hence the conduct of Sweden looks very much like that of the large economic powers in this respect, while the conduct of Denmark is similar to other small OECD countries. The figures presented in this section also show that a country can be quite successful in terms of growth and have a high GNP/capita in spite of low R&D expenditures and a poor patenting record.

6. Alternative terms to denote the same thing are, for example, "national systems supporting technical advances" and "national systems of technological change."

7. One way—among others—to try to determine the limits of a national system of innovation would be to try to causally explain the invention, innovation, and diffusion of technologies and let the explanatory factors define the limits of the system. An attempt in this direction—but only with regard to diffusion of process technologies in the engineering industry—was made in Edquist (1989a, pp. 10–11).

8. This theoretical perspective has been developed in Andersen and Lundvall (1988), in Johnson and Lundvall (1988), and in Lundvall (1992).

9. One reason why it is useful to distinguish between development and diffusion of technologies is that the determinants differ between these stages of technological change. The analytical distinctions discussed here are dealt with in more depth in Edquist (1989b, 1991, 1992).

10. For a product technology an innovation is the first economically successful production of a product. A failed innovation is when a product has been marketed and disappeared from the market—and thereby from production. For a production technology an innovation means that new means of production are efficiently used for the first time in production—which, of course, presupposes that they have been produced earlier.

11. For process technologies diffusion means, of course, that additional producers introduce the technology in their process of production. For product technologies diffusion means that additional producers begin to produce the new product. (Hence, we do not mean diffusion to users or consumers when we talk about diffusion of product technologies.) Failed diffusion of a product technology might reflect a technological monopoly based on patents, secrecy, or other barriers to entry.

12. In small economies, the development of generic technologies and radical innovations is currently a rare phenomenon, and the most important activity in the national system of technological change is often diffusion, mainly the absorption and adaptation of technologies developed abroad.

13. For example, an industrial robot is a product technology as output and a production technology when it is used in the process of production.

14. The role of education is, for example, dealt with in Ahlström (1982) and Berner (1991).

15. There are few systematic attempts to write the history of the Danish system of innovation. In this part we have been inspired by several not very widely circulated contributions by our colleague Esben Sloth Andersen (1973, 1978a,b).

16. In Denmark the innovation was made in 1878 by Burmeister and Wain, but the separator was invented by N.J. Fjord—one of the first professors in dairying at the Danish Agricultural College, established in 1874. In Sweden the separator was invented by Gustav de Laval. Later it became one of the core products for AB Separator, a firm that later developed into the multinational firm Alfa-Laval.

17. The transformation of the Danish economy in the last quarter of the nineteenth century is an interesting illustration of the importance of social mobilization and social innovation. Actually, Grundtvig might be regarded as the most important single Danish innovator, as one who has put his marks on the modern Danish system of production and innovation. His successful ideological mobilization of the Danish peasants toward self-reliance, for example, through organizing local education in the popular "höjskoler," prepared the ground for the local organizational undertakings that gradually developed into a coordinated national movement toward farmers' cooperatives.

18. This means, for example, automation and reductions of direct labor costs in dairies and slaughterhouses.

19. Some data on this are presented in the section on the R&D effort.

20. In addition to horses used in mines many thousands were used by transport companies in London and other cities.

21. The large Swedish export of iron ore developed later.

22. Foreign demand for wood products and iron was important in the Swedish process of industrialization (Schön, 1985, p. 35).

23. This includes production of ships (until the 1980s), automobiles, mining equipment, and aeroplanes, except for the product groups already mentioned.

24. In his analysis of small country corporatism Katzenstein (1985) characterizes Denmark as having a weak partner at the capitalist side and a strong one at the labor side. We would rather

point to the fact that in Denmark none of the parties is as centralized, homogeneous, and united as their Swedish counterparts.

25. However, unemployment in Sweden is in the process of increasing in 1990.

26. If this design turns out to be unprofitable compared to automobile assembly according to traditional principles in, for example, West Germany and Japan, the conclusion may be that car assembly cannot be carried out in Sweden—for structural reasons. On the other hand, if it turns out to be profitable, the Uddevalla example may show the way for the general development of assembly work—which is one-fourth of all work in the engineering industry—in the future (Edquist and Glimell, 1989, p. 44). Another possibility is, of course, that the structural conditions change—through increased unemployment, etc.—and traditional assembly becomes viable again in Sweden. The Uddevalla factory has been addressed in more detail in Berggren (1990) and in Clarke (1989).

27. A "development block" has also been defined as a broad set of interconnected producers and users of products, developing in close interaction with each other and often supported by knowledge-producing private, or public, organizations (Stenberg, 1987, p. 46).

28. In its most complete form, a development block would include whole chains of production, final users of the products, producers of means of production, as well as independent knowledge resources. Only the United States and Japan would today contain complete development blocks in this sense within important future areas (Stenberg, 1987, pp. 46–47). Dahmén uses "development blocks" in both an ex ante and an ex post sense (Dahmén, 1988, pp. 6–7).

29. Their export and import ratios lie typically around or over 90%.

30. If sales from the Swedish-owned engineering companies abroad had been included the figure for this industry would have been much higher.

31. In relation to value added, the figures were 7.6% (Sweden) and 2.9% (Denmark). And in relation to fixed investments the percentages were 57 and 26%, respectively (Edquist, 1989b, Table 11).

32. However, the R&D expenditures (in Sweden) of Swedish firms decreased for the first time between 1987 and 1989 by 7% in real terms.

33. This particular example also indicates, however, that Denmark has a lower R&D intensity than other Nordic countries in one of her most important export sectors.

