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The historical evolution of innovation and technology policy in Norway

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Preface

This paper is an attempt to systematise and extend a line of argument that was central in my doctoral dissertation, *The hierarchical systems paradigm in technological innovation* (Ørstavik 1996). The central theme is how very influential social democrat policies have transcended the conventional dichotomy between "pure" and "applied" science, as well as the so-called "linear" modelling of science and industry dynamics, and how these policies during the post-war period have been aimed at building a *system of innovation* for scientific research, technology development and knowledge based industry. What has changed over time is not the idea that a system had to be built, but *how* this system should be managed, and not least, how it should be *managed*.

I would like to express my gratitude to Arne Isaksen for giving me the opportunity to develop this argument within the framework of the *SMEPOL* project.

Oslo, April 1999

Finn Ørstavik

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1. Introduction

The purpose of the present paper is to offer a brief overview of the evolution of innovation and technology policy in Norway in the post-war period. It is plain, however, that since (i) the ideas of *innovation policy* and *technology policy* are quite recent, and since (ii) the institutionalisation of a policy system with the explicit aim to influence innovation activities in the economy and the "rate" and "direction" of technological change, there is no straightforward "recorded history" of the policies we are interested in. At the same time, there can be no doubt whatsoever that policies have been made that have influenced both innovation and technology throughout the post-war period. It is in particular for industrial policies that such impact can be most easily traced. But also economic policy and policies for higher education have had considerable impact. And gradually emerging, policies aimed specifically influencing research, science and the cross-fertilisation of science, technology and innovation activities in industry have been devised, and have had important consequences.

It is not in itself the development of new policy concepts that is our central theme here. Nor is our primary concern the actual building of institutions to carry out such policies.[1] What we are trying to do, is **to characterise the "de-facto" impact of policies with respect to innovation and technology, and how this impact has changed over time**. In this context, we by *impact on innovation* mean the policy effects on **firms' attempts to introduce new or improved products and production processes**[2] By *impact on technology* we mean the effects of policy on **the exploitation of technology and the "rate" and "direction" of change of the technology**[3] that is exploited by firms.

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[1] The evolution of the concepts and the institutionalisation of the policy system is an interesting field of research, which – among other things – shows that we should not be limiting our analysis in this field exclusively to developments inside one country. Ruivo (1994), for instance, argues that important conceptual developments happened in a very internationalised milieu. Science and technology (S&T) policies were developed by people (scientist, politicians and bureaucrats) with a high degree of knowledge about developments in other countries. The OECD appears to be one arena were cross-fertilisation of ideas was particularly important.

[2] *Production processes* here is understood as including the technical means and the organisational practices involved in created output with added value, as well as the "delivery apparatus" involved in generating income from sales (marketing, distribution).

[3] As Hauknes (1994) points out *Technology* encompasses technique (hardware and software), the knowledge associated with this technique, and the organisational practices attached to its various uses.

In the half century that has passed since World War II, Norwegian politics have been shaped fundamentally by the Labour Party and the Labour movement ideas. In the whole period, Labour has taken a keen interest in promoting its own industrial and economic policies. These policies have dealt with the most fundamental of the party's political concerns, namely the realisation of increasing economic wealth, and a more equal distribution of wealth among citizens. At the same time, it is a striking fact that *science*, *scientific methods* and *scientific knowledge* by a significant share of Labour politicians, also among the people at the apex of the party power structure, have been considered key means to achieve the desired welfare goals. Labour policies of the post-war period have continuously emphasised the expansion of not only of the sphere of salaried work in general (an ambition coined in the slogan "*Hele folket i arbeid*"), but also an increasing rationalisation by way of *professionalisation* of vital processes in society. Rather than relying on what was believed to be the inherent irrationalities of capitalistic market economies, the idea was to enhance our ability to solve problems and to produce wealth by developing an ever larger rational and scientific knowledge base, and to use professional expertise to utilise the acquired knowledge in order to solve real life problems.

Norwegian social scientists have done quite a bit of work on the economic and industrial history of Norway after the war, and they have gone some way in analysing industrial and economic policies, and in explaining the relationship between policies and actual developments.[4] Less of systematic work has been done in order to trace the science policies of the post war period; to analyse the relationship between science policy and industrial policies, and to discuss the role of professions as bridging links between science and the production of services and products. This is an emerging field however, and this paper is meant to be a contribution to this new literature.[5] We wish to analyse what social democrat ideas regarding science and the role of science for industrial, economic and social development led to, in terms of *de facto* technology and innovation policy.

A recurring theme that we will see in our analysis of the science-industry relationship is that policy makers are eager to contribute to and stimulate both "industry in science", as well as "science in industry", but that it is hard to get significant results. In practice, there is a "gap" between scientific and industrial activities, that certainly can be bridged under specific circumstances, but which have a tendency to be sustained and even grow, rather than to diminish over

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[4] A good overview is found in Grønlie 1989.

[5] There is a growing body of historical, sociological and other social science literature in this area. An early and classic contribution was the studies of the role of the economic profession in Norway by Østerud (1972 and 1979). A number of historical and sociological studies have been written during the last ten years which have as a central theme the development of industry, technology and science in Norway. Among these are Hanisch and Lange 1985, Bergh et. al. 1988, Ørstavik 1989 and 1996, Andersen and Collett 1989, Kvaal 1991 and 1997, Nordby (red.) 1993 and Nordby 1994, Wicken (red.) 1994, Collett (ed.) 1995, Njølstad and Wicken 1997 and Sogner 1997. Very recently, a serious attempt has been made by Rune Slagstad (1998) to analyse the role of technocrats and their coupling of science, industry and politics in an attempt to modernise Norway into an advanced industrialised welfare state.

time. Often, scientific institutions appear to be concerned with research for its own sake, and for the institutions own sake. Researchers, whether academic or in institutes outside universities, appear to use the power vested in control over a knowledge field to secure funds and resources to sustain their own research activities. Industry, on the other hand, often has appeared to be interested only in short term profitability, and hence only willing to engage in scientific and technological research only to the extent that it offers them ready-cooked and immediately useful results. Commercial firms seem to have found it difficult (expensive, but also strategically problematic) to integrate ongoing external scientific activities into its activities, and also to establish scientific research processes fully integrated into its own operations. The general pattern seems to be that although science and industry recognise the potential benefits of joining forces, the actual realisation of benefits from integrating science and industry is very hard to accomplish.

