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INNOVATION POLICY: RATIONALES, LESSONS AND CHALLENGES

Jan Fagerberg*

Aalborg University, University of Oslo and University of Lund

Abstract. Innovation policy has emerged as a new field of economic policy during the last few decades. This paper explores the rationales for national innovation policies, as laid out in the existing literature on the subject, and considers what the lessons and challenges for theory and practice in this area are. Innovation policy attempts to influence innovation activity, often with the purpose of increasing economic growth. But it can also have more specific aims such as preventing unwarranted climate change, improving national health, and so on. The increasing attention given to innovation policy at the national level from the 1990s onwards went hand in hand with the development of a new, systemic understanding of innovation, which in a better way than before accounted for the 'stylised facts' of innovation activity as identified by empirical work. The system approach, as the paper shows, came to have a significant influence on the subsequent policy discourse. Drawing on recent advances in innovation-systems theory, a synthetic framework for the analysis of innovation policy is developed and used to highlight issues of particular relevance for the conduct of innovation policy and future scholarly work in this area.

Keywords. Grand challenges; Innovation; Innovation policy; National innovation systems

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 much during the 1980s to increase the interest for the topic (see, e.g. Rothwell, 1982). However, the real surge of interest had to wait until the 1990s, 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).[1]

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.* (2009), in practice it may be necessary to concentrate on the nontrivial impacts of policy (and this requires criteria for doing so).

*Corresponding author contact email: jan.fagerberg@tik.uio.no; Tel.: +4722841610.

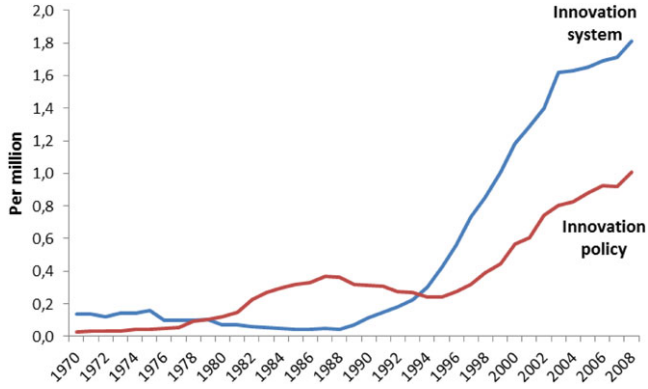

Figure 1. The Frequency of the Terms 'Innovation Policy' and 'Innovation System' According to Google.

Source: Own Calculations Based on Information from https://books.google.com/ngrams.

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 the diffusion of innovations in the economic and social system (broad definition), or is it limited to the first occurrence of a new product, process or way of doing things (narrow definition)? The choice of definition may to some extent reflect the purpose of the analysis. Nevertheless, although 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 a whole. From this perspective the broader definition makes most sense, because what mainly matters for its impact is not the first occurrence of an innovation but its subsequent diffusion and use (Kline and Rosenberg, 1986).

It is also important to take into account that the focus of policy, the terms used, and the theories underpinning its design and implementation change over time. For example, while in the 1960s the focus was on science (and hence the term 'science policy' was popular), it later shifted to technology (and 'technology policy') and more recently innovation (with the associated term 'innovation policy'), see for example, 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 for example Box 1. Arguably, disregarding important evidence just because terminology has shifted would make it very difficult to understand how institutions, organisations 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 at the national level (if not more) and it may be time to take stock of what has been learnt (see, e.g. Smits *et al.,* 2010; Edler *et al.,* 2013). This paper explores the rationales for national innovation policies, as laid out in the existing literature on the subject, and considers what the lessons and challenges for theory and practice in this area are. The next section outlines the theoretical rationales for innovation policy and considers the relationship between the assumptions underlying these rationales and empirical evidence from innovation-surveys. [2] Based on recent advances in innovation-systems theory, Section 3 presents a synthetic framework for analysing innovation policy, whereas Section 4 focuses on so-called 'mission-oriented' innovation

policies, that is, 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, labour 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 increased welfare for the population could be achieved. Technological progress, naturally, was seen as crucial for realising this goal, and quickly attracted the attention of policymakers. A technical research council (TFR), the first research council in Sweden, was set up in 1942. 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 policymakers 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 the cooperation between the firm Ericsson and the Swedish telecommunication agency (Televerket) on the developments of digital switches (the AXE system) may serve as an example. Hence, during this period, the state played quite a proactive role in fostering innovation and the technological capabilities underpinning it (although the term 'innovation policy' was not used).

