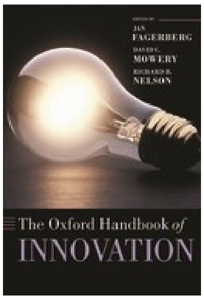

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CHAPTER

22 Science, Technology, and Innovation Policy

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Abstract

This article is about what governments have done and could do to promote the production, diffusion, and use of scientific and technical knowledge in order to realize national objectives. This article begins with "story-telling" based on sketchy historical facts. The aim of the two stories is to illustrate that innovation policy covers a wide set of issues that have been on the agenda far back in history while still remaining important today. Furthermore, this article moves on to sketch the history of innovation policy, splitting it up into the three ideal types: science, technology, and innovation policy. It uses the documents from Organization for Economic and Co-operation Development and other sources to do so. Finally, it points to future challenges, and highlight research opportunities.

Keywords: diffusion, innovation policy, science, technology, Organization for Economic and Co-operation Development

Subject: Business Strategy, Innovation, Business and Management

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22.1 Introduction

THIS chapter is about what governments have done and could do to promote the production, diffusion, and use of scientific and technical knowledge in order to realize national objectives.

We begin the chapter with "story-telling" based on sketchy historical facts. The aim of the two stories is to illustrate that innovation policy covers a wide set of issues that have been on the agenda far back in history while still remaining important today. We move on to sketch the history of innovation policy, splitting it up into the three ideal types: science, technology, and innovation policy. We use OECD documents and other sources to do so. Finally we point to future challenges, and highlight research opportunities.

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22.1.1 From Guns …

One important early example of successful technology policy was the initiative by Henry VIII to develop the competitive production of cannons made out of iron in England in the first half of the sixteenth century. The reason for establishing this technology policy program was that England desperately needed more cannons to win the ongoing war with France, and that the bronze cannons at use were too scarce and too expensive (Yakushiji 1986).

One factor making the success of the program possible was that England had access to iron ore as well as forests for fuel. Another important factor was that skilled people who were expert forgers had moved to England from the Continent, especially from France. Some came because they had been expelled because of their religious faith, while others were brought to England because of their unique skills. The programwas realized through establishing a consortium under the leadership of William Leavitt, head of the royal iron works in Newbridge, and bringing together expertise coming from different countries, especially founders with their roots in France.

Many of the instruments of technology and innovation policy that were used at that time are still in use today. Technological diffusion through immigration was important. Competition policy and property right regimes were manipulated, and public procurement used. After a period when several competing companies were allowed to export cannons (pirates were among the more advanced users!) monopolist rights were guaranteed to one producer (Ralph Hogge). Barriers to the movement of skilled people to the Continent and export licensing were established to make sure that only Protestant countries got access to the technology. Public procurement was certainly a policy instrument that promoted the refinement of the technology, in this case with a national security objective.

22.1.2 … to Butter

In the middle of the nineteenth century the Danish economy was highly dependent on the export of corn to England. Danish rye served as the "fuel" driving the English horse-based transport system. In the second half of the century and especially in the 1870s a dramatic reduction in overseas transport costs gave Russia and the US easier access to this and other markets. Prices were brought down to a level where Danish farming could not compete anymore. A major agricultural crisis broke out.

At that time there was already some export of animal products including butter especially from the manor houses. But the most important barrier was the uneven quality of the products. Standardization was a key element in the transformation of Danish production and exports away from corn toward butter and other
p. 601
animal ↳ products. This transformation involved a combination of technical and social innovation and a combination of state and "non-state intervention." The public policies involved were "diffusion oriented" rather than "mission oriented." The episode made deep imprints on the Danish innovation system that are still possible to identify.

The most important technology brought into use was related to dairy processing. To separate the fat from the milk the "separator" was developed in Sweden, however it was first produced in Denmark and first brought into use in Danish dairies. But the single most important innovation driving the transformation was social rather than technical and it came neither from the state nor from the market. Grundtvig—priest, philosopher, and nationalist—was a key person who founded a social movement that changed the mode of production in Danish agriculture. In his writings and in the lectures he held all over the country, he emphasized the need for farmers to get educated and take on responsibility for their own fate. Over a short timespan local "folk high schools" spread quickly in the countryside.

Inspired by this ideology and forced by economic necessity farmers got engaged in cooperative ownership around new local dairy plants. In the 1880s, the number of cooperatively owned dairies grew from three to 700. Between 1850 and 1900 the share of butter in Danish exports to the UK went from 0 per cent to 60 per cent. The cooperative form of ownership created a framework supportive for rapid diffusion of dairy techniques and for standardization.

State policies supported these developments. The Agricultural University in Copenhagen was established as early as 1856 (Wagner 1998). Dairy consultants played an important role in the process of diffusing good practice and on this basis the dairy oriented Agricultural Research Laboratory was established in 1883.

This example might be of special importance for developing countries with "soft states." In these countries ordinary state-led science, technology and innovation policy might not be sufficient to overcome the obstacles for economic development. A broader social mobilization might be necessary in order to overcome barriers to socio-economic development.

22.1.3 Modern Innovation Policy between Guns and Butter

If we go to the leading economy in the world in terms of technology—the US—we find elements in the innovation system that remind us of both these stories. The successful development of the atomic bomb at Los Alamos has many characteristics in common with the "gun-story." It was a crash-mission project aimed at winning a war and it brought together skilled people from different parts of the world. It also set the agenda for much of what followed in terms of technology policy not only in the US but all over the world.

p. 602 But the US innovation system does not have characteristics in common solely with the gun-story. One of the most successful examples of innovation policy in the US has been the upgrading of agricultural activities in terms of products and productivity. The establishment of land universities and extension services were crucial for training, and also for research and development of new technologies and products. It was especially important for the rapid diffusion of new ideas among farmers. In spite of this success there have been few attempts to introduce similar diffusion oriented policies in relation to manufacturing and services. The US now has a "Manufacturing Extension Partnership," created in the late 1980s, which seems likely to survive politically although its effectiveness is uncertain. When attempts were made to apply the model to construction industries in the US, the attempts failed (Nelson 1982).

22.2 Science Policy, Technology Policy, and Innovation Policy

As can be seen from the other chapters in this book—and from the two stories told above—innovation policy covers a wide range of initiatives and it is necessary to give some structure to the complex reality. One way to do so is to introduce "ideal types" that bring out in a more distinct form classes of phenomena that are muddled and mixed in the real world.

The distinction to be used here is between science policy, technology policy, and innovation policy. For each we will discuss how it became an explicit policy field, what the major issues at stake are, what part of the innovation system is in focus, which are the major actors involved and what are the instruments used. We will point to the critical sets of data supporting the policies. And since the OECD has played a unique role among international organizations in the diffusion of ideas about innovation policy we will use OECD documents to illustrate some of the more important shifts in the post-war debate.

It would be misleading to argue that we pass from science policy to technology policy and then to innovation policy as we pass from one historical stage to another. For instance some of the classical issues in science policy are very high on the current policy agenda (Pavitt 1995; Martin and Salter 1996). Current developments in biotechnology and pharmaceuticals have made the distance from basic research to commercial application much shorter and therefore the organization of universities has become a major issue (see Ch. 8 by Mowery and Sampat). Genetic engineering ↳

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p. 604 ↳

brings in fundamental issues about ethics that we normally would connect with science policy. In the real world the forms overlap and mix.

