Innovation policy, national innovation systems and economic performance: In search of a useful theoretical framework

by

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Abstract

Innovation policy has emerged as a new field of economic policy during the last few decades and it may be time to take stock of what is learnt and consider what the challenges for the theory and practice in this area are. The first section introduces the issue. Section 2 outlines the development of theoretical frameworks of innovation policies and considers the relationship between the assumptions underlying these frameworks and empirical evidence from innovation-surveys. Based on recent advances in innovation-systems theory, section 3 presents a synthetic framework for the analysis of innovation policy. Section 4 considers so-called "mission-oriented" innovation policies, i.e., policies aimed at solving particular social challenges. Finally, lessons and challenges for future work in this area are discussed.

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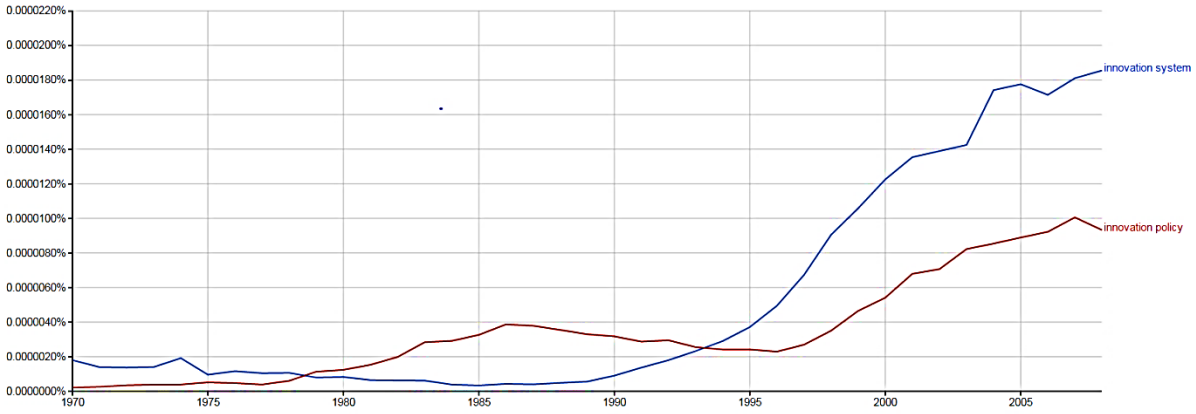
1. Introduction

The popularity of the term "innovation policy" is as Figure 1 shows of relatively recent origin. To the best of our knowledge it comes – as so much within the field of innovation studies - from the intellectual environment that developed around the Science Policy Research Unit (SPRU) at the University of Sussex from the late 1960s onwards (Fagerberg et al 2011). In particular SPRU-Professor Roy Rothwell did during the 1980s much to increase the interest for the topic (see e.g. Rothwell 1982). However, the real surge of interest had to wait until the1990s, when international organisations such as the OECD (alongside various national governments) started to pay attention to the phenomenon. As Figure 1 shows this growing interest coincided with the spread of the new, systemic approach to the study of innovation that emerged around 1990 (see e.g., Edquist 2004, Lundvall 2007).

Figure 1. The frequency of the terms "Innovation Policy" and "Innovation System" according to Google



Source: https://books.google.com/ngrams

The term "innovation policy" may be used in different ways. For example, it may be defined broadly as all policies that have an impact on innovation, or more narrowly as policies (or policy instruments) created with the intent to affect innovation (Edquist 2004). Nevertheless, if we are interested in the impacts of policy on innovation and economic performance, the former, more comprehensive definition appears more appropriate (although it arguably complicates life for the analyst). As pointed out by Veugelers et al (2010) in practice it may be necessary to concentrate on the non-trivial impacts of policy (and this requires criteria for doing so).

Different usages of the term may also reflect different understandings of innovation: Does it refer to the entire process from the emergence of new ideas to their economic exploitation (broad definition), or is it limited to the first occurrence of a new product, process or way do things (narrow definition)? The choice of definition may to some extent reflect the purpose of the analysis. Nevertheless, while innovation may be a fascinating topic in its own right, this is not the reason why most policymakers are interested in it. Rather what they are interested in are the beneficial economic effects that innovation is assumed to have, not only for the innovator, but for a country or region as whole. From this perspective the broader definition

makes most sense, since what mainly matters for the economy is not the first occurrence of an innovation but its subsequent diffusion and use including the effects that this gives rise to (Kline and Rosenberg 1986).

It is also important to take into account that the focus of policy, the terms used and the theories underpinning design and implementation of policy change over time. For example, while in the 1960s the focus was on science (and hence the term "science policy" was popular), later it shifted to technology (and "technology policy") and more recently innovation (with the associated term "innovation policy"), see e.g., Lundvall and Borras (2004) and Boekholt (2010) for further details. Thus, the fact that the notion "innovation policy" is relatively recent does not necessarily imply that policies affecting innovation did not exist before. Innovation is an old phenomenon, and over the years innovation activity is likely to have been influenced by a number of policies carried out under a variety of labels, see e.g., Box 1. Arguably, for the social scientist, history is the most relevant laboratory, and disregarding important evidence just because terminology has shifted would make it virtually impossible to understand how institutions, organizations and policy instruments affecting innovation in different countries have evolved to their present stance. Hence, when studying the evolution of innovation policies and the broader systems in which they are embedded, it may be highly relevant – even essential - to take the effects of policies pursued under other labels into account.

