The Co-evolution of Innovation Theory, Innovation Practice, and Innovation Policy

An analysis of the possible roles of parliamentary technology assessment in innovation policy

Study commissioned by the Flemish Institute for Science and Technology Assessment

viWTA

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1 Motivation and key questions

1.1 Context of the present study

The development of the Flemish innovation policy with regard to science and technology illustrates the importance that is currently attached to science and technology as instruments in the development towards a knowledge economy and a knowledge society. According to the figures quoted in the recent policy statement issued by Minister Van Mechelen, the budget for science and technological innovation grew considerably in the period 1995-2004, from almost EUR 1.4 billion in 1995 to just under EUR 2.6 billion in 2004. There have also been extensive adjustments to the Flemish innovation system and its guiding principles. Telling examples are, for instance, the so-called 'Innovation Pact' and the introduction and development of various instruments in the three newly introduced domains (research on the initiative of the researcher; strategic basic research; and technological innovation policy).

Another remarkable finding is that, in the concluding paragraph of the minister's introduction to his policy statement, companies and universities are explicitly invited to take part in a debate on the decisions to be made in the Flemish policy on science and technology, though 'knowledge policy' is perhaps a better name. The statement points out the need to take an even more structural approach to the policy philosophy of concentrating knowledge and investments, and the necessity of paying attention, in this process, to networking, enhancing cooperation in Flanders, developing centres of excellence, and concentrating resources (Beleidsbrief, 2003, p. 6). The policy statement further indicates that imposing a policy on the parties involved is out of the question, and stresses that the initiative lies with the stakeholders themselves. The primary stakeholders that seem to be envisaged here are companies and knowledge institutions.

This brings us to a number of crucial questions, to wit:

- How are decisions on science and technology made?
- Are all sections of society – including the citizens – in a good position to make a meaningful contribution to these decisions?
- Besides economic and scientific interests, what other interests are involved in the decision-making on science and technology?
- In addition to generating economic growth, can science and technology or innovation also contribute to solving various social problems?
- How can citizens make a meaningful contribution to a more broadly defined innovation policy?
- What information is required in the processes involved in decision-making on science and technology?

These and other question are key issues in present-day innovation theory and innovation practice. Through its work, viWTA (*Vlaams Instituut voor Wetenschappelijk en Technologisch Aspectenonderzoek*, Flemish Institute for Science and Technology Assessment) wants to become more deeply involved in the ongoing discussion on the strategy and structure of the Flemish innovation policy. It has commissioned a consortium, formed by *Universiteit Utrecht*, Dialogic, and *Universiteit Antwerpen*, to investigate the role of technology assessment (and in particular parliamentary technology assessment) in the practice of the Flemish innovation policy, taking into account the latest developments in innovation theory and the dominant trends in the innovation policy of other countries and of international organisations such as the EU and the OECD.

In the framework of this study, four products were to be delivered:

a. A *literature study on the development of theories on innovation processes and systems* with special attention to the links between innovation theory, innovation practice, and innovation policy. This study does into a number of essential questions, such as: What are the characteristics of modern innovation practice? In what sense has the thinking on innovation changed? How have these changes been reflected by changes in innovation policy? Eventually, this study addresses the question of what role (parliamentary and other) technology assessment (hereafter referred to as 'TA') can play in the management of innovation in the economy and society.
b. *An analysis of trends and developments in the Flemish innovation policy of the last twenty years*.
c. A short *policy-oriented document* that summaries the added value of TA and, in particular, parliamentary TA, for the innovation policy to be pursued.
d. An *executive summary* of the study as a whole.

Products 1 and 2 were produced by the *Disciplinegroep Innovatiewetenschappen* of *Universiteit Utrecht*, in collaboration with Dialogic (Prof. Ruud Smits and Pim den Hertog) and STEM/*Universiteit Antwerpen* (Prof. Lieve Goorden), respectively. Products 3 and 4 were co-produced. The present document is the report on the literature study (product 1).