Box 22.1 OECD and the evolving discourse around science, technology and innovation policy

The OECD has played a key role in the evolution of the understanding of the policy fields discussed in this chapter. It is certainly one of the best sources for internationally comparable data on science technology and innovation. Data are accessible through regular publications in the form of periodical policy reviews and through data bases that are regularly updated. But it is also interesting to follow the policy discourse organized at the OECD secretariat. What has been said at OECD meetings and recommended by its expert groups might not always be transformed into practical use in member countries but it reflects the new ideas. Therefore a brief summary of the most important reports (in fact they all tend to arrive at the beginning of a new decade) will be made here.

OECD 1963: Rationalizing science policy and linking it to economic growth. Inan OECD document from the beginning of the sixties (OECD 1963*a*) a shift in attention toward economic objectives was signaled for science policy. This document with Christopher Freeman, Raymond Poignant, and Ingvar Svennilsson as major contributors is quite remarkable in the emphasis it gives to national and rational planning. It came the same year as the Frascati meeting on a new manual for gathering R&D statistics took place and it argues for a strong link between better data on R&D and more systematic policy. This report obviously aimed at giving science policy legitimacy outside the narrow circles of ministries of education and science.

OECD 1970: Bringing in human and social considerations on technology policy. This report (the "Brooks Report") introduced a broader social and ecological perspective to science and technology policy. It also gave strong emphasis to the need to involve citizens in assessing the consequences of developing and using new technologies. The new focus reflected a combination of growth satiation and dissatisfaction with the social consequences of technical change. Therefore it was also assumed that room should be given for wider concerns and the uncritical optimism was challenged.

OECD 1980: Innovation policy as an aspect of economic policy. The OECD expert report "Technical Change and Economic Policy" (OECD 1980) redefined the agenda for innovation policy in the light "of a new economic and social context." Its message was that the slow-down of growth and the increase in unemployment could not be seen as something that macroeconomic expansionary policies could solve. Neither did the report restrict itself to recommending an increase in investments in science and R&D. As compared to earlier reports on science and technology, the focus was moved toward the capacity of society to absorb new technology. The experts included, among others, Freeman, Nelson, and Pavitt. It is interesting to note that this report was published simultaneously with a more traditional document on innovation policy (1980). This was obviously a period when innovation policy began to be regarded as a legitimate policy field.

OECD 1990: Innovation defined as an interactive process. The TEP project, edited and given its flavor by Francois Chesnais and with Luc Soete as one of the leading external experts brought together in one coherent framework a broad set of new research results on innovation and used those to point in new policy directions (OECD 1990). The report took as its starting point "innovation as an interactive process" and gave a prominent role to national innovation systems as an organizing concept. There was a stronger emphasis on network formation, new forms of organization and industrial dynamics than in earlier OECD contributions to innovation policy. The demand side and strengthening the absorptive capacity of firms as well as the feedback from users to the supply side were given strong emphasis. This report gave the systemic version of innovation policy an analytical foundation.

OECD 2001: The new economy beyond the hype. In the middle of the 1990s the idea of a new economy based upon ICT and vibrant entrepreneurship began to be diffused in the US with Federal Reserve

President Alan Greenspan as an important source. At the end of the millennium OECD began to analyze the phenomenon and its first reports came in 2001. These reports were interesting because they were coordinated by the Economics Department at OECD that so far had treated innovation as a secondary phenomenon and had been a spokesman for a pure market innovation policy. The catalog of recommendations with regard to innovation policy is more extensive than what OECD economists had ascribed to so far—see for instance the Jobs Study (OECD 1995). The new economy episode is interesting because it is the first time that innovation becomes widely accepted among economists as a fundamental factor that needs to be analyzed and understood. At the same time, it is clear that the basic hypothesis was too simple and the policy recommendations remained colored by the traditional pro-market and anti-state philosophy of the OECD economists.

22.2.1 From Science Policy …

The two historical examples given above belong to the realm of technology policy rather than science policy. Science policy is a concept that belongs to the post-war era. Before the war, regional and federal governments were funding university research and the training of scientists. But they did so primarily for historical and cultural reasons and, before World War II, the idea of science as a productive force was taken up mainly in the planned economies.

According to Christopher Freeman science policy was recognized as a policy area through the pioneering work by Bernal (1939). Bernal was a pioneer in measuring the R&D effort at the national level in England and he strongly recommended a dramatic increase in the effort since he was convinced that it would stimulate economic growth and welfare. In the US, the Vannevar Bush report from 1945, "Science: The Endless Frontier," has a specific status in defining an agenda for the US post-war science (and technology) policy. It
p. 605 defined the task for science policy as ↳ contributing to national security, health and economic growth. Like Bernal, the Bush report gave strong emphasis to the potential economic impact of investments in science.

The real reason for the breakthrough of science policy and the increased public investment in research was probably the way World War II ended and the ColdWar started. The success of the Los Alamos project made plausible the idea that a massive investment in science (especially physics but also chemistry and biology), applied science and technological development could produce solutions to almost any difficult problem, and underscored the importance of science and technology for national security. This pressure to invest in the promotion of science was reinforced in the arms and the space races between the US and Soviet Union. In 1957 the launch of Sputnik put extra pressure on the West, and especially the US, to invest in defense and space-related research.

The major issues in science policy are about allocating sufficient resources to science, to distribute them wisely between activities, to make sure that resources are used efficiently and contribute to social welfare. Therefore, the quantity and quality of students and researchers receives special attention. The objectives for science policy that are actually pursued by governments are mixed and include national prestige and cultural values besides social, national security, and economic objectives.

The elements of the innovation system that are focused upon are universities, research institutions, technological institutes, and R&D laboratories. Science policy is both about the internal regulation of these parts of the innovation system and about how they link up to the environment—not least to government and industry. However, strengthening this linkage becomes even more crucial in technology and innovation policy.

There are two more or less standing debates within the science policy community. The first debate has to do with how far scientific progress is identical with progress in general. Critical scholars would point to how science is abused in the control of people and nature—including genetic manipulation and undermining ecological sustainability. Those more positive to science would respond that none of this can be seen as emanating from science: rather, it should be seen as the result of unwise use of science. Scholars from humanities and sociology might more frequently join the first camp while scientists and technologists have a tendency to join the second.

The second debate is about to what degree science should be made the obedient servant of the state and/or capital and to what degree it should be autonomous. Sociologists of knowledge have devoted considerable attention to this question, also in relation to different national research policy styles—with more or less governmental steering and with different levels of aggregation—large/small research activities (Rip and van der Meulen 1997; Jasanoff 1997). Others have argued that there is a shift in the mode of research and knowledge production, with different effects upon the autonomy of science (Cozzens et al. 1990; Gibbons et al. 1994; Jasanoff 2002).

p. 606 University scholars tend to argue that "freedom" and "autonomy" of academic research is important for at least two reasons. One is the long-term value of serendipity—only when basic research is allowed to move along its own trajectories will it produce the unsuspected that can open up new avenues for applied research and technical solutions. The second reason is that critical science is an important element in modern democracy, because scientific knowledge from independent sources is an important input for open, transparent and representative political decision making. Most scholars of innovation would agree that this is an area where there is a trade-off. While the idea of basic research as "free" science—signaling a complete absence of direction and use—is an illusion, the massive subordination of science under political and economic interests would certainly undermine its long-term contribution to society and economy.