By now we have several decades of experience with innovation policy (if not more) and it is time to take stock of what has been learnt and consider what the challenges for the theory and practice may be (see, e.g., Smits et al 2010, Edler et al 2013). The next section outlines the development of theoretical frameworks of innovation policies and considers the relationship between the assumptions underlying these frameworks and empirical evidence from innovation-surveys. Based on recent advances in innovation-systems theory, section 3 presents a synthetic framework for analyzing innovation policy (and its effects), while section 4 considers so- called "mission-oriented" innovation policies, i.e., policies aimed at solving particular social challenges. Finally, section 5 discusses the lessons and challenges for future work in this area. Historical and statistical evidence or examples are introduced at various points to illustrate the relevance of the arguments brought up during the discussion.

Box 1. Innovation policy is not a new phenomenon: The Swedish example

"The Swedish model" is often used as a short hand for the close cooperation between big business, labor unions and the state that influenced Swedish politics and the social and economic development of the country from the 1930s onwards. A central goal for this cooperation was to increase productivity so that both healthy profits and increasing welfare for the population could be achieved. Technological progress, naturally, was seen as crucial for realizing this goal, and quickly attracted the attention of policy makers. A technical research council (TFR), the first of research council in Sweden, was set up in 1940. It was succeeded in 1968 by STU, literally the "board for technological development" and later, in 1991, by NUTEK (the directorate for industrial and technological change). A characteristic feature of Swedish policy in this area was a strong emphasis on supporting university R&D in areas which policy-makers considered to be of high political and economic importance, such as nuclear energy or telecommunications. Moreover, a major effort was made to engage the large, technologically advanced Swedish firms in technologically demanding, infrastructural projects initiated by the state, of which is the cooperation between the firm Ericsson and the Swedish telecommunication agency (Televerket) about the developments of digital switches (the AXE system) may serve as an example. Hence, during this period, the state played a quite proactive role in fostering innovation and the technological capabilities underpinning it (although the term "innovation policy" was not used).

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2. Theoretical frameworks: From market failure to innovation systems

The interest for science, technology and innovation policy started in earnest in the aftermath of World War Two. The dominating theoretical perspective was what has later been termed "the linear model" (see Kline and Rosenberg 1986 for a critical account), which sees scientific progress as the main causal factor behind economic progress. The main challenge, according to this approach, is to achieve fast scientific progress, from which economic benefits can be assumed to follow more or less automatically. Problems associated with transforming scientific knowledge, mainly created in universities and research institutes, into innovation and economic value in the business sector were if not ignored assumed to be of relatively minor importance.

Market failure

However, if science is the main factor behind creation of economic value, why do private firms not undertake the necessary investments themselves? This question was of course of concern to economists who were brought up to believe that self-regulating markets would create the best result for everybody. The explanation offered by them was that knowledge had "public good" properties that markets were not designed to take into account. For example, one actor's use of a body of knowledge would not preclude other actors from doing the same. However, the fact that other firms may benefit just as much or more, also implies that it may be difficult for a firm investing in the creation of new knowledge to recoup its investment, not

to say earn a profit from it. Rational firms would therefore according to this reasoning tend to stay away from such investments, even if the potential benefits for society as a whole might be very large. Thus, in this case, a self-regulating market would fail to secure a socially optimal allocation of resources in the economy. For economists such "market failure" provides a justification for market interventions - or policy instruments - aiming at increasing investments in science in the economy towards the socially "optimal" level (Nelson 1959, Arrow 1962). Such interventions can take different forms, such as financing universities and research institutes, subsidizing research in private firms and changing the rules of the game by, say, strengthening intellectual property rights.

The "market failure" argument continues to be invoked as a rationale for public investments in science in modern capitalist societies. As commonly advanced, however, it does not provide much guidance on how much governments should spend on science (what the amount of public investment necessary for arriving at the "optimal" allocation of resources would be). A more serious problem may be that it is not obvious that the argument holds much beyond basic science (and perhaps not always there either). It is particularly problematic in the case of private firms, because it is quite evident that the underlying premises of the theory: (1) that knowledge is very fluid (i.e., non-appropriable) and (2) that firms are omnipotent entities, endowed with full knowledge ("perfect information") about all potentially relevant factors and capable of instantly processing all this information to arrive at the optimal choice, do not hold in practice. For example, it is well established that much economically useful knowledge is contextual in character, hard to identify, difficult to get access to and demanding and costly to absorb. Hence, high "fluidity"/ non-appropriability of knowledge may not be such a big hurdle for firms in most cases. In fact, the exact opposite, that knowledge is very "sticky" (von Hippel 1994), may be a much harder problem for firms. Indeed, far from being omnipotent, firms are as Nelson and Winter (1982) emphasized generally rather constrained in their abilities, and this holds in particular when trying to prepare for future developments, which tend to be clouded by genuine (or radical) uncertainty. Arguably, such uncertainty may well prevent firms from investing in innovation, but this is something the traditional theory would lead the analyst to not give much attention to, as it conflicts with the underlying premises of the approach.