2. Rationales for Innovation Policy: Theory and Evidence

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.

2.1 *Perspectives on Knowledge*

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, let alone earn a profit from it. Rational firms would therefore according to this reasoning tend to underinvest in the creation of new knowledge, 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 – aimed 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, subsidising research in private firms and changing the rules of the game by, say, strengthening intellectual property rights.

The public good nature of knowledge continues to be invoked as a rationale for public investments in science in modern capitalist societies (OECD, 2010a). 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) emphasised 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 pay little attention to, as it conflicts with the underlying premises of the approach.

2.2 *'Stylised 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 'stylised 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 *et al.,* 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 'stylised 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.[3] The most important source is to be found within the firm itself. Among the external sources, by far the 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 frequently, they do also cooperate with universities and public research institutes.

Information about how firms go about appropriating the benefits from their innovative activities is provided in Figure 4.[4] 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

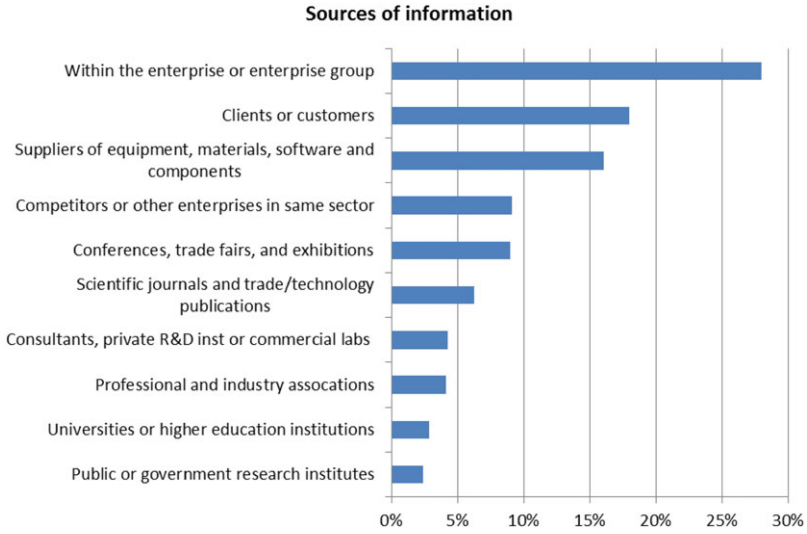

Figure 2. Important Sources of Information for Innovation.

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

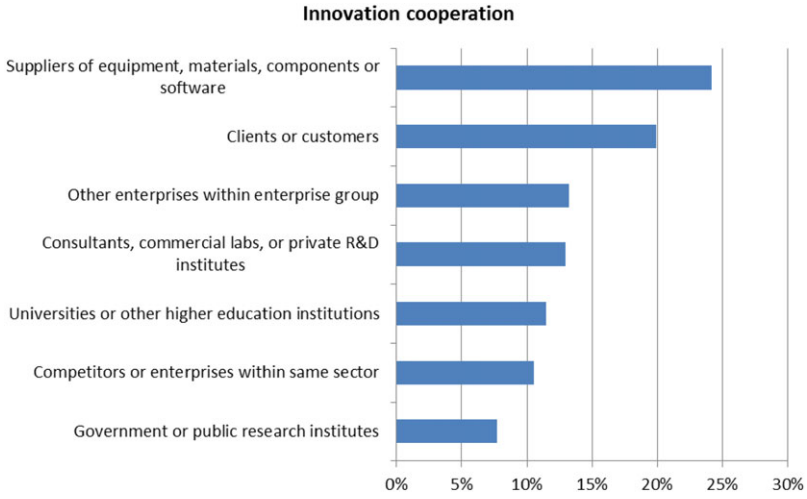

Figure 3. Innovation Cooperation.

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

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, 2010).