1.2 Key questions and basic principles

From the formulation of the main question of this study in the paragraph above, it is already clear that the study focuses on the relationship between TA - more specifically, parliamentary TA (hereafter 'PTA') - and innovation policy in Flanders. More specifically, it seeks to answer the question of what is the added value of actively involving users[1] in a modern innovation policy and the way in which TA (and PTA in particular) can contribute to the realisation of social learning processes involving innovation.

The literature study focuses on the following four key questions:

- Question 1: What is the relationship between innovation theory, innovation practice, and innovation policy, and what is the role of TA in this mutual interaction?
- Question 2: How has the thinking on innovation and innovation processes developed over the past few decades, in general outlines?
- Question 3: Given the development towards a knowledge society, how has the thinking on innovation policy developed? This question is further divided into three sub-questions:
  - What are the main developments in practice?
  - What does the systems approach to innovation suggest?

[1] In this study, the word 'users' is to be understood in the broadest sense, i.e., including intermediary users and citizens, and not in the more limited sense of 'end users'.

- What can we learn from the confrontation of innovation theory with innovation practice?

- Question 4: What roles can users, strategic intelligence, and TA – and PTA in particular – play in a modern innovation policy?

1.3 Structure of this report

The following chapters 2 up to and including 5 address the questions set out above, in that order. To answer them, we have drawn from a rapidly growing body of theories, concepts, and outlooks on innovation and the role of the user in the process of innovation. In the past few decades, the field of innovation has attracted many scientists from different disciplines, ranging from various sorts of economists (neo-classical, evolutionary) and management scientists to sociologists, historians, political scientists, and others. Interdisciplinary approaches are becoming increasingly common in many fields, especially in the policy sciences, cultural sciences, and innovation sciences. The starting point of this literature study is the interdisciplinary approach to innovation. This implies that we take a 'bird's-eye' view of the field, and will tend to use general and frequently used concepts and approaches rather than turn to exclusive, mono-disciplinary approaches, concepts, or theories in the area of the development of science and technology and/or innovation. Nevertheless, it is impossible to describe a phenomenon such as innovation, or the innovation policy in relation to TA, without making choices (and being normative in that sense). These are the preferences and emphases of the two authors, based on their long-standing experience in the field.

Chapter 2 (which addresses question 1) primarily serves to offer an analytical framework. The key idea is that practice (P), intervention or policy (I), and theory (T) in the domain of innovation co-evolve. Chapter 2 starts with the presentation of a few key starting points for this study. In the process, we define an outlook on innovation, the position of users in this process, and the possible role of TA as a method in this whole. In this context, we will briefly illustrate the concept of the so-called 'PIT helix' by looking at the development of the Dutch innovation policy. One of the findings is that interaction and learning are crucial to this co-evolution and that TA can play a major role in this process. We also briefly introduce the innovation systems concept. This is one of the interdisciplinary concepts that are still gaining force in innovation studies. Perhaps even more crucial is the fact that the innovation systems approach (IS approach for short) is generally recognised by players in innovation practice and policy practice. Both the PIT helix and the IS approach offer a framework enabling structured communication on the subjects of innovation theory, practice, and policy.

In chapter 3 (on question 2), we present a few key concepts of innovation theory (the 'T' in the PIT helix). First, we look at the concept of innovation and how its meaning has changed over time. Next, we go into some fundamental concepts and insights from innovation theory. The main aim of these insights is to view the thinking on innovation not as a linear, discrete, and technological development process, but as an evolutionary, cumulative learning path that is largely shaped by social actors and institutions, in interaction. In fact, we are dealing with a complex (multi-actor, multi-level) management area in which uncertainty, learning, and experimentation play a central role. At the end of this chapter, we go over a few views on the role of users in the development of technology.

Chapter 4 (question 3) describes how the IS approach is gaining the upper hand in present-day thinking on innovation policy against the background of a developing knowledge economy and society. Moreover, we examine a few dominant developments in policy practice, such as the trend towards innovation governance and the advance of policy learning and integrated or multi-purpose innovation policy. However, at the level of instruments, only the start of what we will call ‘systemic instruments’ is apparent as yet. A remarkable aspect of the IS approach is that the role of users in innovation and social learning processes has received relatively little attention so far. TA can fill this gap.