Several analysts have attributed this difficulty to a basic cultural divide, and a big literature has addressed the problems of managing organisations with both scientific and non-scientific personnel.[6] In this paper, however, we wish to look at the difficulty of collaboration from very specific point of view: Both science and business involves making choices. Choices on what to work on, how to develop knowledge, resources, results and products. This means that for science and industry to "join forces" some way of making choices for the common good has to be established. Since science and commercial operations certainly are different, it will not be obvious how to do this. In some degree, issues will boil down to influence and power. What should be the rules to play by? What should be the guidelines for making decisions? Who should be the ones to make these decisions? It would appear that any real technology- and innovation policy must make up its mind on such questions. ***What answer has been given, then, explicitly or implicitly, in the de facto and the expressed technology and innovation policy as these have evolved in Norway after World War II?*** This is the central problem that will guide our investigations in this paper.

2. Origins of Labour policies for industry, technology and science

Any "beginning" in historical overviews such as the one rendered in this chapter, is obviously never really the beginning. The year 1945, in spite of marking the end of World War II, was clearly not the beginning of policy-thinking with respect to science and industry in Norway. For example, already during the period 1917-21 attempts were made to organise cooperation between the authorities, industry and science for systematic exploitation of technological research for industrial purposes. A committee for scientific research to promote industry (*Centralkomiteen for videnskabelig samarbeide til fremme av næringslivet*) was established in 1918, and in 1921 it was reorganised into a semi-public unit which aspired to a role as a national research council, under the name *Rådet for an-*

[6] Kanter 1983, Drucker 1985 and Burgelman 1986 are three interesting, albeit somewhat arbitrary, examples of a substantial literature.

vendt videnskap. *Stortinget* (the Norwegian parliament) established *Det Videnskabelige Forskningsfond* in 1919, and several other relatively small private funds were also established, in part on the basis of fortunes made in the extraordinary financial growth period during World War I. *Råstoffkomiteen* in 1919 proposed the establishment of branch-specific research institutes, and the parliament responded favourably to this proposal when it allocated 600.000 crowns to the establishment of industry specific research institutes. The condition was set that private industry contribute economically to the establishment and to the running of such institutes. Little came out of this initiative, one reason clearly being lack of commitment in industry itself. The economic setback during the 1920s was one reason why firms were unwilling to commit money. However, there are also traces of significant resistance towards establishment of new technical research institutes *outside the Norwegian institute of technology* (Norges Tekniske Høgskole – NTH – in Trondheim) from prominent representatives of this very institution.[8]

World War I helped making people aware of the potential of application of science, research and technology. That this is true for engineers and technical personnel is reflected in the pages of the leading Norwegian polytechnic journal *Teknisk Ukeblad*. But this was part of a much broader "awakening" which was associated with, among other things, the establishment of new, science based industries (such as electrical and chemical industries), which took place at the turn of the century in Norway. We can see the interest for science and the application of scientific practice and knowledge reflected also among industrial leaders of the period. For example, in the Rudeng (1989) biography over *Johan Throne Holst*, owner and director of the *Freia* chocolate company (established 1889), we can see how industry expanded in the first years of Norwegian independence up until about 1920, and how Holst and other industrialists became very aware of the potential of a scientific basis for industrial production. Science was instrumental in the development of new, high quality products and processes, but it was also seen as a potential source of knowledge on how to organise both an industrial firm and a national governance system.

Several firms established laboratories and established collaborations with leading people at the NTH in Trondheim. The Norwegian historians Hanisch and Lange state that this institution during the 1920s was more concerned with its scientific capabilities and reputation than in collaborating with industry, but admits that in spite of this, some interesting collaborations took place in areas such as adding vitamins to margarine, hydroelectric power turbines, and in process development for the metallurgical industry.[9]

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[7] "Teknisk-industriell forskningsorganisasjon i Norge 1945-80. Prinsipiell debatt og hovedlinjer i utviklingen." In: NOU 1981: 30B, pages 95-96.

[8] A remarkable expression of this hostility is Sem Sælands article in **Teknisk Ukeblad**, number 17, 1920, page 229, where he proposes to establish an industrial research institute at NTH instead of spending public money on contributing to a research institute for the canning industry in Stavanger, in South-west Norway.

[9] Hanisch and Lange 1985, pages 130-132.

Labour policies in the late 1930s was centred around the socialist concepts of planning and heavy industry. Norwegian engineers endorsed fully the ambition of the Government to take an active role in economic and industrial development. It was clear to them that strong, centralised government and rational planning would be necessary to create new growth and employment. Such ideas had had good currency among the promoters of scientifically based technical education, at NTH and among other engineer-profession-builders for decades. Especially after World War I, Norwegian engineers followed the example of German engineers in voicing strong frustration with the existing political establishment and the dominance of juridical expertise in the government system. There were several misgivings about the bureaucratic "dysfunctions" created by the legal quibbling and segmented and compartmentalised public bureaucracy run by jurists in the State administration.[10] There can be little doubt that many of the keenest profession builders, those publishing the periodical "Teknisk Ukeblad" for instance, were more attracted by the more conservative "national socialist" governance ideas than by the radical socialist or communist ideas. But several radical engineers, affiliated with the labour movement, came to play important roles developing Labour's strategy for state involvement in the build-up of industry and research.[11]

Already in the first year of Labour government, in 1935, a Council for technical-industrial research was established under the Ministry of trade (*Rådet for teknisk industriell forskning*). Before the war, in 1938, the Ministry of church and education established a Culture department, with a Science office as the very first office.[12] Also before the war, an Industry bank was established, and a Commission for public works (*Tiltakskommisjon*), and a committee of engineers laid down plans for a Norwegian steel plant, while economists proposed a system of 5 year plans to guide the development of the economy. (Due to the parliamentary situation however, these plans were not realised before the end of the war.)[13]

In addition, new plans were made to establish a *central institute* in Oslo for industrially relevant research. This initiative followed the initiatives already mentioned to set up industrial research institutes, which with a few exceptions had stranded. (A paper industry research institute was established in 1930, and a canning industry research institute started operations in 1931.)[14] Again, however, the major developments took place after the war.

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[10] See for example the editorial in Teknisk Ukeblad number 3, January 16, 1920:"Teknikeren og samfunnet".

[11] One example of this is Finn Lied, who was a member of the communist organisation *Mot Dag* during the 1930ies.