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

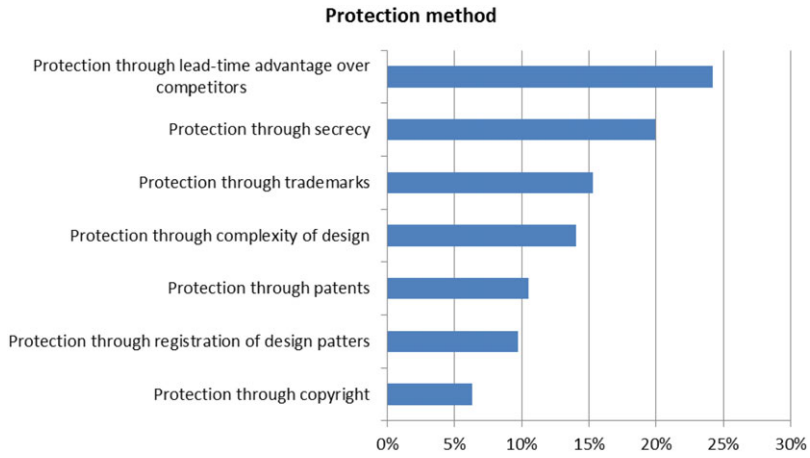

Figure 4. How to Appropriate the Benefits from Innovation?

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

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, emphasised by several studies (Rothwell *et al.,* 1974; Lundvall, 1985; Kline and Rosenberg, 1986; 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 have intimate knowledge about the requirements that an innovation needs to satisfy. Moreover, in some instances users, being highly competent and sophisticated, may play a proactive role in innovation (von Hippel, 2005).

2.3 *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, for example, Freeman (1987), Lundvall (1988, 1992) and Nelson (1988, 1993), made interaction between actors, organisations and institutions involved in innovation and diffusion the central focus of their approach.[5] The strong emphasis on the interactive nature of innovation provided support to the development of innovation policy instruments[6] – applied in many countries – aiming at bringing different parts of the system together in the pursuit of innovation. Equipping the actors in the system with the required capabilities for making the most out of innovation-diffusion became another central priority. The approach quickly attracted the interest of policymakers and, not the least, the OECD, which did much to propagate it in the decades that followed its creation (OECD, 1997, 1999, 2002).[7] Subsequently, the national innovation system approach has been applied in studies of a number of different countries (see, e.g. Edquist and Hommen, 2008), and the OECD has adopted it in evaluations of the national innovation system and supporting policies in countries from all parts of the world.[8]

Basing itself on Schumpeterian and evolutionary perspectives, the national innovation system approach leaves little room for the idea of an 'optimal' state. Rather, a national innovation system is seen as the result of a long historical process characterised by coevolution between a country's economic system (major industries, firms etc.) and its political and institutional system (Freeman and Louçã, 2001; Smits and Kuhlman, 2004; Fagerberg *et al.,* 2009). The resulting system may – once established – be remarkably persistent in spite of changes in the environment (Pierson, 2000). As a consequence, national innovation systems may end up looking rather different (see Box 2). Hence, a policy mix that works in one context is not necessarily equally well suited to another (Flanegan *et al.,* 2011; Borras and Edquist, 2013). Thus there is no place in this approach for mechanical transfer of polices from one context to another: Detailed studies of the workings of the national innovation system will be required to determine what the 'problems' facing policymakers are and what the appropriate policy response may be (Edquist, 2011).[9]

Box 2. History matters

The Nordic countries are often considered to be similar, as epitomised 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, that is, 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 organisations (PROs) outside universities (the 'institutes') developed in close interaction with important industries, firms and organisations, 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 on its website of being 'the biggest multi-technological applied research organisation 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.

3. Innovation Systems, Technological Dynamics and Policy: A Synthesis

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 characteristics of the system at a particular point of time, rather than on its dynamics. After the turn of the millennium, the scholarly work on innovation systems 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). In the literature, the factors influencing innovation have invariably been called (fundamental) activities, processes, functions and subfunctions. 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).[10]