34. STU has an annual budget of about 1 billion Swedish Crowns and is the main technology policy agency in Sweden.

35. The emergence of the program has been analyzed in Glimell (1988, 1989). It has been evaluated ex post in Wennerberg (1989).

36. The first phase of the IT program has been evaluated in Arnold and Guy (1989).

37. The mechanisms behind this process are dealt with in Edquist (1989b, 1990).

38. In Edquist (1989c, 1990) supply-side as well as demand-side technology policy instruments relevant for technology development as well as for technology diffusion are discussed in more detail.

39. In this sense, the "system of technology diffusion"—including absorbtion, assimilation, and incremental change—is much more important than the R&D system for small countries. There are, therefore, strong reasons for spending as much energy on analyzing the mechanisms, institutions, and policies for acquiring foreign technology and disseminating it domestically as on the R&D system—although this is seldomly done. (To do so would be a major task, since we do not know the detailed features of the systems of technology diffusion in Denmark and Sweden.) One reason for this neglect may be that the diffusion system is less often the object of public policy intervention. Diffusion is normally left to be handled spontaneously by the market forces (although Denmark has been an exception in this respect). As we will see this may also be true when the diffusion system does not function satisfactorily—as in the case of the the diffusion of new product technology in Denmark and Sweden.

40. Incremental innovations are, in this chapter, considered to be part of the process of technology diffusion.

41. Such a combination of labor-saving technical change with lack of presence in growing markets may lead to "technological unemployment." This is the basic idea behind the Pasinetti (1981) analysis of economic growth and structural change. The argument has been adjusted and applied to small open economies in Lundvall (1987).

42. When a new product is developed in one country its diffusion to another country is often presented in the framework of product life cycle theory. However, the product life cycle model tends to understate the difficulties involved. The reason is that it may be quite complex to move complete production processes between countries. The knowledge base may involve tacit elements that are difficult to transfer or it may involve extremely complex combinations of scientific knowledge. Infrastructure and institutions in the receiving country may also not be adapted to the product family.

43. The indicators used in Tables 8.8 and 8.9 are somewhat blunt because of the rather high level of aggregation. This is because of lack of more detailed R&D data. The analysis of the diffusion of R&D-intensive product technologies in Sweden has later been developed in Edquist and McKelvey (1991).

44. In the section on problems we will address structural and institutional problems without distinguishing between those problems that can be solved through (further) political intervention in the systems of innovation and those that cannot. Such a distinction would be necessary if the policy implications of the present analysis were to be explicitly and systematically drawn out.

45. In a country such as Japan the resource base may have been less important, and civilian technology policy a more important determinant of the direction of technological change. In the United States the government-financed military R&D and procurement may have been the most important factors.

46. There are many challenging questions in this context! How do national systems of innovation use their resource base without being constrained by it (e.g., by neglecting new product areas) in later stages of development? Except for liberating the system from the domestic natural resource base (like the Japanese and Koreans), can a country also "liberate" its system of innovation from socioeconomic and cultural conditions? How do transfers between technological trajectories and paradigms actually take place?

47. As a matter of fact, both the automobile producers (SAAB and Volvo) seem to start trembling in mid-1990, having announced drastic profit reductions and considerable layoffs.

48. The large devaluations around 1980 have most probably contributed to the conservation of the product structure—by making traditional products more profitable and leaving little room for offensive ventures (in an economy of full capacity utilization).

49. In the process of implementation of this program during 1990, the resources have, to a large extent, been allocated to subcontractors within the automobile industry. This is probably related to the emerging problems for the Swedish automobile industry—and looks more like crisis management than an offensive strategy of the future.

50. However, the sum of inflation and rate of unemployment is still in 1990 relatively low—which means that the Swedish model, in this sense, has not broken down completely.

51. As we have shown earlier Sweden is good at the introduction of advanced process technology but bad at increasing productivity—which is not necessarily contradictory.

52. If only one or two of the very large and internationalized "Swedish" firms decide to move their R&D abroad the ratio between R&D expenditures and GDP would dwindle. However, this has not happened so far.

53. Previously the Swedish Central Bank could determine the domestic interest rate and adjust it to the business cycle. Now the interest rates in the surrounding world determine the Swedish one. Hence, the interest rate is no longer controlled from the political level in Sweden

but by the global market. The same seems to be becoming increasingly true for taxation—at least taxation of incomes emanating from capital.

54. And during the first half of 1990 Swedish corporations bought firms in Western Europe for a total of 72.2 billion SEK. This is to be compared to the acquisitions of U. S. firm of 32.7 billion and of Japanese of 10.5 billion. This exceptional record may, of course, have been related to the insecurity among Swedish firms concerning the future relations between Sweden and the European Community. However, during the autumn of 1990 the Swedish government declared its intention to apply for membership in the EC. A large majority in Parliament supports this.

55. This structural weakening concerns issues such as industrial democracy and codetermination. In the field of wage formation it is balanced by the shortage of labor—as long as that persists. A labor shortage may lead to problems of competitiveness (i.e., full employment contains the seeds of its own destruction). On the other hand, unions tend to accept labor-saving technical change if full employment is the case.

56. As mentioned in note 1, this chapter was written in 1990 and completed in January 1991. Hence the analysis does not address changes occurring thereafter. However, we want to mention a few events that have since occurred in Sweden. In July 1991 the Social Democratic government submitted Sweden's application for membership to the EC. In the election of September 1991 the Social Democrats were replaced by a center–right coalition government. Further, the rate of unemployment increased to about 4% in 1991. These changes are not unrelated to each other. Together they seem to strengthen the observations expressed at the end of this chapter (e.g., on the gradual disintegration of "the Swedish model," on internationalization, and on the changes in the power balance among the labor unions, the state, and private capital).

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