The main policy actors in the public sector are ministries of education and research and research councils. But sector ministries in charge of health, defense, energy, transport, and environment may also play a role since they organize their own research communities, and in some industrial economies account for the majority of public spending on R&D. Ministries of finance play a role when it comes to decide the total budget for research. Civil organizations representing consumers and citizens may be invoked as corrections to a bias in favor of commercial interests.

The instruments used are budgetary decisions on allocating funds to public research organizations, such as universities, and subsidies or tax relief for private firms. Finding institutional mechanisms that link universities and public laboratories to the users of research is of course a fundamental issue. But it becomes even more so when we turn to technology and innovation policy and therefore we will save the discussion of such instruments until later. Designing intellectual property rights for universities has recently become a major issue (see Chapters 10 by Granstrand and 8 by Mowery and Sampat in this volume).

The evaluation of research is an important policy tool and it can be seen both as creating incentives for scholars and institutions to become more effective and as a means to allocate public money. Academic life has built evaluation procedures into it. To make an academic career exams must be passed and books and articles will be peer reviewed. At well-functioning departments weekly seminars expose ongoing work to criticism from colleagues. These days such processes increasingly involve international expertise.

The criteria used for these ongoing evaluations are mainly internal to scientific communities and they might be regarded as misdirected by external authorities. Evaluation by peers organized according to disciplines may promote "middle of the road" work rather than new ideas coming from crossing disciplinary borders. Where this is the case, it might be helpful to establish alternative sources of regarding interdisciplinary efforts more kindly. The European framework programs for R&D have represented an opening in this direction for European researchers.

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Policy makers may also see internal evaluation as being too slack. This seems to have been the case in the UK where a very ambitious and detailed reporting system has been imposed on scholars doing research and teaching. So far the effect seems to be a lot of time used to report on research and that in England university scholars have become the professional group most unsatisfied with working conditions. While this kind of draconian reform linking quantitative indicators of performance to access to public money might be useful in shaking up conservative institutions for a brief period they tend to become a nuisance for the innovation system as a whole if not loosened up again.

One of the most fundamental questions in science policy is whether it is true that "good research is always useful research" or, more demanding, "the higher the scientific quality the more useful is the research." If it were true it would be a strong argument for leaving at least some of the allocation to the academic communities. However, the evidence on this question is contradictory. While Zucker and Darby (1998) demonstrate that star scientists are important for the success of biotechnology firms, Gittelman and Kogut (2003) show that at least within biotech there is no clear relationship between prestigious publishing and high impact innovations—if anything the relationship is negative (Mowery and Sampat 2001).

It might be expected that the requirements between doing outstanding research and creating well-designed technology are even more distinct in other fields where the distance from scientific discovery to innovation is longer. The truth may be that also science has a lot to learn from interacting with its users and that the best system is one with several layers and with career shifts—some going only for "excellence" within a scientific discipline, others focusing only on user-needs and some operating in a mode between the two.

Since the early 1990s, basic science has been constantly pushed by politicians to demonstrate its social and economic usefulness. This has been termed the "new social contract of basic science" in the age of budgetary retrenchments, particularly in Europe and the US (Martin and Salter 1996). Several authors argue that this "value for money" attitude disregards some essential aspects of science policy, such as the training of scientists and technicians, and the development of knowledge capabilities in areas where uncertainty about exploitation is so high that private investors lack incentives (Sharp 2003) and that lessons from the US experience should be examined critically, and along with for instance the Scandinavian and Swiss experiences (Pavitt 2001).

22.2.2 … to Technology Policy

Technology policy refers to policies that focus on technologies and sectors. The era of technology policy is
p. 608 one where especially science-based technologies such as ↳ nuclear power, space technology, computers, drugs and genetic engineering are seen as being at the very core of economic growth. These technologies get into focus for several reasons. On the one hand they stimulate imagination because they make it possible to do surprising things—they combine science with fiction. On the other hand they open up new commercial opportunities. They are characterized by a high rate of innovation and they address rapidly growing markets.

Technology policy means different things for catching-up countries than it does for high-income countries and it might also mean different things for small and big countries. In big high-income countries the focus will be on establishing a capacity in *producing* the most recent science-based technologies, as well as applying these innovations. In smaller countries it might be a question about being able to absorb and use these technologies as they come on the market. Catching-up countries may make efforts to enter into specific promising established industries using new technologies in the process of doing so.

Common for these strategies is that they tend to define "strategic technologies" and sometimes the sectors producing them are also defined as strategic sectors. The idea of strategic sectors may be related to Perroux and to Hirschman, both students of Schumpeter. Perroux used concepts such as "industrializing industries" and growth poles while Hirschman introduced unbalanced growth as a possible strategy for less-developed countries (Perroux 1969; Hirschman 1969).

In the lead countries, government initiatives of the technology policy kind were triggered when national political or economic interests were threatened and the threats could be linked to the command of specific technologies. Sputnik gave extra impetus to a focus on space technology and the Cold War motivated the most ambitious technology policy effort ever in the US. In Europe, Servan Schreiber's book *Le Défi américain* (Servan Schreiber 1967) gave a picture of a growing dominance of the US multinational firms especially in high technology sectors. It gave the big European countries such as France, the UK, and Germany incentives to develop a policy of promoting national champions in specific sectors. A specific important event triggering French and, later, European efforts was the export embargo of computer technology that was seen in France as blocking its progress in the development of nuclear technology.

The motivation behind the technology policy in Japan—and later on in countries such as Taiwan and Korea—is different. It is driven by a national strategy aiming at catching up and in the Japanese case it has roots back to the Meiji revolution when the first ideas of modernization based on imitating the technology of the West were formed.

At this point we need to be aware of a number of fundamental questions regarding technology policies.

- Is it at all legitimate and effective for the state to intervene for commercial reasons in promoting specific sectors or technologies? Or is the only legitimate technology ↳ policy one where national societal issues are at stake, including establishing national military power? It is a paradox that in the country having the most massive public intervention in terms of technology policy (the US), most of the policy has been motivated by non-commercial arguments and the discourse has been anti-state. Japan is the country with the most explicitly commercially driven technology policy with a recognition of a role for the state, and here the intervention has been much more modest, at least in terms of the amount of public money involved.

- What technologies should be supported? Is it always the case that high-tech and science-based sectors should be given first priority? Again the Japanese government as well as governments in smaller countries has been more apt to think about the modernization of old industries than the US and the big European countries.

- At what stage should the support be given? Should it be given only to "precompetitive" stages or should it also be helpful in bringing the new products to the market? In the second case there might be a combination of government support of new technology and more or less open protectionism.

- What limits should be set for public sector competence? Technology policy may be pursued with competence where government operates as a major user but when it comes to developing new technologies for the market, the role of governments must be more modest. To be more specific, there are several historical examples of how government ambitions to make technological choices that reduce diversity have ended in failure, for example, the "minitel" experience in France, and the high definition TV policy in the EU, both in the early 1990s.

- How can promoting a technology or a sector best be combined with competition? The period in the 1980s of promoting single firms as national champions in the bigger European countries was not a great success while the Japanese public strategy to promote "controlled competition" among a handful of firms was more successful.