In Figure 5 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

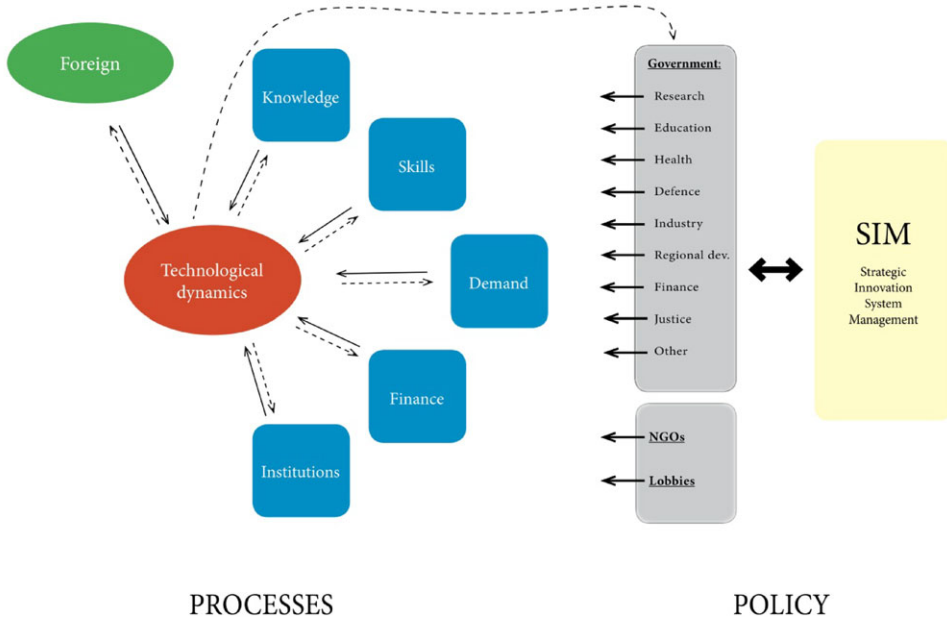

Figure 5. The National Innovation System: Dynamics, Processes and Policy.

course of paramount importance economically 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.

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, whereas the possible feedbacks from technological dynamics on the generic processes are represented by dotted arrows. Policymakers 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'. 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:

1. **Knowledge**: Knowledge may, for example, be provided by public R&D organisations (universities, etc.) that complement firms' own capabilities and through schemes that promote interaction between firms and other actors (e.g. cooperative R&D). Such processes are influenced by various layers within government, particularly the Ministry for Research, but also other ministries, such as those for industry, regional development, health, defence, etc.
2. **Skills**: Skills, both specialised 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).

3. **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.
4. **Finance**: Finance is necessary for innovation to persevere. Some innovative initiatives, particularly from small firms, entrepreneurs, etc., or in cases characterised 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 of 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.
5. **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 closing down businesses, regulations regarding hiring or firing of 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.[11]

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'. Thus, what matters from an innovation system perspective is not the name of a policy, but its impact.

An important feature that has increasingly come into focus is the strong complementarities that commonly exist between the different parts of an innovation system or policy instruments (Freeman, 2002). 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 system. For example, it is of little help to have superior knowledge if you do not 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 it follows that the effect of a specific policy cannot be assessed in isolation, that is 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 logically from the underlying theory but is arguably challenging for policymakers. First, calculating the total effects of a broad set of interacting policies (or 'policy mix'; see, e.g. OECD, 2010b) 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 policymakers 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'.[12] The Finnish example

(see Box 3) is perhaps the most ambitious effort to date of doing so (Pelkonen, 2006) but similar examples may be found in a number of other countries as well (OECD, 2010b).

Box 3: Finland: A system perspective on governance

Finnish policymakers were quick to embrace the new, holistic understanding of innovation which emerged around 1990 under the label 'national innovation systems' (NIS). 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 years 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, whereas 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).

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, and so on, 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 United States (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 (see, e.g. Fagerberg *et al.,* 2004). 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, and so on, 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 policymakers in this context may for example be (1) to help mobilise the necessary support so that the experiment can get going, (2) to avoid that it is aborted too early (for reasons that policymakers 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 policymakers in mobilising 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 policymakers themselves. An example of the latter is the 'technological innovation system' approach, mentioned earlier, which was developed and improved through interaction between researchers and policymakers in Sweden (see Carlsson *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'

at various levels that hamper one or more of these processes (and/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 policymakers' 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,[13] has been developed in the Netherlands under the label 'multilevel perspective' (MLP). Multilevel perspectives are well known from evolutionary theorising, which has been a source of inspiration for the MLP approach and 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[14] 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). Policy-relevant 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).[15]

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 as well as (and increasingly so) a means to tackle social challenges.[16] The growing attention to innovation policy has gone hand in hand with the development of new theoretical frameworks, most importantly the national innovation systems approach.