[12] Devik in Mortensen 1974, page 22.

[13] For a more detailed analysis, see Ørstavik 1996, esp. pages 158-162.

[14] See also NOU 1981: 30B, pages 95-100.

3. The Norwegian post World War II growth model

The Second World War, and the 5 years German occupation of Norway, brought with it strong support for Labour (as well as for the Norwegian Communist Party). In the first post-war elections in 1945 Labour won an absolute majority in the parliament, and the party continued to increase its share of votes in the next three general elections. Labour kept its absolute parliamentary majority until 1961, and kept government power, except for an intermezzo of two weeks in 1961, until 1965.

According to Mjøset and his colleagues, Labour managed to "mould the Norwegian society and economy into a remarkably coherent system". The main features of this system were:[15]

- A regulation of labour-capital relations, anchored in a constant long-run ratio of wages to profit.
- A restricted but directed funnelling of surplus labour power to new industry from agrarian zones.
- A policy which allowed the industrial sector to function as an enclave. Shipping (being a highly international business, and Norwegian shipbuilding being weak at least until the late sixties) was to a significant degree isolated from ups and downs of the domestic economy, and the energy based industry relied on imported raw materials and on large scale export of semi-finished products. These export industries generated most of Norway's export earnings, while contributing significantly to a stabilisation of the economy.
- A system of fiscal and monetary policies where credit to the private sector was strictly rationed. Employing the 1951 Joint Committee (*Samarbeidsnemnda*) which was dominated by the Ministry of finance and the Central bank, Labour could enforce its view that low interest rates would deter idle financial speculation and spur investment in real capital.
- State banks for agriculture, fishing, housing, education and (from the late fifties) regional development were other tool in the new system of credit rationing. Due to the co-operative nature of this arrangement, the government had to regulate direct issue by law, and private financial institutions ended up playing a rather insignificant role in allocating credits for corporate investment.[16]

The overall industrial and economic policy in the first post-war years was oriented towards build-up of heavy industry and a system of macro-economic control of the economy. The establishment of aluminium factories had been initiated by the Germans during the war, and was set forth by the Labour government. Also, the steel plant plans were revived, and a state owned firm was set up in Northern Norway (Mo i Rana).

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[15] Mjøset et. al., page 58-60.

[16] The strategic role of the credit system to influence industrial development is analysed by Sverre Knutsen, who concludes that

> "the system of industrial finance after the Second World War … allowed the government to accomplish strategic resource allocation. This became one of the Norwegian state's most crucial levers for accomplishing strategic industrial promotion and transformation." (Knutsen 1997: 126).

These developments were in line with traditional socialist policies, and economists found good reasons for government taking part in costly development projects that aimed at exploiting the country's natural resources in energy and minerals. However, the idea that the competition between nations was increasingly becoming "knowledge based" was accepted at the highest levels of the political system,[17] and while businessmen such as Alf Ihlen and others (who had remained in Norway during the war) made plans for a revival and expansion of the existing research system, a new breed of "research scientists" with experiences from war research wanted a more radical approach. They looked for new organisational arrangements, with the State in a key role as an initiator and organiser of research, under an umbrella of a new and centralised research directorate.[18]

In the end, and in the name of national compromise that marked the political system in the immediate post-war period, the second major innovation in the research system - the establishment of a research council for scientific and industrial research (NTNF) in 1946 - was done in a way that in a significant degree reflected the ideas of the pre-war technical and industrial establishment: The council was created as a relatively independent institution which shielded more from direct government influence over research than the directorate model would have done.[19] (The first major innovation was the establishment of a military research institute, an event that we will return to shortly.)
Under the research council umbrella of NTNF, selected people with a "mind for science" (from academic institutions, government and business) could develop plans and find financing for new research. The ambition no doubt was to let men from industry and scientists join forces and develop joint research activities that could lead to industrially useful research results.

The struggle over organisation which preceded the NTNF establishment no most fundamentally concerned who were to influence choices, over who in fact were going to take leadership. The outcome was a research council which at least on paper did offer opportunities for industry. However, in the actual development of activities

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[17] Prime minister Gerhardsen in a speech immediately after the war stated that: "Den industrielle konkurransen mellom landene er begynt å bli en kappestrid om teknisk og vitenskapelig forskning. Her må vi ta et kraftak for å ta igjen det forsømte." [The industrial rivalry between nations is becoming a competition in technical and scientific research. We have to make a major effort to compensate for earlier neglect. *My translation.*] Devik in Mortensen (ed.) 1974, page 28.

[18] See the discussion of these developments in Ørstavik 1996: 147-203. Stig Kvaal (1991) also analyses these developments, and specifically with respect to industrial and science policies of the dominating Labour party distinguishes between a labour-and-capital perspective on one side, and a science-and-technology perspective on the other. This matches the analysis here, and his analysis makes clear how the economists and the engineers were on opposite side of this dividing line at least until the Sputnik shock of 1957. Thereafter, a gradual merging of perspectives took place within the party.

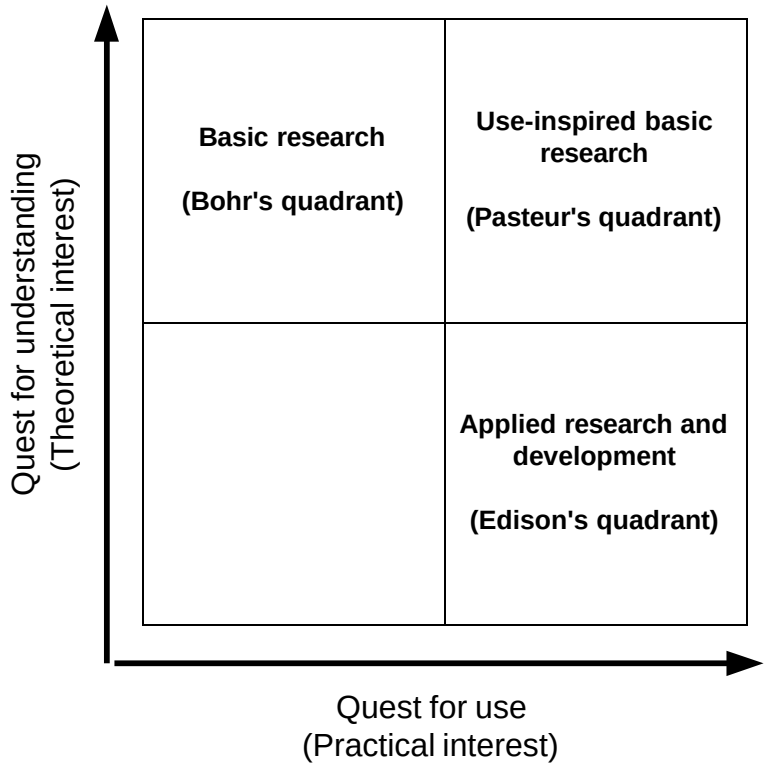
[19] For a more detailed analysis, see Collett's analysis in NOU 1981 30 B, pages 101-105. See also Hanisch & Lange 1985, 177-186.