The objectives of technology policy are not very different from those of science policy but—at least to begin with—it represented a shift from broader philosophical considerations to a more instrumental focus on national prestige and economic objectives. Technology policies were developed in an era of technology optimism. But later on—in the wake of the 1968 student revolt—more critical and broader concerns relating to technology assessment and citizen participation came onto the agenda (OECD 1971).

The elements of the innovation system in focus remain universities, research institutions, technological institutes, and R&D laboratories. But the attention moves from universities toward engineering and from the internal organization of universities toward how they link to industry. Technology policy may go even further and include the commercialization of technologies, but then we approach what we will call innovation policy.

p. 610 In some countries such as the US, the main technology policy actors in the public sector are sector ministries promoting and sometimes procuring technology for purposes of telecommunications, defense, health, transport, energy etc. while in others, such as Japan, they are ministries in charge of industry and trade. Ministries of education and research are important since they organize the education and training of scientists and engineers. Authorities in charge of regulating competition as well as other regulating authorities may have a major impact on technology policy and on technological development. Public authorities may, as elements of technology policy, organize technology assessment and other ways of involving citizens.

There are many possible instruments to be used in promoting specific technologies and sectors. Most efficient may be combinations of instruments in fields where public procurement is involved. When the government has the leading user competence, it is in a better position to judge what kind of instruments will work (Edquist et al. 2000). Besides public procurement direct economic incentives in terms of subsidies and tax reductions may be offered to firms. Supporting research at universities in the science fields in which the new technologies are rooted may be an important part of a public mission policy. The danger of these kinds of policies is that "industrial complexes" combining the vested interests of a segment of public users with those of a segment of industry emerge and that a lack of transparency is exploited by vested interests. A more subtle problem is the kind of convergence and agreement on the direction of technological trajectories that might develop in such complexes, excluding new and more promising venues (Lundvall 1985).

In areas where the main application of the new technologies is commercial, the set of instruments used may be a combination of sector or technology specific economic incentives with more or less protectionist trade policy. An example might be the high definition TV policy of the EU in the early 1990s, where the attempt to define a compulsory analogical standard would have been a technical trade barrier to emerging digital standards, combined with specific economic incentives for European producers. Such packages may create a sheltered atmosphere for the firms involved. More promising may be project-organized support bringing different firms and knowledge institutions together in order to focus on generic and common and *new* technological problems while making sure that the use of the new knowledge takes place in a global competitive climate. Experience also shows that making the projects well defined both in terms of content and time but open in terms of what specific type of technical solutions should be aimed at, limits the negative impact on competition.

While the evaluation of research is important in science policy there are similar general policy tools that are useful when designing and redesigning technology policy. Technology forecasting is a way of capturing new technological trends. Asking leading experts among scientists and among the most advanced producers and
p. 611 users about what technologies are rising on the horizon helps to scout the next ↳ generation of "strategic technologies." In order to limit the capturing of public interest by private firms, independent policy evaluation of specific initiatives may be useful. Many evaluations end up addressing users of the programs with questions about the efficacy of the program. Not surprisingly, such studies often end up reporting that the program was very good and that more of the same would be welcome. In this situation, as in many other situations, where too much agreement among partners threatens to become a lock-in, it should be

considered whether to give “outsiders” a strong role as evaluators. It is as important for public policy as it is for science-based firms to promote “job rotation” and “interfunctional teams.”

As pointed out, science and technology policy are ideal types, which serve our broad analytical purposes. In the real world of advanced capitalist economies, however, the policy focus, instruments and actors involved in science and technology policy-making are not always easily grouped in one or the other of these categories. As we will examine now, innovation policy takes a step further by bringing in an even broader set of policy issues.[1]

22.2.3 … and to Innovation Policy

Innovation policy appears in two different versions. One—the laissez-faire version—puts the emphasis on non-interventionism and signals that the focus should be on “framework conditions” rather than specific sectors or technologies. This often goes with a vocabulary where any kind of specific measure gets grouped under the negative heading “picking the winners.” The extreme version of this type of innovation policy is one where basic research and general education are seen as the only legitimate public activities and intellectual property right protection as the only legitimate field for government regulation. In more moderate versions public initiatives aiming at fostering “entrepreneurship” and promoting a positive attitude to science and technology in the population may be endorsed.

The other version may be presented as the “systemic” version and by referring to the concept of “innovation system.” This perspective implies that most major policy fields need to be considered in the light of how they contribute to innovation. A fundamental aspect of innovation policy becomes the reviewing and redesigning of the linkages between the parts of the system. The first approach is built upon the standard assumption made in economics that firms always know what is best for them and that they normally (in the absence of market failure) act accordingly. The second perspective takes into account that competence is unequally distributed among firms and that good practice in terms of developing, absorbing and using new technology is not immediately diffused among firms; and that “failures” may extend beyond neoclassical “market failure” to subsume “failures” of institutions to coordinate, link, or address various systemic needs, etc. (see Ch. 7 by Edquist in this volume).

 Both of these approaches cover all aspects of the innovation process—including diffusion, use and marketing of new technologies—and in a sense they may be seen as an important form of “economic policy” where the focus is more on innovation than on allocation. Both tend to put stronger emphasis on “institutions” and “organizations” than do science and technology policy. In the laissez-faire version, the predominance of the market and of competition becomes the most important prerequisite for innovation—there is in principle one single recommendation for institutional design valid for all countries.

In the systemic approach the importance of competition is recognized but so is the need for closer cooperation vertically between users and producers and sometimes even horizontally among competitors when it comes to develop generic technologies. In the systems approach it is recognized that the institutional set-up differs across national economies and that this has implications for what types of technologies and sectors thrive in the national context. To design a suitable innovation policy requires specific insights in the institutional characteristics of the national system.

Innovation policy does not imply any a priori preference for high versus low technology. The systems approach introduces a vertical perspective on the industrial system, seeing it as a network and as value chains where certain stages might be more suitable for firms in a specific country.

The respective theoretical foundations of the two different versions of innovation policy are (1) an application of standard neoclassical economics on innovation, and (2) a long-term outcome of research on innovation and economic evolution (Metcalfe 1995; Metcalfe and Georghiou 1998). The innovation system approach may be seen as bringing together the most important stylized facts of innovation. It makes use of empirical material and analytical models developed in innovation research, as well as in institutional and evolutionary economics.

The major reason for innovation policy becoming more broadly used as a concept was the slow-down in economic growth around 1970 and the persistence of sluggish growth as compared to the first post-war decades. The reasons for the slow-down in the growth in "total factor productivity" were, and still are, not well understood but there was a feeling that it had to do with a lack of capability to exploit technological opportunities. At the same time, the restrictions imposed on general economic policy by fear of inflation made it important to understand the possibilities to promote growth from the supply side.

This implies that the major objectives of innovation policy are economic growth and international competitiveness. In the European Union discourse these objectives are combined with "social cohesion" and equality. Innovation might also be seen as a way to solve important problems relating to pollution, energy, urbanism, and poverty. But the main focus is on the creation of economic wealth.

Among the instruments to be used are the regulation of intellectual property rights and access to venture
p. 613 capital. One fundamental distinction in innovation ↳ policy lies between initiatives aiming at promoting innovation within the institutional context and those aiming at changing the institutional context in order to promote innovation. The first category overlaps with instruments used in science and technology policy. The second may include reforms of universities, education, labor markets, capital markets, regulated industries, and competition laws.