Chapter 5 (questions 4 and 5) goes more specifically into the part that users and TA could play as part of the broader concept of strategic intelligence (SI) in the systemic innovation policy or, better, in innovation systems policy, a concept introduced in chapter 4. After setting out the reasons why the involvement of users in innovation is desirable, we will go into the role of TA as an instrument in the ‘management of innovation in economy and society’ or in the facilitating of social innovation and learning processes. This will bring us back to the main question of this research, to wit, the question of how parliamentary TA can contribute to a modern innovation policy. We will formulate a number of options open to the Flemish Parliament and/or viWTA.

2 Analytical framework and basic principles

Question 1: What is the relationship between innovation theory, innovation practice, and innovation policy, and what is the role of TA in this interaction?

2.1 Introduction

This chapter starts with a brief introduction to the basic principles of this study. These principles are best understood as essential to our outlook on innovation, on the position of users in this process, and on the possible role of TA in this whole (2.2). Next, we introduce the three key concepts. First, the concept of the triple PIT helix (2.3), which helps to describe the relationship between innovation theory, practice, and intervention. We will illustrate this first concept with the case of the Netherlands (2.4). The second key concept is the innovation systems (IS) concept (2.5), which has been gaining wider acceptance both in theoretical circles as well as in more practical innovation and innovation policy approaches. Finally, we introduce the third conceptual building block of this study, which is the notion of strategic intelligence (2.6). By no longer viewing TA merely as a relatively isolated (and strongly technology-critical) activity, but as an element of the strategic knowledge necessary to actively influence science and technology (and the innovations they produce) and use them to increase not only economic welfare, but also social well-being, TA and, more specifically, PTA, in our opinion, can be more strongly involved in the current discussions on how to give shape to the Flemish innovation policy.

2.2 Basic principles

Before going into the three key concepts as indicated above, we want to introduce the basic principles of this study. In a sense, they present, in a nutshell, our outlook on innovation, the possibilities and difficulties of steering it in a particular direction, and the role of TA in processes of learning and experimentation, which are inextricably linked to innovation.

1. **Innovation is broader than technological innovation.** In many dissertations on innovation and innovation policy, innovation is immediately reduced to technological change and technological innovation. Recently, however, there has been a growing awareness that innovation has both a 'hard' side and a 'soft' side, i.e., that non-technological innovations and non-technological aspects of innovation processes[2] are important elements of innovation. Indeed, technological innovation

[2] Non-technological innovations are, for instance, conceptual (service) innovations, innovations in the interaction between manufacturer/provider and user, or the organisational innovations that need to be made in order to produce a new item (physical product or service). The non-technological aspects are primarily the innovation process itself and the non-technological factors that play a role in it. Modern innovation management is more than R&D or technology management, but also covers the organisational provisions that need to be made to ensure that an organisation can carry on 'learning' continuously and 'keep moving'. However, to go into one concrete example, even the steam engine, that would seem to be very much a technical innovation, was also, to a great extent, a social,

is very much a social construct. Moreover, it is not an end in itself, but a means to several ands: not only to boost the competitive edge of enterprises and satisfy the curiosity of scientists, but also, and no less importantly, to help in dealing with social problems.

2. **Innovation theory, innovation practice, and innovation policy develop in mutual interaction, i.e., they co-evolve**. The concepts, objectives, and instruments of innovation policy shift and change, reflecting new insights of innovation theory and shaped by experience with stimulation innovation processes in practice. Innovators are increasingly realising that innovation demands much interaction between various parties (the view of innovation as an isolated activity of a genius inventor or scientist is increasingly being abandoned). In innovation theory, there is growing attention for processes of learning, and policy learning in particular. In short, innovation theory, policy, and practice are increasingly being seen to co-evolve, and this co-evolution is getting more and more emphasis.