of the council, the focus came to be on the establishment of a large number of public research institutes. Thus, during the 1950s a publicly funded research system emerged that resembled the sector-based research institute model that had been envisioned before the war, but that lacked serious industry involvement - financially and otherwise - which had been integral to the plans of the period between the world wars.

Evidence suggests that the build up of research capacity in an institute sector for various types of applied research was not conceived as institutions for "pure" scientific research, but that research still ended up as relatively loosely coupled to industry. In the research institutes the ambitions to do advanced research often stood opposed to the ambition to do things that would be of interest for industry. In general, research generated results that were technologically and scientifically interesting (for the technologists), but which did not reflect the immediate interest for industry.

It is important to note here that although one cannot exclude that some of the promoters of research were locked into stereotyped notions of science as "pure science" and development of technology as something else, and external to science, the key issue concerns the ability to decide and to make strategic choices for research and for innovation. If we consider Donald E. Stokes' (1997) simple model of science as oriented according to a dual motivation of knowledge and usefulness (confer figure 1 below), and his critique of the "linear model" of thinking about the relationship between science and technology, we cannot but conclude that the people who constructed the research system in Norway during the 1950ies were already clearly aiming to develop research placed in the most challenging of Stokes' four quadrants; namely in "Pasteur's quadrant": The research ideal was investigations that both were scientifically valid and relevant for the development of the general scientific knowledge base, and at the same time would be of practical use for people and for industries in their quest to produce wealth and welfare.

Figure 1: Stokes' model of science.



Source: Stokes 1997.

Why did NTNF end up playing a relatively modest role with respect to the fundamental ambition, to develop "Pasteurian" scientific research activities with significant impact on industry? There are at least two issues involved here: First, that the way from science to commercially successful operations based on new technology proved to be more difficult than expected. *There was no simple path from Bohr's to Edison's quadrant.* While Vannevar Bush had argued convincingly how science was the ultimate source of all technological innovation, and how nations needed a strong base of "pure science" in order to be at the forefront developing new technologies and thereby maintaining industrial competitiveness, the difficulty of making the sequential steps from basic science to commercially successfully applied technology proved to be much greater than Bush (1944) would have made people believe.[20]

Second, there is a question of power: Who should be the ones to decide; how should directions be set? Researcher-technologists and business-leaders-industrialists to some extent stood against each other. In the Labour policy context, researchers and their interests were the winning team: They were the technocrats involved in Labours push to modernise. The industrialists were in the eyes of researchers were almost always busy exploiting obsolete technologies, and in addition they tended to be woven into the culture of the old capitalist society that the labour movement was opposed to.

[20] See Bush (1944). See also Stokes 1997, which main target is the deconstruction of the rhetoric in *"Science the endless frontier"*.

4. Technocrats and professionals as agents for modernisation.

Another innovation in the institutional structure of the Norwegian system came to reflect more closely the political ambitions of Labour to influence the use of science in industry, and the related ambition to use professions as the spearhead of the modernisation of Norway, in the construction of a democratic socialist state. **The Norwegian Defence Research Establishment** (NDRE, *Forsvarets forskningsinstitutt* in Norwegian) was established in 1946 to continue research with industrial and military relevance that Norwegian engineers and scientists had become involved in while in Britain during the war.[21] This institute was created by people which came in very close contact to the apex of power in the Labour Party, was integrated in the military system, and took up an active role both ostensibly and behind the scenes in the effort to create new development in Norway after the war. The NDRE became a bridging link to Norway's war allies in intelligence, and used its position in the system to integrate the military and its need for new and advanced technology, with the national needs for industry development, and the engineers' and applied scientists' needs for substantial research in emerging technological and scientific fields such as electronics, microwaves, information theory, and nuclear physics.

By cleverly engineering the NDRE's position in the institutional set-up, this institution became the centre for crucial developments in the areas it focused on, in spite of predictable opposition from the established institutions (such as the Oslo university and NTH).

The NDRE (and the Institute for atomic energy – IFA – which was spun off from the NDRE in order to satisfy political demands to separate military and atomic research) was the result of the efforts of engineers and scientists, but it was also the first serious technology policy effort by the Labour government. The Government spent huge resources during the period 1945-1965 on the NDRE and IFA, both in direct allocations via public budgets, and by letting the Americans finance much of what was undertaken by the NDRE on the basis of national interests.

The NDRE may have brought Big Science to Norway in this quantitative sense, but as important was that it brought home concrete operationalisations of the idea that *technological change* and high-tech industry growth ought to be the direct goal of government efforts to develop the economy and the industry, and not only a consequence of efforts to build large scale plants or to develop advanced scientific research. The idea of promoting science so that industry can build on science to develop itself into being a science based industry both in its products, processes and organisation, was not sufficient for the people of the NDRE system. *They came to represent a view that a co-ordinated effort with a strong and technically and scientifically trained central leadership had to push the efforts ahead. Collaboration had to take place on the political and administrative level; institutions had to work together, for the common interest, by technical experts often closely knit and loyal to the political leadership.*

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[21] The analysis relies on Ørstavik 1989 and 1996. See also Njølstad and Wicken 1997.

The case of the NDRE and IFA illustrates a point brought up earlier, namely that the *de facto* technology policy and innovation policy promoted by the Labour Party was ambivalent. On the one hand, and most overtly, economic policies were Keynesian, the economy was shaped by demand and credit regulation, and industrial policies were directed at developing hydro-electric power, and energy consuming metallurgic industry, and scientific research and technological innovation had a relatively limited role to play in this policy making. At the same time, a milieu of people committed to mission oriented science and industrial growth pursued an ambitious programme of building advanced technology based defence, research and industry. In this effort, the hands off and indirect means associated with Keynesian economics were replaced with the hands on commitment and energy to build modernity both in industry, defence and research. This was a genuinely top-down effort: Visionary leaders and professionals, in science, technology, defence, in industry and in politics built integrated innovation systems: Institutions were built, modified and linked into networks of complementary partners, exploiting scientific results and the technologies of the future (atomic energy, electronics).