Box 22.2 The neoclassical economics of innovation policy

According to neoclassical economics a necessary condition for public policy intervention is market failure. If markets can do the job there is no need to intervene. Market failure may have different causes but the ones most often raised in the context of innovation policy are lack of incentives to invest in knowledge production. Knowledge tends to be seen as a public good from which it is difficult to exclude others and also as being non-rival since its user value may not suffer from the fact that others use it. When knowledge is rival but non-excludable, intellectual property rights can be guaranteed and enforced by governments. When knowledge is non-excludable and non-rival governments should subsidize knowledge production addressed for public use or take charge of producing the knowledge by itself.

The problem with this analysis is not the conclusions reached. There are certainly good reasons for governments to support knowledge production and innovation in the ways referred to—actually we have seen that most of these instruments were taken into use long before neo-classical economics was established. The problem is that the argument for support comes from a theory based upon assumptions that are incompatible with a dynamic economy where innovation is a widely spread and ongoing process.

On rationality, markets, and competition

Innovation research has demonstrated that innovation is a ubiquitous phenomenon in the modern economy. In such an economy the idea that the "representative firm" can operate on precise calculations and choose among well-defined alternatives is a dubious abstraction. The point, made by Kenneth Arrow and others, is that innovation by definition involves fundamental uncertainty. Or as Rosenberg puts it "it is not possible to establish the knowledge production function" since the output is unknown (Rosenberg 1972: 172).

To assume that agents know what there is to know and to disregard competence building tends to miss what is at the very heart of competition in a learning economy. The assumption that markets are "pure" with arm's-length and anonymous relationships between producers and users is logically incompatible with the fact that a major part of innovative activities aims at product innovations. The only solution to the paradox is that real markets are organized and constitute frameworks for interactive learning between users and producers (Lundvall 1985).

One fundamental question is how far these other policy fields can and should be adapted to the needs to promote innovation. Universities and schools obviously have other missions than to support innovation and
p. 614
economic growth. And the ↳ ministries and authorities in charge of them are normally acting according to a different logic than the one implied by a focus on innovation. One interesting example is labor market policy where it has been assumed that what matters is flexible markets where flexibility refers both to workers' mobility and to flexible wages. To think about how to design labor market institutions so that they promote competence building and innovation might lead to different conclusions regarding what is a "well-functioning labor market."

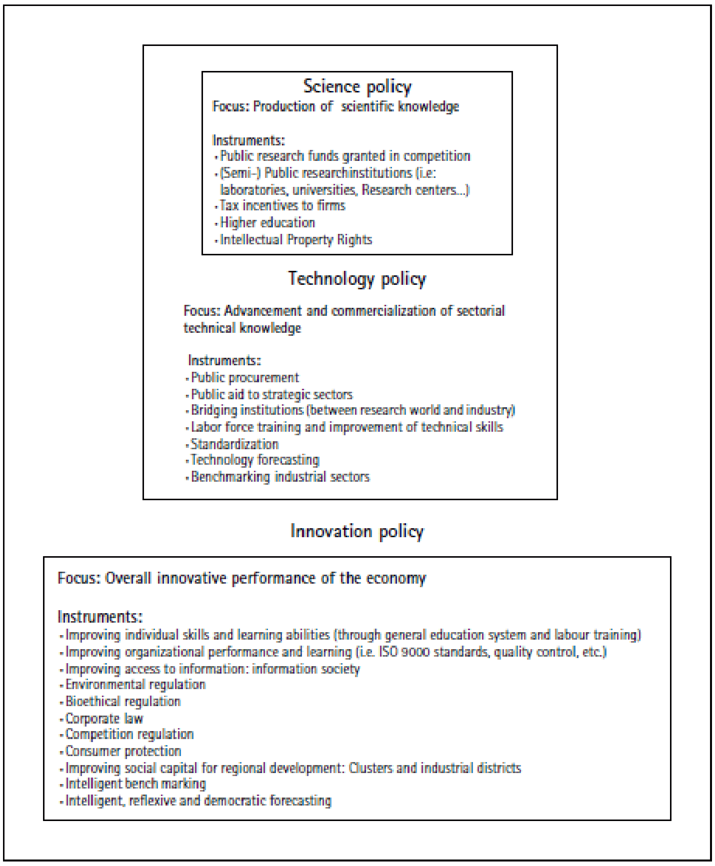
A second issue is about the limits for public sector intervention. Assume, for instance, that it can be demonstrated that the way firms organize themselves internally has a major impact on innovation performance and that economic growth can be explained by differences in this respect. Is there a role for governments in promoting the diffusion of good practices in this respect or should it still be left to management and owners to cope with such problems? It is not self-evident that government should help to diffuse technical solutions while keeping away from supporting the diffusion of more efficient organizational solutions.

As Figure 22.1 indicates, the elements of the innovation system still include universities, research institutions, technological institutes, and R&D laboratories. However, the focus of policy moves from universities and technological sectors, as in science and technology policies, toward all parts of the economy that have an impact on innovation processes. This is the reason why, in Figure 22.1, the instruments of innovation policy are also those of science and technology policy. Innovation policy pays special attention to the institutional and organizational dimension of innovation systems, including competence building and organizational performance. Innovation policy calls for “opening the black box” of the innovation process, understanding it as a social and complex process.

Ministries of economic affairs or ministries of industry may be the ones playing a coordinating role in relation to innovation policy but in principle most ministries could be involved in efforts to redesign the national innovation system. This is actually the case for some specific countries, which have experienced a truly “innovation policy turn” since the late 1990s, like for example Finland, The Netherlands, and Denmark (Biegelbauer and Borrás 2003). Developing an interaction and dialogue on policy design between government authorities on the one hand and the business community, trade unions and knowledge institutions on the other is a necessary condition for developing socially relevant and clear policy programs that can be implemented successfully.

The analytical basis of innovation policy could be a combination of general insights about what constitutes good practice, given the global context in terms of technology and competition, with specific insights in the characteristics of the national innovation system. The system can be analyzed in terms of specialization, institutional set-up, and insertion in the global economy. Attempts may be made to locate strengths, weaknesses, threats, and opportunities through intelligent benchmarking. Missing links and links
p. 615 constituting lock-ins may be especially important ↳ to locate. Human resource development and use is another important dimension. Finally, innovation policy analysis must increasingly give attention to the international dimension.

Figure 22.1



Relationship between science, technology, and innovation policy

22.3 STI Policy Evaluation and Impact Measurement

It is characteristic for the evolution of new policy fields that measurement and quantitative guidance gives more legitimacy to the field. Within the field what can be p. 616 ↳ measured sometimes gets more policy attention than what cannot be measured. A special problem and important area for further research is to measure the impact of policy.

22.3.1 Measuring the Impact of STI Policy

In the 1930s, Bernal made the first attempt to measure the effort made in science by relating R&D expenditure to the national income of the UK. In the late 1950s and early 1960s, Christopher Freeman played a key role in developing the analytical basis of science policy and it is significant that he also was one of the architects behind the Frascati manual that in 1963 gave the OECD and national authorities methods to measure R&D and compare the effort across countries (OECD 1963*b*).

Today, national R&D statistics are quite detailed. They show the effort made within respectively private and public sectors as well as the financial source of the investments. The expenditure can be analyzed according to purpose. Bibliographic methods allow us to locate the scientific fields in which a specific country has its relative strength—using citation frequency even the quality of research in different countries may be assessed.