A key 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 idea, product etc. but the entire process, from the creation of new products, processes and ways of doing things to their diffusion and use. These definitional choices follow logically from the premise that the purpose of innovation policy is not just to encourage creativity but to make a difference in the real world.

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 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 satisfactorily.

Although the characteristics – or structures – of national innovation systems 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 analysed 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 analysing 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 levels/domains,[17] and the development of new forms of governance and supporting knowledge bases that make this possible. This is obviously very challenging. The possibility for success depends crucially on the ability of a country's political system (and its government) to deal with these issues, which cannot be taken for granted.[18] 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, with the purpose of identifying the factors that influence the possibilities for getting the most out of innovation policy.

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 policymakers to keep the cards close to their chests and for evaluators to go along with this.[19] It is highly questionable, however, whether 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', that is involving the expertise of the broader public, is not only more democratic but also more effective (von Hippel, 2005).[20] Arguably, this may apply to innovation policy as well.

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Notes

1. The innovation system approach can be (and has been) applied at different levels of aggregation, e.g., a specific technology (technological innovation systems, see Carlsson and Stankiewicz, 1991), the sector or industry level (sectoral innovation systems, see Malerba, 2004), the regional level (regional innovation systems, see Cooke *et al.,* 1997) and, finally, the national level, which is the main focus here. For an overview and discussion see Edquist (2004).

2. The discussion of theoretical rationales in this paper is limited to contributions with significant influence on discussions on national innovation policy. Broader overviews of innovation economics can be found in Fagerberg *et al.* (2004) and Hall and Rosenberg (2010).
3. The CIS-data used in this paper can be accessed through http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database.
4. The questions included in the European Union's Community Innovation Survey differ somewhat across different waves of the survey. The question underlying Figure 4, whether the firm had used a particular method to protect its inventions or innovations during the three-year period covered by the survey, was not included in later surveys. 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). For a survey of the empirical evidence on different ways to appropriate the economic benefits of invention and innovation see Cohen (2010).
5. Sharif (2006) and Fagerberg and Sapprasert (2011) trace the emergence of the national innovation system approach.
6. For a more comprehensive treatment see the next section and the discussion in Steinmueller (2010).
7. Radosevic (2012), in a survey of the innovation policy literature, notes that there has been less interest for innovation policy (and the theoretical framework supporting it) in the USA than in Europe.
8. The evaluations cover countries from five different continents, with Europe and Asia particularly well represented, see http://www.oecd.org/sti/inno/oecdreviewsofinnovationpolicy.htm for further details. Among the larger economies, China and Russia are included, whereas the USA is not.
9. Such «problems» requiring policymakers' attention are sometimes called 'system failure' (Metcalfe, 2005) and this practice has also been adopted by the OECD (2010a,b, 2015a).
10. For example, Bergek *et al.* (2008) consider the dynamics of more narrowly defined 'technological innovation systems'. These are often subsystems within national innovation systems but may also cross international borders (Carlsson and Stankiewicz, 1991). This difference in focus naturally leads to some differences with respect to the identification of central "functions" or processes in the system.
11. Even attitudes and values change in response to technological and economic changes, albeit very slowly, from one generation to the next (Inglehart, 1977, 2008).
12. The OECD, in the most recent version of the OECD innovation strategy, also emphasises the important role that 'The Centre of Government' may play in 'strategic management of cross-sectoral policy initiatives' such as innovation policy (OECD, 2015a, pp. 240–241).
13. For an analysis of this aspect of innovation policy with a focus on sustainability, see Nill and Kemp (2009).
14. 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'.
15. 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, for example, 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).
16. See, for example, the recent OECD work on 'inclusive innovation', that is innovations that 'serve the welfare of lower-income and excluded groups' (OECD, 2015b, p. 5).
17. This includes not only horizontal coordination (across different ministries, for example), challenging as it may be, but also vertical coordination between different levels of governance (regional, national and international); see, for example OECD (2015a), pp. 237–267.