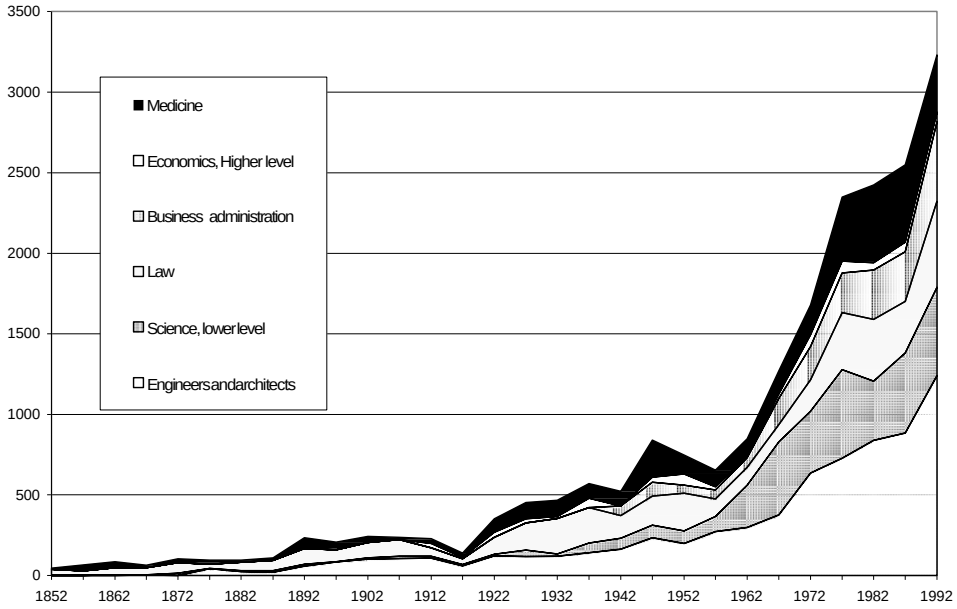
During the fifties, this dualism continued to exist, but did not pose any insurmountable problem. However, as the research system grew during the fifties, at the same time as industrial growth stagnated and new unemployment loomed, both the fact that research in the NTNF system tended to live its own life outside industry, and the fact that the very costly atomic research efforts failed to bring positive economic results became increasingly pressing problems. *The problems were in reality problems in innovation and technology policy*: Firms did not manage to generate new growth from research, and the choice to pursue nuclear technologies on such a grand scale more and more appeared to be a serious error.

5. Institutionalisation of a technology policy system

The first building blocks of a modern Norwegian research system were, as we have seen, put in place in the first decade after World War II. But it was during the sixties that it emerged as a significant sector, and a technology policy system began to emerge.

During the 1960ies the number of students in higher education grew with unprecedented strength. The production of graduates from universities and other higher level institutions increased rapidly, and it was in particular strong growth in the number of graduates in technical fields. This is shown in the figure below.

Figure 2: Graduates from Norwegian universities.[22]

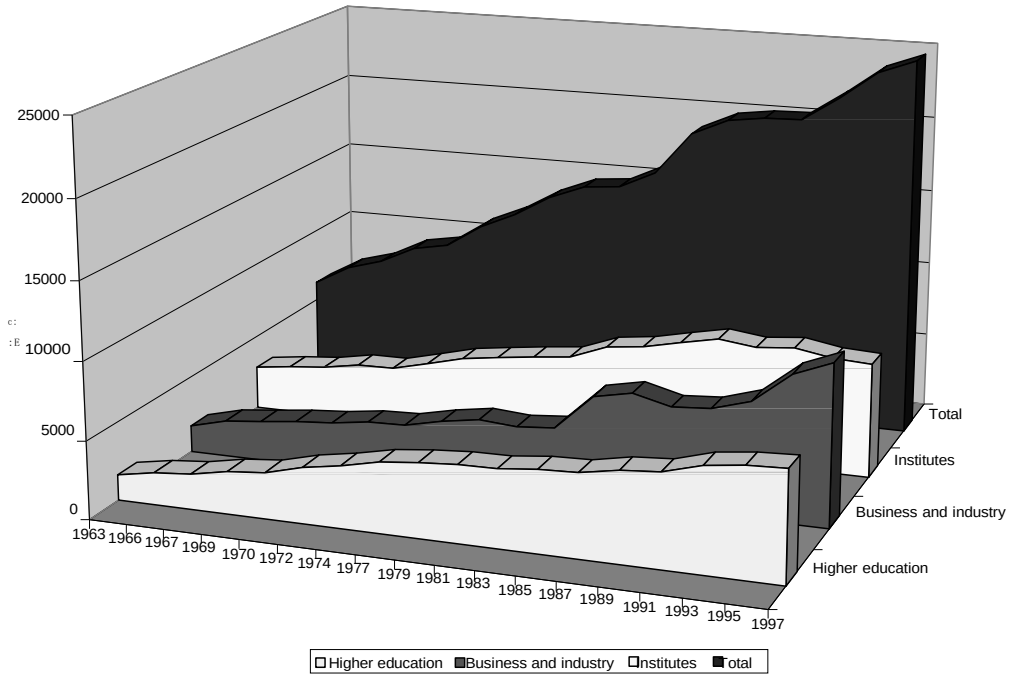


Source: Statistics Norway: Historical Statistics 1994, table 5.17.

We can also get an impression of the growth of the research system when we consider statistics for the growth of man-years of labour in R&D, as this is displayed in the figure below. The R&D man-years doubled over a ten years period; from about six thousand in 1963 to about twelve thousand in 1972.

[22] Includes numbers for graduates from "technical schools" before 1910, graduates from the Norwegian Institute of Technology thereafter.

Figure 3: R&D man-years of labour, by sector. 1963-1997.



Source: Table 5.21 in Statistics Norway: Historisk Statistikk 1994, and additional data from current Statistics Norway/NIFU R&D statistics.