In principle it is possible to construct productivity measures for research using scientific articles in the nominator and resources used in terms of money or manpower in the denominator. One problem with using such crude measures to guide policy is, of course, that there are other outputs not so easily measured. The amount and quality of students and scientists trained may be brought into the analysis, while the interaction with users outside knowledge institutions may be less easy to quantify.

In the field of technology, the data on patents are especially attractive since they exist for long periods and include quite rich information about the technology and agents taking out the patent. Patent statistics can be used to compare national systems in terms of technological specialization—as revealed technological advantage—and it might even be possible to distinguish between more or less important patents using citation patterns.

However, it has to be taken into account that patents play very different roles in different sectors and in some (e.g. pharmaceuticals and biotechnology) they might be more relevant when it comes to judging performance than they are in others (e.g. software and service production). The major use of patent statistics may therefore be to help mapping the evolution of national innovation systems rather than as performance indicators to judge the efficiency of technology policy.

The systemic view of the innovation policy means that these previous measurements are necessary but far from sufficient to investigate the innovative performance of an economy. The Oslo manual for gathering information and data on innovation, which was agreed upon in 1990, is an important step in this direction. p. 617 In Europe, the ↳ Community innovation surveys have been collected several times in most of the member states (see Ch. 6 by Smith in this volume).

Among the more interesting information that can be obtained through these surveys is the share of new products in total sales in firms in different sectors and countries. This is a measure of diffusion of product innovations in the economy and may be seen as an important intermediate performance variable. Another field where the diffusion of technology has been mapped quite thoroughly is in relation to information and communication technologies. These indicators are important since for innovation policy one major performance indicator should be the diffusion and effective use of new technologies.

The most important remaining tasks for building indicators to support innovation policy relate to the diffusion of process innovations, innovation in services, organizational innovations—and their diffusion—and, finally, to experience-based learning. Even with better indicators in these fields, we cannot expect to get very simple and clear conclusions from quantitative evaluation exercises.

Therefore case studies bringing together qualitative and quantitative information and dialogue with policy practitioners will remain important sources of insight when designing policy. Richard Nelson has more than any other scholar developed this approach (Nelson, Peck, and Kalachek 1967; Nelson 1982, 1984, 1988, p. 618 1993). ↳ Not least, in the era of innovation policy, where institutions matter more than ever, it is difficult to see how quantitative analysis could stand alone as the basis for policy.

Box 22.3 Innovation systems and innovation policy

Innovation systems is not an economic theory in the same sense as neoclassical or evolutionary economics, but the concept integrates theoretical perspectives and empirical insights based on several decades of research.

Innovation is seen as a cumulative process that is path-dependent and contextdependent. This is why innovation policy needs to build upon insight in a specific context and why “best-practice” cannot be transplanted from one innovation system to another. Innovation is also seen as an interactive process. The competence of single innovating firms is important but so is the competence of suppliers, users, knowledge institutions, and policy makers. The linkages and the quality of interaction is important for outcomes. This is why innovation policies that focus on subsidizing and protecting suppliers of knowledge at best are incomplete—at worst they increase the gap between technological opportunities and absorptive capacity. At least the same attention needs to be given to users and to linkages.

Innovation systems may be seen as frameworks both for innovation and for competence building. Competence building involves learning and renews the skills and insights necessary to innovate. Innovation processes are processes of joint production where innovations and enhanced competence are the two major outputs. Learning takes place in an interaction between people and organizations. The “social climate” including trust, power, and loyalty contributes to the outcome of learning processes. This is why innovation policy needs to take into account the broader social framework even when the objective is to promote economic wealth creation.

22.3.2 Evaluating STI Programs and Policies

With the growth of STI policies and programs, public authorities have been increasingly interested in evaluating the effects and impacts of public expenditure in these areas. Evaluation is the systematic assessment of programs or related public expenditures in terms of how far they have attained their goals. Evaluation should be considered as an element in a political process, namely, when public administrations try to elaborate conclusions and lessons from past performance in order to become better in the future, or to decide upon the fate of the activity in question. The evaluative exercise is typically conducted by external and independent actors, who use a range of methodologies, including the self-assessment of those persons involved in the implementation of the program. There are as many evaluation methodologies as evaluators, and as many policy styles as public administrations.

Several authors emphasize that evaluating STI policies and programs is particularly difficult given the wide effects throughout the system. It has been argued, for example, that micro-level evaluations (program-specific) are more reliable than macro-level evaluations where issues such as whether a specific program or policy enhanced the competitiveness of an economy are almost impossible to determine (Luukkonen 1998). Similarly, it has been pointed out that most programs have important effects beyond their strict initial goals. This is the case when STI policies p. 619 ↳ have helped the creation of standards, have induced more risk-taking attitudes of innovators, have fostered long-term rather than short-term strategies in firms' research, and have enhanced the acquisition of new skills and knowledge (Peterson and Sharp 1998). This has also been framed as the problem of attribution. Closely related is the problem of synchronizing the evaluators' time horizon with the political time horizon of the political consumers of their work. Big programs' effects may not be realized for years if not decades.

Box 22.4 Normative principles for design of STI policies

Robustness: Decisions and social structures should withstand the occurrence of different future scenarios.

Flexibility: In the occurrence of sudden socio-economic change institutions must be able to change direction rapidly.

Internal diversity: Structurally dissimilar characteristics must be built in to allow survival if the selection environment changes.

External diversity: Variety of links to different kinds of agents will help adaptation when change in the environment arises.

Window of opportunity: Attention to timing and sequence in face of path-dependent systemic context.

Incremental approach: The whole can be changed only through the cumulative impact of small steps.

Experimentation and prudence: new policy ideas should be submitted to trial in localized contexts before full deployment.

Source: Sandro Mendonça

22.4 STI Policy in the US, Japan, and Europe

We have used OECD documents to organize a stylized presentation of the evolution of science, technology and innovation policy. But while what is discussed at OECD is one thing, what national governments actually do to affect science, technology and innovation is quite another. No country has focused on just one of the kind of policies described above. All countries have combined elements of science, technology and innovation policy. But the mix and the policy design has been quite different between countries. Here we will try to capture the most basic characteristics for respectively the US, Japan, and Europe—understood as the big countries in Europe and as the European Union. Finally, the future challenges for each of them will be discussed.

22.4.1 Public Mission Technology Policy in the US

We have already mentioned the crucial Vannevar Bush report published in 1945 entitled "Science: The Endless Frontier." The neglect of one of its major recommendations had a very important effect upon the evolution of technology policy. Bush recommended the establishment of a coordinating authority at the national level, "the National Research Foundation." But it took another five years before "the National Science Foundation" was set up. In the meantime, different sector authorities in charge of contracting out research on nuclear power, defense, space, and health had already established ambitious research programs of their own and the total resources of NSF never came close to the budgets of these sector-oriented activities (Mowery 1994).

Technology policy in the US may therefore be seen as being organized in parallel *industrial complexes*—vertically organized complex networks crossing disciplines, technologies as well as industrial sectors, but with user interests in the public and p. 620 ↳ private sector driving and defining the policy. These complexes were operated with little coordination between them and they went all the way from procurement of specific technical systems and components to the support of basic research and research training. In particular, the defense budget was used for promoting activities with little direct connection to short-term military needs. Research in computer science and software got substantial support from this budget and produced quite generic knowledge, in addition to producing short-term solutions to military needs (Langlois and Mowery 1996).