"Stylized facts"

Theoretical work, if it wants to be relevant for policy, has to be based on assumptions that are broadly consistent with the empirical facts. Therefore, from the 1960s onwards, the search for such "stylized facts" has been the "leitmotif" for a series of investigations into how firms perceive the conditions affecting their innovative activities (which policy may influence). An early attempt to do this, which came to have a lasting influence on how we look at innovation processes in firms, was the SAPPHO project at SPRU (Rothwell 1974). Another important exercise of this kind, this time in the US, was the Yale survey (Levin et al. 1987). From 1991 onwards the European Union has carried surveys of firms' innovation activities and the factors that influence these in their member countries (Community Innovation Survey, CIS, see Smith 2004 for details). The results are very consistent across different surveys and over time. In the following we are going to use some empirical results from the CIS survey to

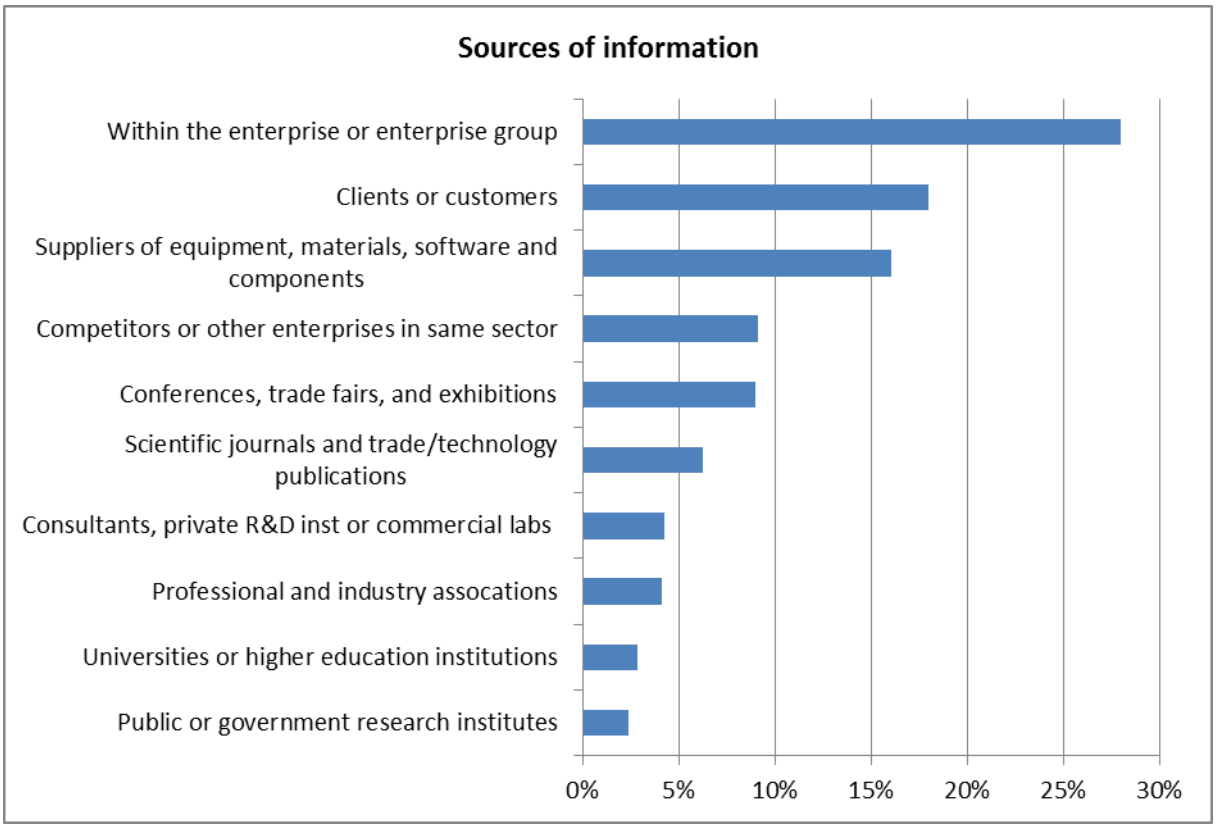
illustrate some of the "stylized facts" associated with innovation at the firm level that are relevant for discussions of innovation policy.

Figure 2 reports the answers from European firms about what the important sources of information for innovation are.[1] The most important source is to be found within the firm itself. Among the external sources, the by far most important are customers and suppliers, followed by other firms in the same industry or sector. Public sources, such as conferences and journals, are also deemed to be of relevance. Universities and public research institutes figure towards the bottom of the list. Hence, there is not much support for the "linear model" in these data.

In Figure 3 we move from sources of information to innovation cooperation. The picture is very much the same; the most important external partners for firms in innovation are, as for information, customers and suppliers. Then follow other firms in the same enterprise group and consultants/private R&D labs. Albeit less frequent they do also cooperate with universities and public research institutes.