At the same time, the institution building of the research system continued. 25 R&D institutions had been established between 1945 and 1960 (15 of them under NTNF). In the following decade another 8 were founded (5 of which were NTNF institutes). The University of Tromsø was proposed by the Government in 1967, and established by Parliamentary decision in 1972. During the 1960ies also the system of state funding of R&D in industry was established. We have seen how the credit system was the major lever for the government to influence industrial development. From 1960 on, new financing tools were developed that specifically aimed promoting industry based on advanced technology, rather than on exploitation of natural resources. A regional development fund (*Distriktenes utviklingsfond*) was established in 1960, *Omstillingsfondet* in 1963 and an industrial development fund (*Utvilingsfondet*) was realised in 1965. In addition to this, *Tiltaksfondet* (established 1935) was reorganised and given a new mandate.[23]

Also in this period, the first comprehensive report on research policy was worked out by the NTNF, known under the name *Forskningsmeldingen 1964.* This report emphasised the strong link between future oriented industrial development and scientific and technological research. Important research areas were defined, and significant funding increases were proposed. Furthermore, the need for closer coupling of research institutes and industry was underlined, and the authors stressed that the public sector ought to function as a *customer* for Norwegian technology firms. As a consequence of the parliamentary report which

[23] Wicken 1992: 13.

was written on the basis of *Forskningsmeldingen*, the *Storting* endorsed a system in which the state was to be able to make development contracts with *specific industrial firms* in order to promote technologies and products that were deemed strategically important.

Forskningsmeldingen 1964 further developed an argumentation which had been launched in a previous - more limited - analysis of the electronics industry. *Elektronikkutvalget* had been established in 1961, with Helmer Dahl as chairman. (Dahl had been a leading person behind the foundation of the NDRE.) The commission argued that it was insufficient to invest in research at institutes and then hope that this would «automatically» lead to the growth of new industry. What was called for was a ***long term cooperation between research, industry and the public sector***. This meant that an expansion of the role of the public sector as demanding high-tech customer was called for. The sector ought to take its share of the responsibility to execute a national technology- and industry-policy. This was a dual responsibility: Public agencies should instigate and finance research in their respective sectors, and they should have a responsibility as customers. The R&D initiatives should be supported also by a policy of preferential buying of the resulting new products.[24]

The Labour party lost government power in 1965, after for several years having been faced with increasing political opposition not least to its industry and technology policies. Several factors contributed to a gradual weakening of Labours top-down hierarchical approach to technology and innovation policy. The promotion of the huge effort in atomic energy met with increasingly hostile opposition, the gradual opening up of the Norwegian economy (with membership in EFTA from 1960), and the new funds for state support to R&D and innovation in industry, all were contributing factors. New openings for initiative from private firms materialised, and several high tech firms – for example in electronics – were established on the basis of access to state support. during the years of centre-right coalition government during the period 1965-1970, among them some that came to play very significant roles later.[25]

6. The ascent and decline of the hierarchical paradigm

One key argument for state support to innovation in a few selected firms, and state support to a public system of R&D, was that success depended fundamentally on size. Only large firms were believed to have real chances to succeed in competitive markets, larger research institutes were believed to bring out more interesting results than small institutes. This reasoning was brought to the forefront of policies again in when Labour returned to government offices after a 5 year absence, in 1971.

During the period in opposition, the party had been planning a new industry policy effort. However, the attempt to join the EEC in 1972 came to distract at-

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[24] The technology policy principles that Helmer Dahl and then Forskningsmeldingen formulated were used as the background for a significant reorganisation of Telegrafverket which took place during the 1960s.

[25] See the discussion of Norsk Data in Ørstavik 1996.

tention from any such effort (Tveite 1993: 32-33), and in addition another urgent issue emerged: Substantial oil and gas resources had been discovered in the North Sea, and a new Norwegian policy for petroleum exploitation had to be built up more or less from scratch. Labour was in the position to orchestrate the effort, and chose to use the core persons in the, then, 25 year effort to build a hierarchical, technologist dominated national innovation system: Finn Lied and Jens Chr. Hauge. The ambition was to develop an autonomous Norwegian capability in this area. A leading bureaucrat and a key figure in the ministry of industry, Odd Gøthe, expressed Labours view of the developments ahead, when he said that "one foresees the establishment of a state exploration firm ... The exploitation of the Norwegian ocean areas can become 'our big research project' in the coming two decades, and in this research program the state must take a significant part of the research costs."

Labour succeeded in building up of the Norwegian techno-industrial cluster in the petroleum sector, giving the Norwegian authorities a significant role to play in this field, both as a regulator and as an owner of industry – not least through the new state owned company Statoil (where Jens Chr. Hauge was the first and Finn Lied was the second chairman of the board).[26]

In her interesting account of the fate of the long planned holding company for state industry, *Statlig forvaltningsselkap for industri (SFI)*, Tveite (1993: 37ff) shows how policy for land-based industry by 1975 had come back into the mainstream of labour policy. In *Stortingsmelding 67 (1974-75)* the government argued that the industry would continue to play a crucial role for the further development of the Norwegian welfare state. Industry would be needed to realise central goals for example for employment and regional development. The task of the state was *overordnet styring* – top-down strategic management and control. Displaying confidence in the possibility of rational planning and strategic management from the top, the government stated that the goal for industry should be profitability *overall*, rather on the level of single firms. As Ørstavik (1989 and 1996) has shown, the techno-industrial complex involving the state owned weapons produces and engineering firm *Kongsberg Våpenfabrikk* (KV) and the NDRE had proven effective in bringing forth new technology and innovation, for example in fields such as turbines, automation and electronics, but KV had huge profitability problems, and at several points depended on extraordinary state support to continue its operations. Reflecting this situation, and the central position of the supporters of KV in the Labour Party power elite, policies in the 1970ies built on the idea that such profitability ought to be only secondary priority; more important *on the national level* was the *technological results* obtained. *SFI was a means by which this technology oriented industrial policy should be attained in practice, and an added element in a hierarchical state-dominated national innovation system.* As Tveite (1993) shows in her detailed analysis, the SFI was intended to be both a business firm and a cornerstone in the Norwegian innovation and technology policy system.

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[26] Hanisch and Nerheim (1992) gives an interesting historical analysis of the development of petroleum technology industry and research at this point.. See in particular chapter 5 on the establishment of *Oljedirektoratet* and Statoil.