18. 'Government failure' may occur when attempts to deal with other 'failures' or challenges instead create new problems that make the situation worse than before (Bach and Matt, 2005). Among the possible reasons for such failure, low capabilities and/or insufficient knowledge on the part of government may be mentioned. However, policymakers may also fail to address challenges adequately due to constraints created by path dependencies in the system, lock-in, capture by special interests etc., see e.g., the discussion by Dodgson *et al.* (2011) on the development of innovation policy in Australia.
19. See Miettinen (2012) for a discussion of what he describes as a democratic deficit in Finnish innovation policy.
20. The European Union's emphasis on "responsible research & innovation" (RRI) in its "Horizon 2020" programme may be seen as an attempt in this direction. See https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation for further details.

References

Arrow, K. (1962) Economic welfare and the allocation of resources for innovation. In R.R. Nelson (ed.) *The Rate and Direction of Inventive Activity* (pp. 609–625). Princeton: Princeton University Press.

Bach, L. and Matt, M. (2005) From economic foundations to s & t policy tools: A comparative analysis of the dominant paradigms. In P. Llerena and M. Matt (eds.) *Innovation Policy in a Knowledge-Based Economy: Theory and Practice* (pp. 17–46). Heidelberg: Springer.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S. and Rickne, A. (2008) Analysing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy* 37(3): 407–429.

Boekholt, P. (2010) The evolution of innovation paradigms and their influence on research, technological development and innovation policy instruments. In R. Smits, S. Kuhlmann and P. Shapira (eds.) *The Theory And Practice Of Innovation Policy: An International Research Handbook* (pp. 333–359). Cheltenham: Edward Elgar.

Borrás, S. and Edquist, C. (2013) The choice of innovation policy instruments. *Technological Forecasting and Social Change* 80(8): 1513–1522.

Braun, D. (2008) Lessons on the political coordination of knowledge and innovation policies. *Science and Public Policy* 35(4): 289–298.

Carlsson, B. and Stankiewicz, R. (1991) On the nature, function and composition of technological systems. *Journal of Evolutionary Economics* 1(2): 93–118.

Carlsson, B., Elg, L. and Jacobsson, S. (2010) Reflections on the co-evolution of innovation theory, policy and practice: The emergence of the Swedish agency for innovation Systems. In R. Smits, S. Kuhlmann and P. Shapira (eds.) *The Theory and Practice of Innovation Policy: An International Research Handbook* (pp. 145–166). Cheltenham: Edward Elgar.

Cohen, W.M. (2010) Fifty years of empirical studies of innovative activity and performance. In B.H. Hall and N. Rosenberg (eds.), *Handbook of the Economics of Innovation*, Vol. 1 (pp. 129–213). Oxford: North-Holland.

Cooke, P., Uranga, M.G. and Etxebarria, G. (1997) Regional innovation systems: Institutional and organisational dimensions. *Research Policy* 26(4–5): 475–491.

Dodgson, M., Hughes, A., Foster, J. and Metcalfe S. (2011) Systems thinking, market failure and the development of innovation policy: The case of Australia. *Research Policy* 40(9): 1145–1156.

Edler, J. and Georghiou, L. (2007) Public procurement and innovation: Resurrecting the demand side. *Research Policy* 36(7): 949–963.

Edler, J., Cunningham, P., Gök, A. and Shapira, P. (2013) Impacts of Innovation Policy: Synthesis and Conclusions. http://innovation-policy.org.uk/compendium/ (Last accessed 6 February 2014).

Edquist, C. (2004) Systems of innovation: perspectives and challenges. In J. Fagerberg, D. Mowery and R. Nelson (eds.) *Oxford Handbook of Innovation* (pp. 181–208). Oxford: Oxford University Press.

Edquist, C. and Hommen, L. (eds.) (2008) *Small Country Innovation Systems: Globalization, change, and policy in Asia and Europe*, Cheltenham: Edward Elgar.

Edquist, C. (2011) Design of innovation policy through diagnostic analysis: Identification of systemic problems (or failures). *Industrial and Corporate Change* 20(6): 1–29.

