

From tendencies to genuine innovation policy - the Danish case

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Introduction

This chapter discusses two decades during which a general, diffuse Danish interest in innovation in the early 1980s gradually transformed into a more active technology policy and eventually into a genuine innovation policy in the late 1990s. The chapter ends with the establishment of the Council for Technology and Innovation, CTI, in 2002, and begins in the 1970s when energy crises exposed the vulnerability of the Danish national economy and welfare and showed the contours of an increasingly globalized world. This ‘burning platform’ with its combination of external economic pressure from an increasing economic globalization and a domestic need for innovation and development in industry to improve national competitiveness fuelled the political will to develop Denmark into a society, which at the time was somewhat vaguely defined and today is a cohesive, synergetic, national innovation system. In other words, Denmark tested – initially forced by necessity, but increasingly of its own free will – new policies to improve its industry’s competitiveness and increase the country’s welfare. During these decades, Denmark gradually abandoned its laissez-faire industrial and research policy in favor of a managed and active technology policy with a cohesive, and in some contexts proactive, innovation policy that encompassed significantly more areas and elements of the national economy (Aagaard, 2000). Chapter 2 discusses the international developments in the theoretical fields of R&D and economic growth, and other conditions that gave rise to the innovation policy, and as noted in Chapter 2, Denmark can be seen as influenced by these developments in theory and policy thinking. However, this chapter will expand on the national intake of these forces in its review of the emergence of innovation policy in Denmark primarily.

As mentioned in Chapter 2, Danish policy development in the 1980s and 1990s found inspiration and ideas in other countries. OECD’s analyses and recommendations, and especially its evaluations of Danish research and technology policy in 1988, and of research, technology and innovation policy in 1994, and OECD’s early coupling of research, growth and welfare already in 1971 influenced the development (OECD, 1971, 1988, 1994). However, it is not always sufficient to implement good ideas. The Danish windmill industry is an illustrative case of how a mixture of

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chance, inspiration from abroad, economic crises, innovative entrepreneurs and political will during these decades ultimately resulted in national core competences and business clusters that were – and still are – internationally competitive (Karnøe, 1991; Erhvervsfremmestyrelsen, 1996; Kamp, 2009; Porter, 1990a, 1990b; Lundvall and Borrás, 2005; Lindgaard Christensen et al., 2008).

Danish society has changed with accelerating speed; also during the decades preceding the establishment of CTI in 2002. New ideas, but especially the foundation of new industries and reduction or loss of old industries became the norm in the period 1970-2000. Danish policies for industry, technology and research increasingly underwent radical change in the 1980s and accelerated into a complex systemic approach and coherent implementation in the 1990s.

In the 1980s, Danish policies were still relatively uncoordinated, but during the 1990s a growing focus on synergy via coordination of policies took hold. Late in the period, individual sector-specific industrial policies were swept aside by a new mantra to look for systemic relations and synergies, and the new bottom line focus became competitiveness in a globalized world. This period was characterized by a holistic outlook, consensus seeking, coordination and a pro-system approach, e.g. the establishment of the Danish Globalization Council in 2005.

As described in Chapter 2, Lundvall (1999) synthesized the fragmented jurisdictional innovation policy areas in his development and description of the national innovation system which, from a business point of view needed an innovation policy that merged and coordinated all national policies that affected Danish competitiveness and implicitly welfare in a global world, among them research, industrial, labor market, education, regional and sector policy (Mandag Morgen, 1995; Lundvall, 1999).

The period before the 1980s

In the decades following WWII, Denmark experienced slowly accelerating societal change away from the sectorized agrarian and industrial society towards a society with growing international influence. Loss of old and establishment of new industries and increased awareness about the burgeoning global influence on Denmark's ability to secure future welfare created a need for new political priorities, primarily in industrial policy. The rejection of nuclear energy and the first oil crisis in 1973 exposed Denmark's vulnerability in an open, global world as well as the need to reduce it. OECD's (1971) early linkage of knowledge, growth and welfare indicated new opportunities and clearly inspired national policy development. However, the sector-specific and uncoordinated governmental support mindset of the industrial policy continued to dominate for many years to come. It was not until the early 1980s that research and not least technology policy

assumed an active and visible position in economic policy where a new type of “dynamic” industrial policy replaced a significantly more passive technology policy (Christiansen and Sidenius, 1988) and “structural policy” replaced “market oiling” (Christiansen, 1988).