We have mentioned two important factors influencing the policy developments in Norway after 1970: The EEC and the North Sea petroleum resources. A further very important factor was the economic downturn which followed after the first OPEC oil embargo. The downturn was by Labour and by influential Norwegian economists predicted to be of a transitory nature; a temporary setback caused mainly by unfavourable economic conditions internationally, but proved to be of much greater significance. The labour government embarked on a counter-cyclical policy and decided to support industry in trouble. Among the industries that got the most support was a labour intensive sector such as shipbuilding, but also the electronics industry – which was considered strategically important - received substantial support. It is important to realise that the support wasn't only intended as support in a situation of emergency, although this motivation was there, and increasingly so as the signs for trouble multiplied.[27] Much of the support to industry was actually intended to be aid for strategic restructuring. Thus, the political motivation for support in many cases was to make firms able to restructure activities in order to be competitive in the medium and long term. In an imperfect policy system, the end result was often futile injection of cash into troubled firms, injections that only relieved pain, but could not solve the underlying problems.[28]

The well known and highly considered consumer electronics firm Tandberg became a symbol for the failure of the technology and innovation policies within the framework of the hierarchical policy system. Leading men (such as Lied and Hauge) had intruded into the affairs of Tandberg from the early seventies, both in order to push the firm to become more ambitious with respect to technology and innovation, and in order to restructure the electronics industry; to merge firms into larger units. When Tandberg collapsed in 1978, this was a very significant political event, which "proved" the failure not only of the counter-cyclical economic policy that Labour had pursued, but also, of the self confident top-down innovation and technology policy approach which the Labour Party had pursued for a long time.[29]

The networks of power that had been active since the war lost much of their strength in the early 1980s. The troubled situation may well have contributed, but the primary fact was simply *age*. The people that had been in their twenties or early thirties during the war, were getting old. Jens Chr. Hauge left the board of KV in 1983. He had been there for almost 30 years. Bjarne Hurlen left the board of KV in 1985. He had been CEO for 20 years, and then chairman of the board for yet another 10 years. Finn Lied left the director chair of FFI in 1983. He had been in the position for more than 25 years, and had occupied central positions in the Norwegian technology policy system (and in NATO) for almost as long. Odd Gøthe left NTNF in 1981, after having played a leading role in the

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[27] NOU 1976: 30, for instance pages 9-10, shows how the electronics industry experienced severe problems, and how leaders in the industry called for state support to overcome the crisis.

[28] Ørstavik 1996: 346.

[29] *Ibid.*, 359-360.

Ministry of Industry and in NTNF, also for about 25 years. Robert Major left only 2 years before Gøthe. He had been the administrative director of NTNF since the council was established in 1946.[30]

Not only did key people leave responsibility to younger people. Their way of working, their way of thinking industry and research, also to some extent appears to have gone with them. With Gro Harlem Brundtland's 2 year in the prime minister office, and then the extended period in the 1980s with conservative and conservative-centre coalition governments, contents of industry and technology policy was transformed. The report on industrial growth that the Lied-commission wrote in 1979 can be seen as the testament of the old generation, and it was a report without any of the self-confidence and self-righteousness which had been an integral part of the style of Hauge and his associates. Although the report still stressed the need for more engineers and technologists and underlined the fundamental role of R&D for industrial growth, and although the commission repeated the call for the pubic sector to increase the support of advanced Norwegian industry and the use of R&D contracts, the tone was different, and a need for policy reversal was pointed out at least in two important respects: First, there was no longer any confidence expressed in the possibility to plan on the level of single firms, and to choose single firms as "national champions". ***Initiative had to be delegated to the industry***, and an element of competition and quasi-natural selection (survival of the fittest) had to be accepted. Second, ***the commission called for establishing a more vital credit system and to stimulate the stock market, in order for risk capital to become accessible for firms***.[31]

7. Towards a new sharing of power and collaborative innovation

Under Gro Harlem Brundtland's first government (Labour), as well as under Willoch's *Høyre*-government from 1981, a search for a new fundament for technology and industry policy began. The *Thulin* commission report was the first broad analysis of the Norwegian R&D system since the NTNF 1964 *Forskningsmelding*, and became a landmark in the Norwegian technology- and innovation policy debate.[32]

As we could see in the illustration of growth trends in R&D work, the expansion of research activities continued during the 1970ies and 1980ies. But, as we see in the table below, while growth rates were in the institute sector was very high during the 1970ies, and substantially lower in the 1960ies and 1980ies, the pattern was opposite for business and industry: Here the growth in R&D (in terms of labour) was much higher in the 1960ies and the 1980ies than in the 1970ies.

Table 1: R&D man-years. Growth rates in selected periods. Percent.

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[30] *Ibid.,* 361.

[31] *Ibid.*, 362-363.

[32] The commission report is NOU 1981: 30 A and B. The subsequent government report to the parliament is Stortingsmelding 54 (1982-83).

	Business and industry	Institutes	Higher education
1963-1970	75	35	79
1970-1981	37	54	66
1981-1991	61	33	21

Source: Table 5.21 in Historisk Statistikk 1994

Much of the growth after 1980 was due to indirect subsidies originating in the petroleum sector. Foreign corporations were encouraged to support Norwegian R&D activities. Such commitments were taken into consideration in the selection of firms that were to take part in the off shore exploration activities in the North Sea.[33]

The new and reformed Labour that emerged under the leadership of Brundtland diverged from the old in its new acceptance of the market in allocating resources in business and industry. It was never a question of a total reversal of old policies, however. Focus continued to be set on effectiveness and efficiency, and on the advantages of having big firms and big institutions in research and higher education. What was disbanded was the idea of a monolithic technocrat leadership, and a top-down hierarchical model for how to generate technological change and industrial innovation. Power would need to be delegated, policies made more less particularistic and more universalistic. Not least important was that the perspective of *users* and *clients* had to come into the perspective in a different way than before. The old paradigm had been that visionary leaders, professionals with scientific and technological training had carried through "religious wars" for change in a stubbornly conservative and unenlightened environment. The new paradigm put the different parties in innovation efforts more on an equal footing. By coupling the competence of researchers and technologists with first, the strategic competence of business leaders, and second, the competence of users and customers, a flatter, more interactive processes of innovation were to be realised.