Edquist, C. and Zabala-Iturriagagoitia, J.M. (2012) Public procurement for innovation as mission-oriented innovation policy. *Research Policy* 41(10): 1757–1769.
Ergas, H. (1986) Does Technology Policy matter? CEPS papers No 29, Brussels, Centre for European Studies.
Fagerberg, J., Mowery, D. and Nelson, R. (eds.) (2004) *The Oxford Handbook of Innovation*, Oxford: Oxford University Press.
Fagerberg, J., Mowery, D. and Verspagen, B. (eds.) (2009) *Innovation, Path Dependency and Policy: The Norwegian Case*, Oxford: Oxford University Press.
Fagerberg, J., Fosaas, M., Bell, M. and Martin, B.R., (2011) Christopher Freeman: Social science entrepreneur. *Research Policy* 40(7): 897–916.
Fagerberg, J. and Sapprasert, K. (2011) National innovation systems: The emergence of a new approach. *Science and Public Policy* 38(9): 669–679.
Geels, F.W. and Schot, J. (2007) Typology of sociotechnical transition pathways. *Research Policy* 36(3): 399–417.
Hall, B.H. and Rosenberg, N. (eds.) (2010) *Handbook of the Economics of Innovation*, Oxford: North-Holland.
Flanagan, K., Uyarra, E. and Laranja, M. (2011) Reconceptualising the 'policy mix' for innovation. *Research Policy* 40(5): 702–713.
Freeman, C. (1987) *Technology Policy and Economic Performance: Lessons from Japan*, London: Pinter.
Freeman, C. (2002) Continental, national and subnational innovation systems: Complementarity and economic growth. *Research Policy* 31(2): 191–211.
Freeman, C. and Louçã, F. (2001) *As Time Goes By: From the Industrial Revolutions to the Information Revolution*, Oxford: Oxford University Press.
Inglehart, R. (1977) *The Silent Revolution: Changing Values and Political Styles among Western Publics*, Princeton, NJ: Princeton University Press.
Inglehart, R. (2008) Changing values among western publics from 1970 to 2006. *West European Politics* 31(1–2): 130–146.
Kemp, R., Schot, J. and Hoogma, R. (1998) Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis and Strategic Management* 10(2): 175–198.
Kline, S.J. and Rosenberg, N. (1986) An overview of innovation. In R. Landau and N. Rosenberg (eds.) *The Positive Sum Strategy: Harnessing Technology for Economic Growth* (pp. 275–304). Washington, DC: National Academy Press.
Levin, R.C., Klevorick, K. A., Nelson, R. R. and Winter, S. G. (1987) Appropriating the returns from industrial research and development, *Brookings Paper Economy Act: Microeconomics*, pp. 783–820.
Liu, X. and White, S. (2001) Comparing innovation systems: A framework and application to China's transitional context. *Research Policy* 30(7): 1091–1114.
Lundvall, B.Å. (1985) *Product Innovation and User-Producer Interaction*, Aalborg: Aalborg University Press.
Lundvall, B.Å. (1988) Innovation as an interactive process: From user-producer interaction to the national system of innovation. In G. Dosi, C. Freeman, R. Nelson, G. Silverberg and L. Soete (eds.), *Technical Change and Economic Theory* (pp. 349–369). London: Pinter.
Lundvall, B.Å. (1992) *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter.
Lundvall, B.Å. (2007) National innovation systems: Analytical concept and development Tool. *Industry & Innovation* 14(1): 95–119.
Lundvall, B.Å. and Borrás, S. (2004) Science, technology and innovation policy. In J. Fagerberg, D.C. Mowery and R.R. Nelson (eds.) *The Oxford Handbook of Innovation* (pp. 599–631). Oxford: Oxford University Press.
Malerba, F. (2004) Sectorial systems: how and why innovation differs across sectors. In J. Fagerberg, D. Mowery and R. Nelson (eds.) *The Oxford Handbook of Innovation* (pp. 380–406). Oxford: Oxford University Press.
Metcalfe, J.S. (2005) Systems failure and the case for innovation policy. In P. Llerena and M. Matt (eds.) *Innovation Policy in a Knowledge-Based Economy: Theory and Practice* (pp. 47–74). Heidelberg: Springer.
Miettinen, R. (2012) *Innovation, Human Capabilities, and Democracy: Towards an Enabling Welfare State*. Oxford: Oxford University Press.