Since the 1970s, it had been a political objective to improve competitiveness via devaluation and cuts in production input, primarily lower wage growth, cf. chapter 2. The result was growing unemployment, high inflation and nominal interest rates, and pronounced political uncertainty about Denmark’s future. In an attempt to jumpstart the economy, the government introduced a fixed exchange rate policy in 1982 and pegged the Danish krone to the Deutschmark to reduce economic uncertainty in the economy and stabilize Denmark’s development potential. This objective demanded new political options to secure and support Danish industry’s competitiveness, first via improved framework conditions for knowledge sharing between technological service institutions and industry and second via new knowledge from research and especially technology policy to support industrial product development, and to a lesser extent process development.

Danish windmill production in the 1970s

In the decades following WW2 and up to the 1970s, a traditional group of wind enthusiasts, in Denmark and in other countries, developed and operated small windmills compared to contemporary standards for, e.g., water supply in the agriculture sector. However, some of them had bigger goals, and when oil prices quadrupled during the energy crisis in 1973 and tripled again during the second crisis in 1979, a focus on alternatives to fossil-based energy forms became justified. Denmark had already rejected nuclear power as an option and launched several alternative energy technology programs in the late 1970s, including a two-track development program for large and small windmills. As was typical for that period, the first was managed top-down, the other bottom-up. The first had by far the most resources, but coordination between the two programs was not planned (Karnøe, 1991). Karnøe describes the actors in the windmill industry during the period 1974-1979 as grassroots and small entrepreneurs. Such entrepreneurs are nowadays seen as indispensable for successful bottom-up driven development of new industries, but this was not recognized knowledge in the 1970s.

The recession in the 1970s provided available production capacity in the engineering industry for establishing, expanding and industrializing the new industry: windmills (Karnøe, 1991). The first mass-produced windmill was connected to the power grid in 1976, but a more explicit industrialization of Danish windmill production did not take off until the early 1980s.

The energy crisis generated the required initial demand both domestically and internationally for alternatives to fossil fuels, and this created a market for windmills (Lindgaard Christensen et al., 2008; Porter, 1990b; Mowery and Rosenberg, 1979). Windmills also attracted political attention and support in the 1970s. The support was not continuous, but the policy instruments established some necessary framework conditions. For example, power companies were required to allow hook-up to the electrical grid and to buy the electricity produced at a relatively high price. Also, the government subsidized erection of new, approved windmills in Denmark by 30 %. An official approval was especially important for domestic production because it took place in Denmark at the local test facility.² Initially, the Danish market was thus only open to windmills produced in Denmark. The legal requirement to allow hook-up to the grid at a good price removed a large degree of uncertainty and supported the Danish domestic market significantly. As a consequence, many small windmill producers emerged.³ In comparison, there was no similar legislation in Germany during that period and the German market was therefore very small.

The emergence of active and coordinated policies in the 1980s

In the early 1980s, Denmark was still trying to secure competitiveness via wage competition and recurring devaluations, and policy coordination was not high on the agenda. While industrial policy was still synonymous with innovation policy at large, an idea took hold that more active research-based technological innovation in a coordinated, intensified technology policy might be the solution to Denmark's structural problems of high budget deficits, high unemployment and declining competitiveness.

As chapter 2 also describes, the political mindset in the 1980s was geared to the linear, uniform innovation model, i.e. scientific knowledge as input to technological development, which industries can then use to improve production (Karnøe, 1991; Rothwell, 1992; Freeman and Soete, 1997). The international currents thus continuously moved towards comprehensive, complex and not least cohesive and active innovation policy. This also occurred in Denmark, albeit slowly and based on the technology policy's input to solving societal needs, and with pronounced traits from the technology push mindset (Christiansen and Sidenius, 1988). In the 1970s, the market pull model appeared, i.e. development and innovation of industrial production required a market demand (Mowery and Rosenberg, 1979). The state was in a position to support the demand via public procurement or by removing market failures that obstructed demand for new products.