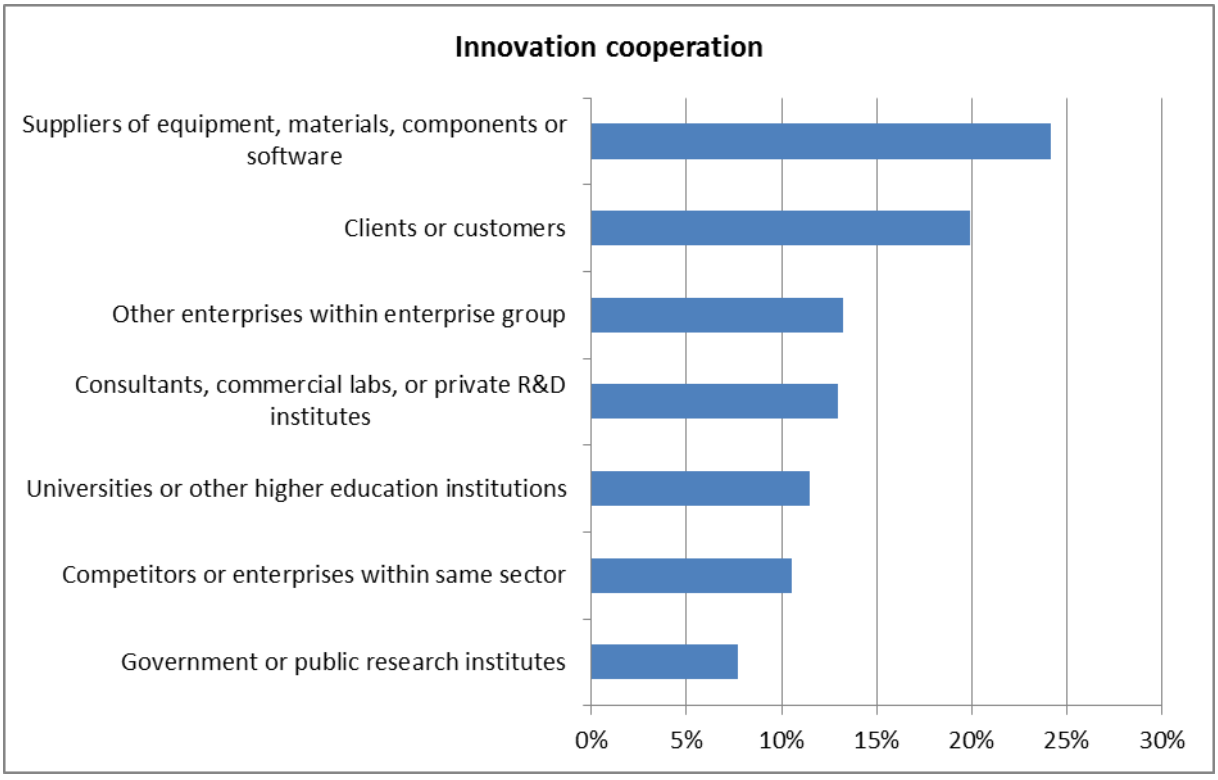
[1] The CIS-data used in this paper can be accessed through http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database.

Figure 2. Important sources of information for innovation



Source: Own calculations based on information from CIS 5 (2006)

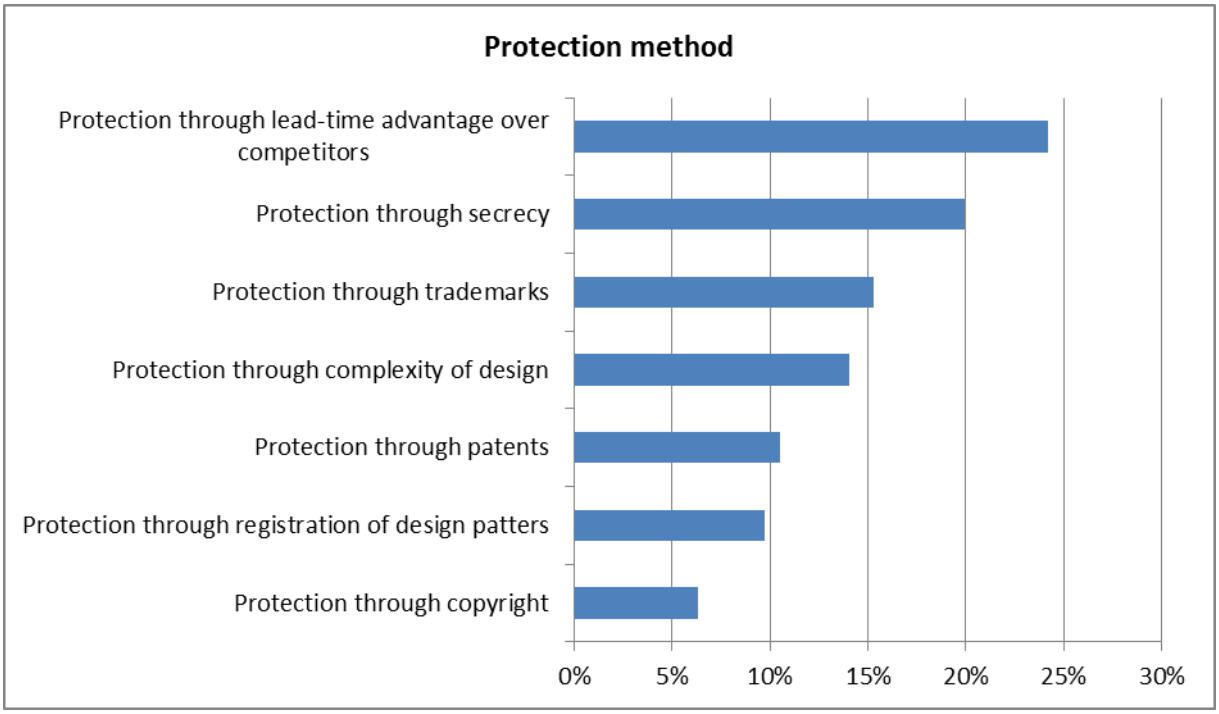
Figure 3. Innovation Cooperation.



Source: Own calculations based on information from CIS 5 (2006)

Information about how firms go about to appropriate the benefits from their innovative activities is provided in Figure 4.[2] The by far most used appropriation methods are lead-time and secrecy. Complexity of design is also listed as an important factor. Among the formal protection methods, trademarks are assessed to be the most important. Patent protection figures relatively low on the list, indicating that firms on average do not regard patents to be very important means for benefitting from innovation, something that is consistent with other research (Cohen 1995).[3]

Figure 4. How to appropriate the benefits from innovation?