The revival of liberalism which occurred in Norway during the 1980ies cannot, obviously, be explained in an exclusively national context. Liberal and market oriented policies were spreading in the political systems in the whole OECD area, and the developments in Norway echoed this broader movement. For the first time since 1928 Høyre formed government alone after the elections in 1981. When Labour again took office in 1986, a new Labour power elite had emerged with Gro Harlem Brundtland as the central leader, and there was no question of reversing the moves towards liberalisation and increased market competition that the Høyre government (from 1983 joined by Kristelig folkeparti) had effected. The system of regulated credit was dismantled, the stock market given a set of fiscal incentives, taxes were reduced, state engagement in industry was reduced, and privatisation initiatives formulated. Instead, the Brundtland Government and the Labour party embarked on a "Freedom campaign" in order to take the steam out of the conservative agenda. Privatisation was continued, while more subtle methods of selective industrial support were deployed which

[33] Nås and Wiig 1992 and 1993.

coupled up more closely with private business and abstained from defining firms with state ownership as industrial locomotives.

8. Conclusion

It is commonly accepted that "the linear model" has been dominating technology- and innovation policy in the US and Western Europe in the post World War II period. In this paper, I have argued that this is a misconception. While the simplistic ideas about the relationship between science, technological innovation and industrial success have certainly had some currency, and have been a useful at times in economic arguments for basic scientific research, the leading people promoting science, technology and industry policy and practice in Norway have certainly not been thinking in these terms. Quite to the contrary: All since Birkeland and Eyde laid the fundament for Norsk Hydro and Holst developed his scientific laboratory activities in his firm Freia, there has been a clear perception that science, technology and industry has to be built together; it is the links between the activities that is the key to success, and not building of walls between them.

As Stokes makes very clear in this discussion of *Science, the endless frontier*, Vannevar Bush argued the need for continued strong state support for scientific research, and his main rhetorical strategy was to employ an *economic argument* – that economic welfare and industrial competitiveness is a direct consequence of a strong and national capability in basic scientific research. This argument was extremely effective in the aftermath of the war, and in the shadow of the Hiroshima bomb. As a rhetoric tool for academic science and expensive technological explorations the argument continued to have weight up until today. The economistic rationale for science is strong as long as the link between basic science and economic growth is credible, but it can easily become a liability if this argument is construed to mean that free, non-directed and non-managed research is the research that gives the most beneficial *economic* results, economically and otherwise. In the light of experience with wasteful investments in science and technology, and all the negative consequences of new technologies, it would appear that, as Sejersted states, "not many today are willing to subscribe to this view, neither on an overall level, nor on the more trivial level".[34]

When the Grøholt commission in 1991[35] argued that one should not give weight to the distinction between applied and basic science, but that the orientation of research and the formulation of problems should happen in a collaboration between political organs, research milieus and users of research results, and that the largest instrumental or economic benefit is accrued by developing effective modes of interaction, then this is very much in line with what had been stated policy of the Labour party in the whole post-war period.

The big and significant change in Labour policies for industry, technology and science was not in the "discovery" of what Stokes has called "Pasteur's quad-

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[34] Sejersted 1991. See also NOU 1991: 24, and Winner 1978: 97-98.

[35] NOU 1991: 24.

rant" of use-oriented and knowledge oriented research. The big change dealt with the question of ***who were to decide, to have the power to make choices*** as for research areas, directions and potential applications. While the traditional view, and the view shared also by economists, was that this should be the task of the firms themselves, subject to competition, but not to state intervention in the running of the business, the science and technology oriented ***technocrats*** of the Labour party had a very different ambition: They meant that it was them, or rather, a scientifically trained, practically oriented and politically cunning profession of technologists (engineers and practically oriented scientists) that should do it. Only they could look far ahead and see the opportunities of science and technology of the future.

The build-up of research institutions, and the development of policy practices under Labour continued to reflect this priority, although the single-minded build up of well funded research institutions gradually was complemented by a build up of a more integrated system of research, production and use, the priority was always on making it possible for the technocrat elite to have the upper hand. During the seventies, a general restructuring effort where small firms were attempted merged into bigger units, a new initiative was taken to establish a state holding company for high technology companies, and the wish to focus on overall profitability for society in the longer run was put over the conventional demands for profitability of single firms in the short and medium term.

It was this ambition that broke down at the end of the seventies, and labour reoriented its science, technology policies in a fundamental way: The top-down model was transformed; the market as an allocation mechanism was again given priority, and rather than a top-down hierarchical approach to decision making, a more interactive model gradually took form: While visionary leaders were to be the spearheads for a better society before, faith was now increasingly being put into the idea that it is in an interactive process of learning and development that advances should be made. The elitist calls for industry to take research results seriously, and to use opportunities presented to industry by technical researchers, has been replaced by a more balanced approach in which the secret to success is in constructive interplay between parties with different tasks and different areas of expertise. There has been a transformation of policy outlook from a hierarchical systems understanding, into a non-hierarchical innovation system marked by interactive learning, and by evolutionary "survival of the fittest" rather than the "survival of the good" which was so marked in the earlier policy.

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STEP gruppen

STEP-gruppen ble etablert i 1991 for å forsyne beslutningstakere med forskning knyttet til alle sider ved innovasjon og teknologisk endring, med særlig vekt på forholdet mellom innovasjon, økonomisk vekst og de samfunnsmessige omgivelser. Basis for gruppens arbeid er erkjennelsen av at utviklingen innen vitenskap og teknologi er fundamental for økonomisk vekst. Det gjenstår likevel mange uløste problemer omkring hvordan prosessen med vitenskapelig og teknologisk endring forløper, og hvordan denne prosessen får samfunnsmessige og økonomiske konsekvenser. Forståelse av denne prosessen er av stor betydning for utformingen og iverksettelsen av forsknings-, teknologi- og innovasjonspolitikken. Forskningen i STEP-gruppen er derfor sentrert omkring historiske, økonomiske, sosiologiske og organisatoriske spørsmål som er relevante for de brede feltene innovasjonspolitikk og økonomisk vekst.

The STEP-group was established in 1991 to support policy-makers with research on all aspects of innovation and technological change, with particular emphasis on the relationships between innovation, economic growth and the social context. The basis of the group's work is the recognition that science, technology and innovation are fundamental to economic growth; yet there remain many unresolved problems about how the processes of scientific and technological change actually occur, and about how they have social and economic impacts. Resolving such problems is central to the formation and implementation of science, technology and innovation policy. The research of the STEP group centres on historical, economic, social and organisational issues relevant for broad fields of innovation policy and economic growth.