² This test facility later became a part of Research Center Risø and is today a part of The Technical University of Denmark.

³ Windmill giants like Vestas Wind Systems and Siemens Wind Power have roots in one or more Danish windmill enterprises founded around 1980.

These ideas do not, however, seem to have inspired an active political prioritization of demand for innovations in Denmark in the 1980s.⁴

In the early 1980s, support for the industry was still dominated by governmental subsidy schemes or market 'oiling' (cf. Christiansen, 1988). The industrial policy was industry neutral (Asheim and Mariussen, 2010) and in reality implied a passive, unprioritized technology, industry and innovation policy that supported competitiveness via wage restraint or devaluations. From 1983, political initiatives changed toward a nascent dynamic and active industrial policy with strategic support via R&D programs under the technology policy and with a gradual blurring of the separation of research policy and industrial policy (Christiansen and Sidenius, 1988). The Danish innovation policy was in these years generally based on a combination of diverse industry services, e.g. technological service institutes and regional technological information centers as well as technological research programs in biotech, energy, environment, materials, food, information technology etc. The program for Research and Technological Development from 1985 is a manifestation of the shift in objectives towards research with focus on industrial technology (Christiansen and Sidenius, 1988). However, even though the coupling of technology policy and overall politically determined societal needs was present via the research programs, an acknowledgement of the interactive link between research, industry and market was neither stated nor framed at this point in time.

The launched technology programs focused on certain politically prioritized, sector specific areas, and aimed to correct erroneous allocation of technological resources in an otherwise unregulated market. So, despite a solid economic-theoretical foundation, the programs were still influenced by the simplicity of the technology push mindset. By facilitating technological knowledge, the state was able to improve the framework conditions for Danish industry, which demanded and had use for the new technologies developed in the research programs. A more direct coupling between technology policy and small enterprises was still lacking despite the presence of the technological service institutes (Mandag Morgen, 1995; Nyholm and Langkilde, 2003; Lindgaard Christensen, 2003). However, during this period, ideas about a more cohesive approach to drivers of societal growth and change emerged, e.g. in the joint discussion paper by the ministries of labor, industry, research and education (Arbejdsministeriet et al., 1986).

Christiansen and Sidenius (1988) reviewed the development in Danish industrial technology policy in the 1970s and 1980s in light of the incipient coordination.⁵ The overlap with other policy areas

⁴ In this light, the significant domestic market for windmills approved in Denmark appears to be a result of random, although convenient timing (Karnøe, 1991).

had become so pronounced in the period that they found it necessary to explicitly demarcate the technology policy. They only include few aspects from other policy areas that are relevant in a review of a national innovation policy, but coordination of jurisdictional policies were still in an infancy stage and rare in the 1980s. They also portray a country being forced into motion after a turbulent decade with oil crises, devaluations and high unemployment. However, these crisis markers help focus the discussions on how the state assumes a corrective role in terms of erroneous allocation of technological knowledge in the market. The theoretical justification for this role paved the way for a new political prioritization of more active and strategic initiatives. The political priorities did not always result in economic-rational initiatives, but the economic-rational societal arguments became a guiding factor in the selection of initiatives in the increasingly intervening technology and industrial policy in the second half of the 1980s (Christiansen, 1988). From an industry-neutral, passive and relatively cheap research and technology policy in the 1970s, focus now shifted to strategic initiatives, collaboration, knowledge facilitation and service and just overall a more active and, obviously, more costly engagement by the state.