Source: Own calculations based on information from CIS 3 (2000)

These observations are consistent with the view that in most cases innovative firms do not regard fluidity (non-appropriability) of knowledge as a big problem, probably because many aspects of the technological capabilities they draw on are not so easily copied. To be first in the market with their new innovative solutions - keeping their competitive edge - is what matters most to them. The data also show that firms do not try to insulate themselves from their environments, jealously guarding their secrets, but on the contrary interact closely with external partners, among which customers and suppliers tend to be the most important. Hence, the central role of users for innovation, emphasized by several studies (Rothwell et al. 1974, Lundvall 1985, von Hippel 1988), is also confirmed by the CIS. Arguably, there are good reasons for this: Users are an important part of the selection environment for innovations and

[2] The questions included in the European Union's Community Innovation Survey differ somewhat across different waves of the survey. The particular question underlying Figure 4 was not included in later surveys.

[3] However, it may be noted that use of appropriation methods differs a lot across industries (patenting is for instance much more important in pharmaceuticals than the above average pattern would suggest).

have intimate knowledge about the requirements that an innovation need to satisfy. Moreover, in some instances users, being highly competent and sophisticated, may play a proactive role in innovation (von Hippel 2005).

National innovation systems

It is evident from the preceding discussion that innovation is an interactive phenomenon, and for a theory to be helpful in shaping policy, it needs to take this into account. From the very beginning the contributors to the literature on national innovation systems that emerged around 1990, e.g., Freeman (1987), Lundvall (1988, 1992), Nelson (1988, 1993) and others, made such interaction the hallmark of their approach.[4] Basing itself on Schumpeterian and evolutionary perspectives, the approach left little room for the idea of an "optimal" state towards which the system should be assumed to converge if only appropriate policies were applied. Rather the national innovation system is seen as the result of a long historical process characterized by coevolution between a country's industrial structure and its political system (Smits and Kuhlman 2004, Fagerberg et al. 2009). Such processes, through which one part of the system influences the other and vice versa, are also likely to be path dependent, meaning that established policies – and the organizations carrying them out – may be remarkably persistent in spite of changes in the environment (Pierson 2000). As a result national systems of innovation may differ greatly, see Box 2, and a policy mix that works in one context may not be adequate in another (Flanegan et al 2011, Borras and Edquist 2013).

The first empirical analyses of national innovation systems were descriptive in nature and focused on what the authors of the studies considered to be the main actors and their interrelationships (Nelson 1993). As a consequence, these studies often had a static perspective, focusing on the structure of the system at a particular point of time, rather than on its dynamics. Since, as pointed out above, differences in structure are the results of long run historical processes (reflecting the coevolution between industrial structures and political systems), it became challenging to draw policy-relevant conclusions from the comparative work that emerged.

[4] Sharif (2006) and Fagerberg and Sapprasert (2011) trace the emergence of the innovation system approach.

Box 2 History matters

The Nordic countries are often considered to be similar, as epitomized in the concept "the Nordic model". Nevertheless, their national innovation systems differ in important respects, and this has to do with differences in the historical origins of these systems (which influenced how innovation policies subsequently developed). For example, the countries with well-developed nation states and university systems over a century ago, i.e., Denmark and Sweden, have developed innovation systems in which universities play a very central role. This is still the situation today. In contrast, in Finland and Norway - younger nation states with less-well developed university systems a century ago – public research organizations outside universities (the "institutes") developed in close interaction with important industries and firms and eventually became large and powerful actors in the innovation system. This continues to be the case. For example, Finland's leading PRO – VTT – has around 3000 employees, and prides itself in its website of being "the biggest multitechnological applied research organization in Northern Europe". The Norwegian parallel – SINTEF – has around 2000 employees, and in Norway the "institutes" collectively get more funding through the research council than the universities do. Hence, for historical reasons innovation systems differ a lot, and this needs to be taken into account when designing and implementing policy. Arguably, a mechanical transfer of so-called "best practice" from one system to another may easily do more harm than good.

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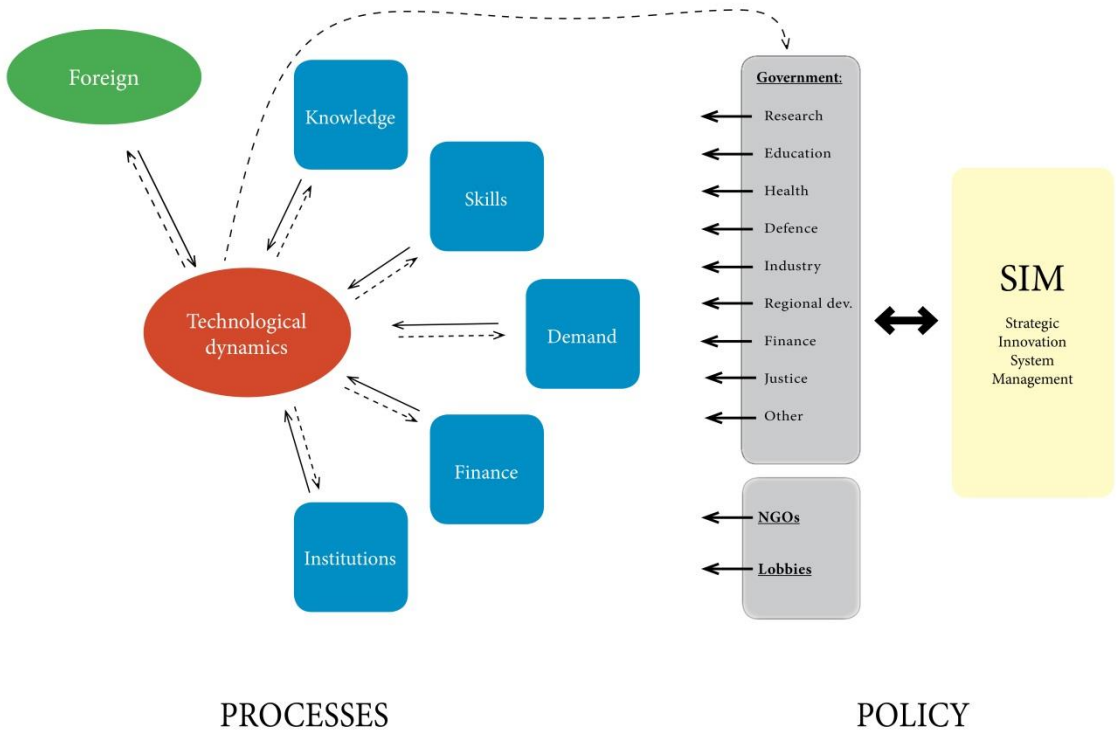
3. Innovation systems, technological dynamics and policy: A synthesis