One major issue in relation to the public mission technology policy is the lack of coordination. One negative aspect is the resulting bias in the direction of military and space expenditure. It seems as if it is much easier to mobilize taxpayers' money and development efforts to go to the moon than it is to solve the problem of the ghetto (Nelson 1977). In part, this reflects the presence of well-organized lobbies and interest groups among private sector beneficiaries; it also reflects the sheer difficulty, noted by Nelson, of "solving" such intractable problems as urban poverty or primary educational achievement. Another problem is that the calculation of expected costs and benefits of specific projects may either be completely neglected because national pride is at stake or be systematically biased downwards to make a project look more attractive. A third weakness may be a one-sided focus on the development of science-based industries and technologies and a general assumption that science and technology is a quick fix for all kinds of problems. More mundane industries aiming at consumers, and problems where the solutions are less glamorous in technological terms, may be neglected.

But the US-type national innovation system certainly has its strong points beyond its sheer scale advantages. The fact that several of the agencies are prepared to finance more or less generic research and research training while still having the use of research in mind tends to overcome the bias toward the supply side. It tends to establish a "chain-linked model of innovation" with strong feedback elements (Kline and Rosenberg 1986). One strong element is diversity. The fact that different agencies "compete" in funding good research may be beneficial in supporting the diversity of research efforts. The coexistence of big private foundations that commit resources to research teams on the basis of their track record also contributes to diversity. In these respects current European centralistic initiatives in research policy in connection with the sixth framework program and the European Research Era could learn from the US, which benefits not only from scale *but perhaps even more from* diversity.

22.4.2 Sector Technology Policy in Japan

While the international competitiveness of US firms has been a concern in US technology policy, it has, with
p. 621 few exceptions, been an implicit rather than explicit ↳ objective. This is different when we look at technology policy in Japan. More than perhaps any other market economy Japan has made use of an explicit national policy to promote specific sectors and industries—with the ultimate aim of stimulating economic growth and competitiveness. According to Freeman (1987), the radical character of the policy had to do with the fact that since the mid-1950s policy ended up being designed by experts with an engineering background in the Ministry of Technology (MITI) who were much less concerned with "comparative advantage" than the economists in the Bank of Japan.

But the MITI has not acted alone. In the area of telecommunications, NTT—a public company in monopolistic control of telecommunication services—has played an important role in coordinating technology development efforts in major electronic firms such as Hitachi and NEC. The policies pursued have not involved massive subsidies and, actually, the public sector has been much less involved in financing R&D in the private sector than has been the case in the US (Nelson 1984).

The strategic promotion of the car industry, consumer electronics, and "megatronics" typically combined different policy instruments such as subsidies to research and development of generic technologies with elements of "infant-industry" protection. Bringing together competing firms in consortia aiming at solving common problems has been an important role for MITI. This has been done on the basis of attempts to map new trends in technology and markets through, for instance, technology forecasting.

One interesting aspect of MITI's technology policy has been that it did not focus exclusively on high technology sectors. For instance, consortia initiated by MITI aiming at promoting the modernization of textile and clothing industries brought together firms producing textiles and textile machinery with electronics firms.

22.4.3 European STI Policies: From the Promotion of National Champions to EU Framework Programs

Europe is certainly a much more diverse region than the US and Japan. University systems are different in the UK, France, and Germany. The role of engineering in industry and corporate governance differ as well. Bringing less rich countries such as Portugal and Greece into the picture makes it even less homogeneous in terms of R&D efforts and innovation styles. Therefore, to treat Europe as one region and compare it with the US and Japan in terms of, for instance, R&D effort or patenting, without being explicit about the dispersion of the variable, is not helpful.

The formation of a common European approach to science and technology is still evolving. Figure 22.2 indicates the elements of the European scientific and technological architecture, within and outside the functional–administrative borders of the EU. As can be seen, some international research organizations
p. 622 were established in ↳ the 1950s, whereas the main thrust came in the 1970s. This figure does not include the European standardization bodies (ETSI, CEN, and CENELEC[2]) and the European agencies granting intellectual property rights (like EPO, OHIM, and Community Plant Variety Office[3]), which have also played important roles in promoting scientific, technological, and innovative synergies.

CERN is the oldest and one of the most successful organizations, and is dedicated to nuclear research. Its undeniable scientific success contrasts sharply with the troubles of its “twin,” the JRC (Joint Research Center), under the European Communities and also dedicated to nuclear energy research. Disputes between France and Germany about nuclear reactor designs in the 1960s weakened this institution, until the launch of the Joint European Torus (JET) concerned with nuclear fusion (Guzzetti 1995). Other European but non-EU scientific and technological organizations emerged in the 1960s and 1970s, among them the European Southern Laboratory (Astronomy), the European Molecular Biology Laboratory (EMBL), the European Space Agency (ESA), the European Science Foundation (ESF), gathering national research councils, and Airbus, a public–private enterprise with heavy investment in aviation technology. All these bodies are internationally constituted and directed toward one specific scientific–technological field.

In 1971, COST (Cooperation in Science and Technology) was established as an intergovernmental program.
p. 623 The novelty with COST was that it covered several ↳ scientific areas, and envisaged a very flexible form of cooperation. Later on, EUREKA developed this concept further, and became a successful tool of European collaboration outside the EU, mainly due to the high degree of participation by firms and to its market orientation.

Figure 22.2

The scientific and technological architecture of Europe, 2001

Source: Borrás (2003)

In the 1980s attempts to build strength in ICT technology were still national in France, the UK and Germany and the basic strategy was to promote national champions. The success was limited and this was one important reason why the ESPRIT program was developed in the early 1980s, under the realm of the EU. ESPRIT was inspired by Japanese technology policy style and its actual design came out of intense consultation of the EU commission with the top leaders of the fifteen biggest European ICT firms (Peterson 1991).

The first EU framework program was established in 1984 as a multiannual, multisectoral (covers several scientific fields) and multinational program (grants funding to projects submitted by researchers of at least three EU countries). The most recent framework program (the sixth) is very ambitious in terms of promoting European-wide networks of excellence, as a means of creating a European Research Area, reducing national barriers. Furthermore, in 2002 European ministers of science set as their ambitious goal that the share of R&D should reach 3 per cent of GNP in member states (2 per cent private and 1 per cent public as the rule of thumb). This should be seen in the light of declarations made by prime ministers at the Lisbon Summit held in 2000, that Europe should become the world's most competitive knowledge economy by 2010, with social cohesion as a twin goal.

In general, it is a problem that the European construction calls for dramatic declarations to build support for European STI policy. It contrasts with Japan and the US where less is said and more is done. The share of total R&D expenditures that the commission distributes to member states is still quite small. Another problem is that the Brussels administration tends to take on more than it can master in terms of defining research programs, evaluating applications and administering projects; the result being that it is quite demanding to be a project coordinator for EU projects. Last, but not least, another major problem is that the general idea behind the European Research Area is scale, rationalization, coordination, and concentration of effort. Much less weight is given to the dimensions of diversity and competition, two key elements for successful innovation systems (Lundvall and Borrás 1998; Borrás 2003).