Technology policy was still seen as neutral in terms of industrial sectors in the 1980s. The aim was to produce or develop new technology that would increase industrial competitiveness. This was a consequence of the rules for national industrial subsidies in the European Community, EC, and of a continued belief that it was possible to improve Danish competitiveness solely by making new technology available to Danish industry (Forsknings- og Teknologiministeriet, 1993). In 1986, the Danish Board of Technology⁶ was established under the National Agency of Technology to assess and counsel on the possibilities and consequences of technology and to promote a debate on technology, including ethical challenges in new technology. The Board increased its activities in the second half of the 1980s and the following decades, and especially in the late 1980s it worked for a greater political understanding of the societal effects of new technology and for social acceptance and understanding of the technological possibilities. In light of several dramatic episodes with radioactive leaks from nuclear power plants around the world, the Board's assessments and later technological visions were in high demand in connection with prioritization of research areas in the strategic research programs mentioned above, e.g. exclusion of nuclear research and support of alternative energy research among others.

⁵ See also the detailed review and analysis of Danish research and technology policy in Christiansen (1988).

⁶ The Technology Board was renamed to the Technology Council in 1995, and it was shut down in 2011 and reborn as the non-profit DBT Foundation.

Already in the 1980s, other elements in the industrial policy also had focus on the big picture, coordination and the many small Danish businesses (Erhvervsministeriet, 1994, 1998a). Knowledge dissemination and technological consulting were thus prioritized via, e.g., the Advanced Technology Group (ATG; GTS in Danish) institutions and the regional Technological Information Centers (TIC), (GTS, 2008; Forsknings- og Innovationsstyrelsen, 2008).⁷ Their function was to disseminate research and provide knowledge and services to businesses. Consulting and knowledge transfer was primarily targeted at technological framework conditions, and in the late 1980s it was only seen as one aspect of a larger whole in the form of a unifying innovation policy. This was quite typical for that period.

In 1988, Denmark asked the OECD to evaluate Danish research and technology policy, but did not find it relevant to ask for an evaluation of its innovation policy (OECD, 1988). However, already in 1994 Denmark asked the OECD (1994) to evaluate all three policies. Innovation policy had thus reached the level of research, technology and industrial policy (Olesen-Larsen, 2003; Mandag Morgen, 1995). Innovation had become a positive word late in the decade, but innovation policy was still mainly conducted via industrial and technology policy. The intensity and scope of initiatives were still growing, however. Even though innovation policy was still targeted at the industry, it became increasingly clear in the second half of the 1980s that several ministries could join in increasing the effect of the current policies by coordinating them. The first inter-ministerial programs for businesses were launched in a partnership between the ministries of industry and energy and environment, and science parks were established and seen in a broader perspective of matching targeted and applied research with industrial needs (Forskningsministeriet, 2000). In the same category, the European cross-national EUREKA program for market-driven industrial research and development was established in Paris in 1985 (Danish Agency for Science, Technology and Innovation, 2011). Likewise, EU's research-driven framework program for research, technology and development was increasingly seen as a proactive and useful national instrument that could also benefit the industry via research partnerships with universities. In 1989-90, the Technology Board under the Ministry of Industry and Commerce took the initiative to reorganize and merge the 36 ATGs from 1973 into fewer and more focused institutes.⁸ The Board provided effective overall management of the technological service up through the 1980s (Christiansen and Sidenius, 1988). The institutions that remained after 1990 were still too different

⁷ The ATGs were initially subsumed under the same legislation already in 1973 and were subject to multiple mergers in the late 1980s. The TICs were also established in the 1970s.

⁸ In 1990 they were 20, in 1995 14, and today there are 8 ATG institutions, which are gathered in a national ATG network to improve the coordination and impact of their industrial contact (GTS, 2008).

to be gathered under one ministry. Instead, the institutions established the 'Institution Council' which today corresponds to the Advanced Technology Groups, ATG.

In general, the initiatives and programs from that period were still targeted at the few enterprises with the capacity to handle the knowledge required to benefit from the participation. Despite the increased efforts to disseminate new knowledge to businesses, the dominant policy trend was to improve the framework conditions for the industry via technology push, i.e. it was up to the businesses to acquire and use the produced knowledge. However, in the late 1980s a new approach began to take root, especially in the industrial policy (Industriministeriet, 1986, 1989).