After the turn of the millennium the scholarly work on national innovation system took a new twist with a sharper focus on the relationship between the output of the innovation system (its technological dynamics) and the factors influencing it (Liu and White 2001, Edquist 2004, Bergek et al. 2008). If the dynamics is deemed unsatisfactory by e.g., policymakers, the approach may then be used to identify the factors – or "problems" - behind the result and discuss what can be done about it (Edquist 2011). In the literature the factors influencing innovation have invariably been called (fundamental) activities, processes, functions and sub-functions. However, in this paper the more generic term processes will be preferred. Although the number and definitions of these processes differ somewhat across the various studies, these differences may arguably be seen as minor (and may to some extent be explained by differences in focus).

In Figure 5 below we illustrate the dynamics of a national innovation system. The output of the system, i.e., innovation, diffusion and use of technology, is labelled "technological dynamics". It is a result of influences from abroad ("foreign"), activities within the business sector and interaction with actors in other parts of society. The former activity, i.e., interaction with knowledge holders in other countries, is of course of paramount importance economically (see Fagerberg et al 2010 for an overview), but we will in this paper concentrate on the latter, because policy - the topic under scrutiny here – has more of a say in that case.

Figure 5. The National Innovation System: Dynamics, processes and policy



In the figure technological dynamics is depicted as influenced by five generic processes in the national innovation system, labelled knowledge, skills, demand, finance and institutions. The influences on the technological dynamics from these processes are indicated with solid arrows, while the possible feedbacks from technological dynamics on the generic processes are represented by dotted arrows. Policy makers may influence the technological dynamics by helping to shape the processes that impact it. To do so they need to have access to an adequate supporting knowledge base and they may, as argued below, need to coordinate policies across different domains. Their actions will also be motivated by strategic choices they make and their "visions" for the development of society. Therefore we have labelled this process "strategic innovation system management".[5] Their incentives to do so may also be affected by how vibrant (or lacklustre) the technological dynamics are conceived to be, giving rise to a feedback from performance on policy.

The five generic processes included in the figure may be described as follows:

- **Knowledge**: Knowledge may for example be provided by public R&D organizations (universities etc.) that complement firms' own capabilities and through schemes that promote interaction between firms and other actors (f.i. cooperative R&D). Such processes are influenced by various layers within government, particularly the Ministry

[5] The choice of this term is inspired by the literature on strategic "niche" or "transition" management (Kemp et al. 1998, Rotmans et al. 2001).

for Research, but also other ministries, such as those for industry, regional development, health, defence, etc.

- **Skills**: Skills, both specialized and more general, are essential for firms' abilities to generate technological dynamics, and the provision of these is normally the responsibility of the Ministry of Education but other ministries may also influence aspects of this process (such as supporting vocational training for example, which may fall under the Ministry of Industry).

- **Demand**: Without demand for new, innovative solutions, innovative firms get nowhere. The government can help to relieve such constraints by supporting the creation of markets for innovative solutions, changing standards and regulations and using public procurement proactively to foster innovation (Edler and Georghiou 2007, Edquist and Zabala 2012). Such policies often fall under the Ministry of Industry but other ministries, such as those for defence, energy, environment and health may also have say.

- **Finance**: Finance is necessary for innovation to persevere. Some innovative initiatives, particularly from small firms, entrepreneurs, etc., or in cases characterized by high uncertainty, may have difficulties in raising the necessary finance in ordinary financial markets, and in such cases the public sector may play an important role. This would normally fall under the responsibility the Ministry of Industry or the Ministry of Regional Development. However, the design of the tax system, which is the responsibility of the Ministry of Finance, may also matter.

- **Institutions**: Institutions refer to the "rules of the game" that influence entrepreneurial actions. They range from law and regulations, the responsibility of the Ministry of Justice, to informal norms and rules. Examples of relevant institutions include IPRs, requirements for setting up or close down businesses, regulations regarding hiring or firing personnel and the prevalence of corruption. Institutions are often considered to be relatively stable, but laws and regulations of relevance for business activities do sometimes change, often related to "voice" on the part of the business community.[6]

As Figure 5 illustrates there is a broad range of processes that influence the technological dynamics of a nation, and these processes are affected by a large number of policies and actors. Most of these policies are not dubbed "innovation policies" and have traditionally not been regarded as such either. Nevertheless, their effects on innovation may be much more important than those of more narrowly defined "innovation policies". What matters from an innovation system perspective is not the name of a policy, but its impact.