Mowery, D.C. (2011) Federal policy and the development of semiconductors, computer hardware and computer software: A policy model for climate change R&D? In R.M. Henderson and R.G. Newell (eds.) *Accelerating Energy Innovation: Insights from Multiple Sectors* (pp. 159–188). Chicago, IL: University of Chicago Press.
Nelson, R.R. (1959) The simple economics of basic scientific research. *Journal of Political Economy* 67(3): 297–306.
Nelson, R.R. (1988) Institutions supporting technical change in the United States. In G. Dosi, C. Freeman, R. Nelson, G. Silverberg and L. Soete (eds.), *Technical Change and Economic Theory* (pp. 312–329). London: Pinter.
Nelson, R.R. (ed.) (1993) *National Innovation Systems: A Comparative Study*. Oxford: Oxford University Press.
Nelson, R.R. and Winter, S.G. (1982) *An Evolutionary Theory of Economic Change*. Cambridge: Harvard University Press.
Nill, J. and Kemp, R. (2009) Evolutionary approaches for sustainable innovation policies: from niche to paradigm? *Research Policy* 38(4): 668–680.
OECD (1997) *National Innovation Systems*. Paris: OECD.
OECD (1999) *Managing National Innovation Systems*. Paris: OECD.
OECD (2002) *Dynamising National Innovation Systems*. Paris: OECD.
OECD (2010a) *The OECD Innovation strategy: Getting a head start on tomorrow*. Paris: OECD Publishing.
OECD (2010b) The innovation policy mix. In OECD (ed.), *OECD Science, Technology and Industry Outlook 2010* (pp. 251–279). Paris: OECD.
OECD (2013) *OECD's reviews of innovation policy: Sweden*. Paris: OECD.
OECD (2015a) *The Innovation Imperative: Contributing to Productivity, Growth and Well-Being*. Paris: OECD.
OECD (2015b) *Innovation Policies for Inclusive Growth*. Paris: OECD.
Pelkonen, A. (2006) The problem of integrated innovation policy: Analysing the governing role of the science and technology policy council of Finland. *Science and Public Policy* 33(9): 669–680.
Pierson, P. (2000) Increasing returns, path dependence, and the study of politics. *The American Political Science Review* 94(2): 251–267.
Radosevic, S. (2012) Innovation policy studies between theory and practice: A literature review based analysis. *STI Policy Review* 3(1): 1–45.
Rip, A. and Kemp, R. (1998) Technological change. In S. Rayner and E.L. Malone (eds.), *Human Choice and Climate Change, Vol. 2, Resources and Technology* (pp. 327–399). Washington, DC: Battelle Press.
Rothwell, R., Freeman, C., Horlsey, A., Jervis, V.T.P., Robertson, A.B. and Townsend, J. (1974) SAPPHO updated: Project SAPPHO phase II. *Research Policy* 3(3): 258–291.
Rothwell, R. (1982) Government innovation policy: Some past problems and recent trends. *Technological Forecasting and Social Change* 22(1): 3–30.
Rotmans, J., Kemp, R. and van Asselt, M. (2001) More evolution than revolution: Transition management in public policy. *Foresight* 3(1): 15–31.
Sharif, N. (2006) Emergence and development of the national innovation systems concept. *Research Policy* 35(5): 745–766.
Smith, K. (2004) Measuring innovation. In J. Fagerberg, D. Mowery, R. Nelson (eds.), *The Oxford Handbook of Innovation* (pp. 148–178). Oxford: Oxford University Press.
Smits, R. and Kuhlmann, S. (2004) The rise of systemic instruments in innovation policy. *International Journal of Foresight and Innovation Policy* 1(1–2): 4–32.
Smits, R., Kuhlmann, S. and Shapira, P. (eds.) (2010) *The Theory and Practice of Innovation Policy: An International Research Handbook*. Cheltenham: Edward Elgar.
Steinmueller, W.E. (2010) Economics of technology policy. In B.H. Hall and N. Rosenberg (eds.), *Handbook of the Economics of Innovation*, Vol. 2 (pp. 1181–1218). Oxford: North-Holland.
Veugelers, R. (ed.) (2009) *Evaluation of the Finnish national innovation system. Policy Report*, Helsinki University Press.
von Hippel, E. (1988) *The Sources of Innovation*, New York: Oxford University Press.
von Hippel, E. (1994) 'Sticky information' and the locus of problem solving: Implications for innovation. *Management Science* 40(4): 429–439.
von Hippel, E. (2005) *Democratizing Innovation*, Cambridge, MA: MIT Press.