The Danish windmill industry in the 1980s

The development in the Danish windmill industry, or rather the windmill sector, illustrates "how learning is cumulative and often based in the national production structure and at the same time 'accidental' or unplanned" (Lindgaard Christensen et al., 2008). The state had established a test facility in 1978 for approval of new windmills and legislated about hook-up to the electrical grid and trade prices, but the big joker was the combination of perfectly timed factors up through the 1980s (Kamp, 2009; Teknologirådet, 2006). The test facility's approval of windmills was, as mentioned, a requisite for achieving the favorable state subsidies. Since all Danish manufacturers had to pass through the test facility, it became a knowledge bank for the industry in accordance with the ideas about the industry-related ATG institutions. Even though the manufacturers were competitors, their technical solutions became useful for other manufacturers via the test facility's knowledge gathering and contacts to researchers within the field (Karnøe, 1991). This, combined with active, organized feedback from windmill buyers gave the Danish windmill industry a global head start, and the public administration and regulation had – by chance – created a market for sale of produced mills and for testing facilities.⁹ Unlike in Germany, the political system in many ways challenged the inherent structural barriers in the established power companies by allowing private actors to establish windmills and especially by giving Danish windmill owners the right to hook up their mills and power production to the nationwide grid.

Subsidies for construction and operation costs and technological research and consulting existed in most countries, but the Danish industry benefited from other factors up through the 1980s. For example, USA, with approximately the same set-up as Denmark, focused on advancing technological knowledge derived from the aviation industry, whereas Denmark already had good

⁹ The domestic market for windmills approved in Denmark appears to be a result of random, although convenient timing according to Karnøe (1991).

experience with electricity-producing windmill technology that was effective and relatively reliable, from the several decades old Gedser mill, erected in 1957. Despite considerably larger subsidies in the USA, the American development failed in the 1980s because solutions from the aviation industry could not be transferred directly to windmills. As a consequence, Denmark was the largest supplier to the windmill boom in California 1982 and 1985. The Danish export benefited from generous subsidies and a high dollar rate of close to DKK 10. As industrialization took off in the early 1980s, the Danish windmill manufacturers were ready for the American boom, and 1983-86 was a hectic period, which is probably best characterized as forced industrialization with lots of trial, error and adjustments in the following years. 1986-88 was a period of survival and technological development when the export market began to shrink again. In the late 1980s, the export and domestic markets increased moderately again, and the industry, having learned its lesson during the recession after 1986, used the period to consolidate technology as well as industry in the form of technologically improved, larger and more cost-effective windmills and better economic profitability in the remaining industry. In the late 1980s an improved national economy drove domestic demand up.

The ministry of energy, the power companies and the Technical University of Denmark, DTU, launched in the 1970s a top-down controlled initiative in parallel with the individual actors, to build large windmills. Similar initiatives were seen in the US, Germany, the Netherlands, Sweden, and elsewhere. The three Danish actors faced large technological challenges and ultimately lacked a market for large windmills (Teknologirådet, 2006). This type of market did not appear until the 1990s, and even though the state ordered the power companies to install windmills already in 1985, it was too late for the initiative to succeed (Lindgaard Christensen, 2008). However, the test facility had accumulated knowledge and experiences, which benefited the Danish windmill manufacturers up through the 1980s and 1990s, when developments towards larger and more effective mills secured the Danish manufacturers international competitiveness.