An important feature that increasingly has come into focus is the strong complementarities that commonly exist between the different parts of an innovation system or policy instruments (Mohnen and Röller 2005). If, in a dynamic system, one critical, complementary factor is lacking, or fails to progress, this may block or slow down the growth of the entire

[6] Even attitudes and values change in response to technological and economic changes, albeit very slowly, from one generation to the next (Inglehart 1977, 2008).

system. For example, it is of little help to have superior knowledge, if you don't have the skills necessary for its exploitation, or if finance or demand is lacking. Thus the processes that policies may influence are to a large extent complementary, and from this follows that the effect of a specific policy cannot be assessed in isolation, i.e., independent of other relevant policies (Flanagan et al. 2011). The innovation system perspective therefore leads to a holistic perspective on policy (Boekholt 2010).

This "holism" follows logical from the underlying theory but is arguably challenging for policy makers. First, calculating the total effects of a broad set of interacting policies (processes) requires a larger (and more sophisticated) analytical capacity in public administration than what has been common. In some countries deliberate steps have been taken to generate such capacities, for example the creation of the "Swedish Governmental Agency for Innovation Systems" in 2005 (Carlsson et al. 2010), but in most countries such capacity building is probably still in its infancy. A further complicating factor is that applying the innovation system perspective to policy would mean that policy makers from different domains (ministries, sectors, administrative levels etc.) have to work together and coordinate their activities (policies). This is something that is known to be difficult to achieve, as it tends to conflict with the established structures, practices and routines in public administration (Flanagan et al. 2011). Successfully applying the innovation system approach to policy may therefore require the development of new "systemic instruments" (Smits and Kuhlman 2004) facilitating the creation, adaptation and coordination of policy (Braun 2008), what we above called "strategic innovation systems management". The Finnish example (see Box 3) is perhaps the most ambitious attempt to date of doing so (Pelkonen 2006).

Box 3: Finland: A system perspective on governance

Finnish policy makers were quick to embrace the new, holistic understanding of innovation which emerged around 1990 under the label "national innovation systems". An important vehicle for the diffusion of the NIS approach became the "Science and Technology Policy Council of Finland", renamed "Research and Innovation Council" in 2009 as part of the adoption of "Finland's Innovation Strategy" that year. The council, chaired by the Prime Minister, is an advisory and coordinating body for research, technology and innovation policy, consisting of representatives from relevant ministries, public innovation actors, major firms, business associations etc., and meets regularly. It develops plans for the development and implementation of innovation policy in Finland and publishes every 3-4 year a "review" devoted to these issues. An analysis of these reviews (Miettinen 2012) shows that in the 1990s the focus was primarily on increasing national investments in R&D while more recently the perspective has broadened with respect to what it is about (including so-called social innovation for example), where it takes place (not only in "high-tech"), how innovation may be encouraged (including demand- and user- driven innovation) and what it is relevant for (for instance the public sector as well).

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4. Coping with societal challenges

Up to now we have mainly concentrated on the general effects of innovation for society, related to phenomena such as welfare, standards of living, productivity, etc., and the role of policy in this context. However, innovation policy may also have more specific aims, such as developing a solution to a particular societal challenge, so-called "mission-oriented" policies (Ergas 1986), of which there for instance have been many examples in the US (Mowery 2011). In fact, this is something governments have been engaged in long before the term innovation policy was invented (e.g., the Manhattan project during the Second World War).

However, much has happened in innovation research since the Manhattan project, and we now have a much more elaborate understanding of how new technologies develop and diffuse. Contemporary attempts to use innovation policy to cope with particular challenges may build on this understanding. For example we now know that there are many hurdles during the early phase of the development of a new technology, such as uncertainties with respect to a technology's potential, market, costs, etc., that may easily kill the embryonic project. Moreover, although there is a possibility that the new technology will yield substantial benefits, it may also fail to do so for reasons that were not (and in many cases could not) be properly understood ex ante. To learn more about the technology's potential, real life experiments may sometimes be necessary, and failures will occur (and need to be tolerated). The challenges for policy makers in this context may for example be (1) to help mobilize the necessary support so that the experiment can get going, (2) avoid that it is aborted too early (for reasons that policy makers can influence) and (3) not to draw premature conclusions about the superiority/potential of the new technology before a sufficient knowledge base about the focal technology and alternatives has been accumulated.

To assist policy makers in mobilizing innovation in the solution of specific challenges, process perspectives of the type discussed in the previous section have been applied and further developed based on the experiences, sometimes in interaction with the policy makers themselves. An example of the latter is the "technological system" approach, mentioned earlier, which was developed and improved through interaction between researchers and policy makers in Sweden (see Carlson et al. 2010). This approach consists of studying the processes that influence the development, diffusion and use of a specific new technology, with particular emphasis on identifying so called "blocking mechanisms" that hamper the development of one or more of these processes (or their interaction) and hence the dynamics of the system as a whole (see Bergek et al. 2008 for an overview). The implication is that policy makers' attention may fruitfully be directed towards removal of the "blocking mechanisms".