The framework programs have been used as instruments to promote European integration and there is no doubt that the programs have had an enormous effect in terms of building research collaboration of a lasting kind across Europe. And in spite of administrative problems the money is still regarded as attractive.

This is especially the case in countries that have very little alternative free funding such as France and in countries where the European efforts have been used to reduce national efforts such as the UK.

p. 624

22.4.4 The Challenges for the US, Japan, and Europe

There is a tendency to glorify the innovation system and the innovation policy of the country doing especially well in international competition. In the beginning of the 1990s Japan was seen as a model and Europe as a second-best alternative, while the US was seen as a threatened but big power in the field of technology. Today the roles have been reversed. The truth of the matter is that each system has its own strengths and weaknesses and that these do not go away in periods of rapid economic growth.

The US economy could probably do even better if it invested more broadly and more equally in human resources. For instance it is remarkable that the unwillingness of citizens in California to pay taxes has resulted in students in schools in Silicon Valley having more limited access to computers than students have in the Nordic countries. The work organization in industry with a strong division between trained and unskilled workers—and the resulting income gaps—probably makes the diffusion and use of new technologies less efficient than would a more even distribution of competence. We believe that for the US these are some of the major challenges in the broad field of innovation policy.

One major weakness of the Japanese system of innovation has to do with science policy. The universities do not have the same incentives and traditions for promoting high quality research. In Europe, the major challenge might be calling for a combination of science and technology policy. The so-called European paradox—that Europe is doing well in science while being weak in technology—might be somewhat off the mark due to its high intra-EU disparities (Pavitt 1998). Rather, Europe seems to be weak both in science and technology in some of the most rapidly growing fields and markets—not least within biotechnology and pharmaceuticals.

22.4.5 The Triad Game

As long as the ColdWar was a reality, the existence of a common enemy supported scientific collaboration between US, Europe, and Japan. Given the current predominant unilateral approach of the US and the attempts to build a coherent European research area there are growing risks for conflicts within the triad regarding STI policy. There is especially a risk that access to knowledge is used as a political instrument as it was used by England for 500 years against the Catholic states in Europe. Since more and more technologies can be argued to have military relevance this could become a major problem for the global knowledge society.

The growing emphasis on the protection of intellectual property rights in relation to trade and extension to software and services may establish great obstacles for the catching-up countries and reduce their possibilities of pursuing the successful strategies of Japan and NICs. An interesting question, in this context, is whether p. 625 ↳ Europe and Japan are prepared to compete with the US in becoming centers for global interaction with "the rest." The more positive scenario would be one where the three poles used their capacities to promote the diffusion and use of knowledge to less privileged parts of the world. In any case, the extent to which there is a true globalization of knowledge production and diffusion, and the different forms it assumes, is a topic that has started to be analyzed (Archibugi and Michie 1997; Georghiou 1998), but deserves more attention.

22.5 Conclusions

It should be clear from what has been said that the most pressing issues on the policy agenda are specific to each national system. Even so, there are some issues that are common for all countries, and these represent new research challenges for scholars in this field. We have presented a stylized sequence, beginning with science and ending with innovation policy. In the most recent debates about the learning economy and the knowledge-based society we can see the contours of a new policy that we might call "knowledge policy."[4] It recognizes that innovation and competence building involve many different sources of knowledge and that innovation itself is a learning process. This raises the need for new analytical efforts and for rethinking the organization and implementation of policy in several respects.

It is increasingly important to understand better the connection between science and technology on the one hand and economic performance on the other. The rise and fall of the new economy demonstrates that assumptions about simple and direct connections are problematic. Between the new technologies and the performance of the economy the organizational characteristics of innovation systems and firms including "slippery" elements such as "social capital" affect the impact. This is an issue that remains understudied. In terms of public policy there is a need for innovative thinking about how governments can support the diffusion of good and sustainable practices in cooperation with management and employees. In terms of research opportunities, this links with the importance and need to devote more analytical efforts examining how technical innovation interacts with organizational change. The academic traditions of business organization and of innovation systems' research have to come closer to each other in order to answer questions regarding how organizational change affects innovation processes in the economy.

A second issue is about aggregate demand. In a period of growing fears for deflation and with little room left for expansionary monetary policy it might be useful to reconsider what Keynesian policy could mean in "a knowledge-based ↳ economy." Establishing large-scale technological–military programs (like the Star Wars programs under the Reagan and Bush administrations) may perhaps be seen as the modern version of building "pyramids"; however, other more socially oriented and low-scale options could also be considered. Establishing firm- or sector-specific funds through tax exemptions for upgrading the skills of all categories of employees and for making extra development efforts in periods of low economic activity could be one option.

A third common concern in the era of innovation policy is how to coordinate policies affecting innovation. The prevailing institutional set-up means that ministries of finance are the only agencies taking on a responsibility for coordinating the many specialized area policies. Area-specific ministries, on the other hand, tend to identify the interests of their own "customers" and take less interest in global objectives of society. It could be decided to establish new types of institutions such as cross-sector and interdisciplinary *Councils on Innovation and Competence Building* at the subnational and national level (in Finland the prime minister is chairman of a National Council of Science and Technology). This should be complemented by the much-needed research efforts towards developing sophisticated measuring methods about the innovation system trends and about the impact of STI policy on it. More advanced innovation indicators would be a crucial input for such holistic perspective of public authorities.

In 1961, the OECD expert group—Freeman, Svennilsson, and others—presented a kind of manual for how to design science policy in such a way that it became integrated with economic policy and provided a real impact on economic growth. Perhaps a suitable closing of this chapter might be to produce a similar set of recommendations for designing national innovation policy? But the message here is that there is no way to design an effective innovation policy without analyzing the domestic innovation system, including the way it produces and reproduces knowledge and competence, and comparing it with others. The stage of development and the size of the respective economy will affect the resulting plan of action. In small countries and developing countries the structures and institutions that affect absorption and efficient use of technology are more important to understand and act upon than those promoting the production of the technologies at the front. Big countries will necessarily be more focused on the production of the new technologies, but they too would have much to gain from taking into account the absorption and efficient use of innovations and new knowledge.

Notes

1. Ergas has suggested the distinction between "mission-oriented" and "diffusion-oriented" policy designs, based respectively on the massive support to a small number of science– technology fields, and on supporting the scientific–
p. 627 technological infrastructure (Ergas ↳ 1987). This analytical distinction has also been used when comparing policy styles in science and technology policies across countries. (It has been argued that the Japanese and French policies are mission-oriented, whereas the German policy has been depicted as an example of a diffusion-oriented policy style.) Again it is important to note that what is referred to is ideal types and that simple groupings of this kind might miss some of the most important complexities in the set-up of national systems of innovation.

2. ETSI: European Telecommunications Standards Institute; CEN: Comité Européen de normalisation; and CENELEC: Comité Européen de Normalisation Electrotechnique. These three bodies have divided their standardization activities by technological sectors.

3. EPO: European Patent Office; OHIM: Office for the Harmonization of the Internal Market; dedicated respectively to patents, and to trademarks and other intellectual property rights.

4. The concept of knowledge policy has evolved in connection with European policy making and as a follow-up to the Lisbon ministerial meeting 2000. One of the architects behind the Lisbon-strategy, Maria Rodrigues, defines knowledge policies as "policies aimed at fostering and shaping the transition to a knowledge-based society" (Conceçãio, Heitor, and Lundvall 2003: p. xx).

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