The growth in the windmill market in the 1980s inspired many studies of the origin of the success. Karnøe (1991) identifies Porter's diamond model as applicable to the Danish windmill industry (Porter, 1990b; Karnøe, 1991)¹⁰ in the form of: state regulations and subsidies, which created demand; the industrial cluster of competitors with complementary competences, which ensured knowledge competition and exchange; the high national quality of production input, e.g. man power and sub-suppliers; and finally the active industry and technology policy initiatives that ensured the presence of competent sub-suppliers and research-based knowledge accumulation

¹⁰ Other studies include Van Est (1999), Klaassen et al. (2005), Buen (2006), Lindgaard Christensen et al. (2008), Kamp (2009), Sovacool and Sawin (2010), and Neij and Andersen (2012).

and development. The conditions for success were thus present and coincided with other and crucial factors, for example, an American boom when the Danish market was quite small; a favorable exchange rate towards the dollar; the nuclear disasters at Three Mile Island in 1979 and Chernobyl in 1986; and the Brundtland Report in 1987 (Teknologirådet, 2006).

The active and coordinated innovation policy of the 1990s

The demand for a genuine innovation policy became increasingly pronounced up through the 1990s and was gradually operationalized and implemented. Already in 1994, the OECD included all three industry-focused growth policies in its evaluation of Danish research, technology and innovation policy (OECD, 1994). In 1995, Mandag Morgen published an exhaustive discussion paper calling for a unified and targeted Danish innovation policy. Both OECD and Mandag Morgen emphasized the importance of an innovation policy and called for the coordination of growth-stimulating policy areas. Mandag Morgen even put the issue of a new Danish innovation policy on the agenda, thus hinting that the existing policy – to the extent it qualified as innovation policy – was not sufficiently ambitious and holistic. It had various deficiencies, but primarily it was squeezed between research and industrial policy. The solution was increased coordination of policy initiatives across policy areas, and preferably with innovation policy formulated as an independent area (Mandag Morgen, 1995). However, since ministries and politicians failed to place responsibility for an overall innovation policy, the Danish Agency for Trade and Industry in reality headed up the development of a systematic clarification of Danish innovation policy and culture. In the Danish context, the holistic notion of a cohesive society in which segments contribute to innovation was presented, on the Agency's initiative, by a group of researchers associated with Bengt-Åke Lundvall, who provided an overall description of the Danish national innovation system (Lundvall, 1999).

Even though the typology of national innovation systems had been common for many years, e.g., the OECD (1997), it was not until Lundvall's comprehensive report from the DISKO project in the late 1990s that innovation policy was elevated to a systemic instrument for national growth and competitiveness in Denmark, cf. chapter 2. The fact that the notion of a systemic perspective is not new, is evident in Karnøe's (1991) case on the Danish windmill industry and in foreign studies such as Pavitt (1971) for OECD, Rosenberg's anthology (1982), Rothwell's literature review (1992), and Freeman and Soete's 3rd edition of *The Economics of Industrial Innovation* (1997; 1st ed. 1974). In other words, the political and national maturation towards a common policy that can even remotely be characterized as a national innovation policy lasted almost two decades.

Among the most significant coordination initiatives in the 1990s was the establishment of the Industry and Trade Development Council (ITDC) and the Council for Technological Service, CTS, in 1996. The ITDC would advise the government about conditions for and the development of production and about factors affecting the international competitiveness of Danish industry. CTS were responsible for planning and coordinating the technological service under ITDC and primarily for coordinating activities at ATG institutions and the remaining trade promotion system. The council represented technological, societal and industrial insight and was specifically responsible for the ATG institutions. Every three years, the council presented an overall strategy for development of technological service in Denmark and allocated subsidies to the ATGs based on the strategy and action plans. The CTS recommended focus on reinforcing certain elements in the service structure via increased support to the ATG institutions as an important element in public knowledge service (Erhvervsfremmestyrelsen, 1995, 1999). The ITDC and the CTS ceased their activities in 2001-02 when the Danish Council for Technology and Innovation was established and took over.

The act on trade promotion was one of the clearest indications that the Danish trade promotion system in the 1990s needed expansion and better coordination in several focus areas. The act aimed to strengthen Danish competitiveness via initiatives that improved the conditions for growth, international collaboration and trade, structural adaptation to competition, environmental and societal conditions, cohesive efforts for regional growth and the official coordination of and public-private collaboration on industrial development.¹¹ Under this new act, many of the 1990s' industrial initiatives were launched, which showed that The Danish Agency for Trade and Industry had the right of initiative. It was thus quite characteristic that it was the Ministry of Trade and Industry and especially The Danish Agency for Trade and Industry that, based on the industrial policy and the lacking competitiveness in the open global economy, pointed to the need for increased systemic coordination.