A related approach, particularly (but not exclusively) motivated by the climate-crisis and the need for a transition to a more sustainable economic system,[7] has been developed in the Netherlands under the label "multi-level perspective" (MLP). Multi-level perspectives are well known from evolutionary theorizing, which has been a source of inspiration for the MLP

[7] For a recent analysis of this aspect of innovation policy with a focus on sustainability, see Nill and Kemp (2009).

approach as well as other types of innovation research (e.g., Nelson and Winter 1982) on which the MLP approach also draws (see Rip and Kemp 1998). In the case of the MLP approach, three levels are highlighted in the analysis: the macro-level (labelled "landscape") which is assumed to change slowly and for reasons that may be seen as "exogenous"; the meso-level, which following Nelson and Winter (1982) is dubbed the "technological regime" and the micro-level, which is termed "niche". The niches are where the development of radical new technologies - the experimentation - is assumed to occur. However, such experimentation is fraught with difficulties of various sorts, and may require political support to persist long enough so that reliable conclusions can be reached. Moreover, a new, radical technology, even if successful in a narrow technological sense, also needs to be accepted by the broader technological regime[8] structuring the relevant part of the economy, which is seen as challenging since such regimes are perceived as rooted in the past and resistant to change (Rip and Kemp 1998). Much work in this area has therefore focused on the role of policy in nurturing technological experimentation and identifying areas in which the new, radical technologies can be applied so that they can develop further and eventually be more broadly accepted, so-called "strategic niche management" or "transition management" (Kemp et al. 1998, Rotmans et al. 2001).

In the MLP approach much of the focus has been on the interaction between the meso and micro levels, or between regimes and niches. However, more recently attention has turned to the interaction between the regime and the landscape levels, e.g., how differences in the pressure for change at the macro level may influence regimes and, depending also on the underlying technological dynamics, open up for different "transition pathways" (Geels and Schot 2007). The integration of the macro (or "landscape") dimension into the analysis appears as a fruitful avenue for future work in this area. Take the climate change (global warming) issue, for example, which underlies much contemporary research. In reality, climate change is not an exogenous phenomenon, but a result of economic and technological dynamics, past and present. What appears to be needed in order to avoid the detrimental consequences of global warming is a change in the very factors that underpin the current unsustainable trajectory. These factors may have as much to do with the policy choices of politicians at the national level as with experimentation with new solutions at the micro level, or inertia among incumbent firms, organizations or "regimes". Moreover, as for other types of innovation policy, policies aiming at mobilizing innovation to combat the problems associated with global warming may be much more effective if better coordinated across different policy domains and levels (i.e., what we above called "strategic innovation system management").

5. Lessons

Innovation policy is a relatively recent term. Its emergence as a field of politics is related to the increasing emphasis on innovation as an important source of economic prosperity and

[8] Rip and Kemp (1998, p. 338) provide the following definition of a technological regime: "A technological regime is the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems - all of them embedded in institutions and infrastructures".

welfare and as a way to cope with grand challenges. The increasing attention to innovation policy has gone hand in hand with the development of new theoretical frameworks, most importantly the national innovation systems approach.

One important lesson concerns the importance of having a broad definition of innovation policy. Rather than just policies explicitly aimed at affecting innovation, all policy instruments that influence innovation in a non-trivial way need to be taken into account. Moreover, a broad definition of innovation is required, including not only the first occurrence of a new product or process but the entire process from the creation of new products, processes and way to do things to their diffusion and use. These definitional choices follow logically from the premise that the purpose of innovation policy is to contribute to economic prosperity and welfare.

With respect to theoretical frameworks for innovation policy, and particularly the national innovation system approach, an important lesson is that a distinction needs to be made between the characteristics – or "structure" – of a national system and its dynamics. National innovation systems have evolved through interaction between the economic and political system of a country. Since countries differ industrially, industries (or sectors) have different innovation dynamics (and requirements) and political systems differ in their origins and characteristics, national innovation systems may end up as looking rather different. Such differences are not necessarily a problem, however, as much policy-advice based on so-called "benchmarking" seems to take for granted. Arguably, an unsatisfactory state or "problem" cannot be revealed by studying a single component of a system. What is required is an analysis of the technological dynamics of the national innovation system as whole. Only on this basis can it be possible to identify the processes (and policies) that prevent the system from developing satisfactory.

While the characteristics – or structures – of national innovation system may differ a lot, there may still be common features related to the technological dynamics occurring within these systems. This has to do with the fact that innovation and diffusion follow certain regularities, which have been extensively analyzed and documented by innovation research (see Fagerberg et al 2004 for an overview). Guided by recent advances in innovation systems research a synthetic framework for analyzing what shapes the technological dynamics of a country has been suggested. The framework illustrates how the technological dynamics of a country is the result of interaction between a number of different processes that are influenced by a range of policies, many of which do not carry the "innovation" label and primarily have other goals. An effective innovation policy, therefore, requires close coordination of policies across a number of different domains, and the development of new forms of governance and supporting knowledge bases that makes this possible. Researchers studying innovation policy would be well advised to pay greater attention to the policy experiments that have been attempted in various countries to achieve some of these aims.

In recent years a lot of attention has been devoted to the evaluation of single innovation policy instruments in various countries. However, such evaluations may be of little value if interactions between different policies, as well as system-wide effects and feedbacks, are not

taken properly into account. What is needed are system-level evaluations, and the OECD should be credited for attempting to develop their evaluations of national innovation policies in this direction, see for example the evaluation of Swedish innovation policy (OECD 2013). There has been little discussion, though, about the methodologies for carrying out such analyses, a topic on which the research community in this area should be well placed to contribute.

This may also hold for the question of who might profitably be involved at various stages of shaping and evaluating policy. For example, there appears to be a tendency for national policy makers to keep the cards close to their chests and for evaluators to go along with this. [9] It is highly questionable, however, if restricting information, discussion and broad participation is a good strategy for creating effective innovation policy in modern, knowledge-based societies. Eric von Hippel has in another context argued that in such societies "democratic innovation", i.e., involving the expertise of the broader public, is not only more democratic but also more effective (von Hippel 2005). Arguably, this may apply to innovation policy as well.

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[9] See Miettinen (2012) for a discussion of what he describes as a democratic deficit in Finnish innovation policy.

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