For example, the Ministry of Trade and Industry (Erhvervsministeriet, 1998b) for the first time writes clearly, explicitly and cohesively about the framework conditions that are required to improve conditions for innovative SMEs. The ATG institutions and the Technological Information Centers (TICs) are a planned part of these framework conditions, but new initiatives were ready for implementation in the late 1990s. One example is the innovation environment initiative, which aimed to create space, coordination and progress for SMEs (Erhvervsministeriet, 1998b; Erhvervsfremmestyrelsen, 2000). The initiative came the year after the entrepreneur scheme in

¹¹ The act has been updated regularly, most recently in 2014.

1997, which among other things introduced subsidies for very small companies' initial contacts with the ATG institutions. The ministry's publication (Erhvervsministeriet, 1998b) now clearly formulates the wish for and the targeted initiative on 'new' innovative companies. This constitutes a formulated breakthrough in the rhetoric, which had been heavily criticized by, e.g., Mandag Morgen (1995). With the notion of the cohesive national innovation system, OECD's (1994) recommendations, and the spread of the trade promotion system, entrepreneurship climbed higher on the agenda than ever before. However, already back then there was a significant mismatch between the intended and the actual number of new innovative businesses. In fact, it was so large that Mandag Morgen (1995) described the paradox as a culturally determined lack of innovative drive among Danes and called for increased focus on entrepreneurship and framework conditions. The establishment of the Danish Growth Fund in 2001 is another example of the increased focus on framework conditions and barriers to SMEs.

A report from the Nordic Council of Ministers from 1998 only mentions the most important trade and innovation promotion initiatives as drivers of Danish competitiveness. The delimitation to industry and businesses is explained by the fact that 'there are actors within these areas that are targets and focal points of the national innovation systems' (1998, Attachment C). The most important initiatives in the late 1990s were the innovation environments (i.e. start-up support to entrepreneurs), ATG institutions, center contracts (i.e. public-private research partnerships), TICs, development contracts, development companies, the Danish Growth Fund, regional design promotion, industrial researchers and the introduction of intellectual capital accounts (Nordic Council of Ministers, 1998). Likewise, the growing, forward-looking focus on more coordinated policy initiatives in all innovation policy areas is illustrated in the joint MOC (Management, Organization and Competence) initiative launched by four very different ministries (Arbejdsministeriet et al., 1997). The purpose of the initiative is to increase industrial productivity, welfare and innovation through augmentation of employee, leadership and organizational competences, and the Ministry of Trade and Industry was not among the four ministries.

In parallel with the industry's application-oriented approach to specific competitiveness problems, publicly funded knowledge production at the universities was increasingly viewed as a strategic source of knowledge for the industry (Økonomisk Råd, 1997). This renewed role for research policy was manifested via the increased focus on strategic research funding via the coordinating Central Research Council (Forskningsforum) and the subordinated academic research councils (Forskningsstyrelsen, 2003). Starting in 1997, the Central Research Council would coordinate joint initiatives, including strategic research initiatives that it deemed to be of societal importance for Denmark across the academic research councils' domains. Examples are

continuation of existing strategic programs for biotechnology, materials, health, etc., and introduction of new programs like welfare research, elderly research, food technology, etc. The Central Research Council and the six academic research councils were transformed in 2002 to the Danish Council for Independent Research, the Strategic Research Council, and five new academic research councils with more industry- and society-related names.

Another example of coordination, adaptation and professionalization in the research-based part of the national innovation system is the industrial researcher programs, introduced by the Danish Academy of Technical Sciences in the 1970s and regulated and adapted to the universities' PhD programs and administratively transferred to the Ministry of Science with the reform of the PhD programs in 1993, cf. chapter 9.

In view of the many intensified rapprochements and overlaps between the different policy areas in the period 1980-2000, the growing evidence for the need for coordination between policy areas, and finally the explicitation of a systemic framing in 1999 (Lundvall, 1999), the establishment of CTI, whose purpose it was to promote innovation in Danish Industry, in 2002 was a natural consequence.

Denmark's global windmill industry in the 1990s

After the relatively tough recession in the mid-1980s and a period of reorganization, the economic and technological consolidation in the windmill industry resumed in the late 1980s into the early 1990s. Domestic and foreign markets experienced a stable but low growth in sales. As an apt illustration of the technological development, the first Danish offshore wind park was erected in 1991, but the total volume of erected windmills was still low in the first half of the 1990s. In 1993-94, exports exploded again and pushed technological development in the industry, including development of larger windmills with higher capacity. After a revision of a Danish subsidy scheme in 1995, domestic sales and erections of windmills rose dramatically. This combined with the exports created considerable growth in the Danish production capacity. For example, exports grew from DKK 500 million to DKK 10 billion between 1990 and 2000. The industry had learned from the tough years in the late 1980s, and the second half of the 1990s is best described as a period of considerable, but not uncontrolled, expansion of production facilities in Denmark and in the erection of new windmills in and outside of Denmark. During the same period, replacement of old and small windmills with fewer, larger and more effective windmills began (Energistyrelsen, 1995).

The fourth Danish energy plan from the Ministry of Energy in 1996 explicitly dictated a key role for windmills in Danish energy supply. The plan was long term and introduced target figures for more offshore wind parks, replacement schemes for old windmills, and mandatory inclusion of windmill locations in county and municipal planning. Moreover, it stipulated that the power companies had to erect more windmills, including offshore mills. Even though the energy plan was somewhat vague due to its long time horizon, and even though the political goal was increased production of renewable energy, it gave rise to an implicit political wish to support the industry's technological development via pressure for more green energy through erection of new windmills, which required development of new technology. This is comparable to an unintended version of a successful public procurement via the power companies.

Throughout the decade, different forms of subsidies for electricity production were in effect, but constant, minor revisions to subsidy schemes for the erection of windmills in Denmark made the domestic market volatile and uncertain. The windmill manufacturers had become large and industrialized, which along with more economic power and a development capacity secured survival, development and drive. At the end of the 1990s, the industry and its global competitiveness were stronger than ever. After a stable but hectic conclusion to the 1990s, the early 2000s saw a more volatile domestic market but a very favorable export market. The Danish windmill industry was founded as a self-sustaining and world-leading cluster of technology and knowledge, but towards the end of the 1990s the industry faced the question of whether production could remain in Denmark in the future.

After the turn of the millennium, Danish windmill industry continued its internationalization and knowledge development. The cluster of Danish windmill manufacturers made the sector large in a global context at a time when the domestic market was at a standstill. Competition between the manufacturers was intense in Denmark, but due to the global market for power-producing windmills, government support via test facilities etc. and a very competent Danish workforce, they increased their global competitiveness in the early 00s. This was completely in line with the framework conditions that according to Porter's four-sided diamond give nations competitive advantages in specific industries (Porter, 1990a, 1990b; Karnøe, 1991).

The transitional year 2002

The chapter has reviewed two decades of Danish research, technology and industrial policy, during which a coordinated innovation policy was recognized as an indispensable instrument for growth and welfare. This process culminated in the establishment of the Council for Technology

and Innovation, CTI in 2002. CTI was established with the purpose of promoting growth and innovation in Danish industry, and we have come full circle to the old policy objective to secure Danish industrial competitiveness. Even though the purpose to improve national competitiveness is the same as 20 years ago, the instruments and coordination of the the Danish innovation policy in 2002 has become significantly more visible and recognized (cf., e.g., Økonomi- og Erhvervsministeriet, 2002; Mejlgaard et al., 2002; Forskningsstyrelsen, 2003; Mandag Morgen, 2004; LO, 2005; Danish Agency for Science, Technology and Innovation, 2011).

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