3. **Innovation is a systemic activity.** This implies that innovation demands continuous innovation, learning, and adaptation processes from a great many actors. These actors are various categories of companies, public and semi-public knowledge and education institutions, intermediaries, diverse categories of users, as well as parties responsible for creating the framework conditions for innovation, which include policymakers both in the area of innovation and in other domains (e.g. education, ICT, or infrastructure). To gain an understanding of this complex whole of actors and interactions and increase the possibilities of successful intervention, a systems approach is called for.[3] Crucial in this respect is to stimulate learning processes, learning to deal with uncertainty, and developing what we will call systemic instruments, which enable interventions at the systems level (Smits and Kuhlmann, 2004).

4. **Users/citizens deserve a voice in the way science and technology, and the innovations based on them, are prioritised, introduced, and applied.** On the one hand, this is a complicating factor, but on the other, it has several valuable positive effects (into which we will go in greater detail in paragraph 5.2): (a) a more effective articulation of social needs; (b) a greater competitive edge of private enterprises; (c) improved acceptance and social embedding of knowledge and technology; (d) enhanced learning capacity of society as a whole; and (e) a greater degree of democracy in the structure of society. Eventually, this contributes to a better and more broadly supported decision-making on innovation, resulting in a fuller exploitation of technological potential.

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organisational, and economic innovation. Without the First Industrial Revolution, born from the rise of a new financial and economic system (banks and entrepreneurs/factories, respectively), the role of the steam engine would have remained limited to what it had already been for more than a century: that of a very inefficient machine used to pump water out of the shafts of the coal mines in the English Midlands. It was the developments mentioned above that took steam power from these mines, dramatically improved it (Watt regulator, condenser), and transformed it into the central source of energy of the First Industrial Revolution (Smits, 2000).

[3] Another term that is used in this context is innovation ‘governance’. We will not use this term for the time being, because it has proven itself a very elastic concept in practice. In the narrow sense, it covers the formal management of an innovation system, but there are broader interpretations of innovation governance in which it is considered to cover other areas as well, such as processes of policy coordination (vertical, temporal, and horizontal), policy learning, accountability, etc. (see e.g. the MONIT project currently being carried out in the context of the OECD).

5. **The socialisation of innovation demands the socialisation of innovation policy.** Innovation does not only serve processes of economic growth, but it must also eventually contribute to greater social well-being and to solving broadly felt social problems. An extra argument is that practice shows that a good social embedding of innovation processes also benefits the success of economically oriented innovation processes. In a number of countries, such so-called 'horizontal' innovation policy seems to be on the rise. Other terms used in this context are 'third-generation' and 'multi-purpose' innovation policy. Certainly in the more social domains such as education and healthcare, user knowledge, user participation, and interactions between laymen and experts can be beneficial, and in some cases even indispensable, in this broadened innovation policy.

6. **Uncertainty and learning are inextricably linked with innovation.** Uncertainty plays a major role in learning processes. This applies to companies that innovate and knowledge institutions that explore the boundaries of science, but also to users and policymakers. TA can play a role in facilitating those social learning processes, e.g. by phrasing questions, developing strategy, articulating social demands of technology development, and formulating the way in which technology can contribute to solving social problems.[4]

7. **Technology assessment (TA) is not an isolated activity, but part of so-called 'strategic intelligence'** (see paragraph 2.6). In a world of uncertainty and permanent learning, the possession of strategic intelligence (SI) in science and innovation policy is an absolute requirement. Strategic intelligence supports decision-making (in uncertainty) on science and technology and facilitates learning processes in innovation systems. TA should be explicitly considered in relation to the other building blocks of strategic intelligence, which are technology forecasting/foresight and policy evaluation (and monitoring). Technology foresight or forecasting is primarily aimed at identifying promising domains of technology (consequently, focusing on the supply side), possible areas of application, and their economic and social impact. Policy evaluation and monitoring are generally directly linked to the policy process. Together, they aim at tracking the implementation and the effectiveness of policy, i.e., its capacity to learn and, if necessary, adapt a policy that is already being pursued. Traditionally, TA also focuses on the demand side of technology and innovation and provides knowledge about the way demand and supply of technology and innovation can be geared to one another in social innovation and learning processes. In that sense, the constituents of SI are complementary.

2.3 Co-evolution of practice, intervention, and theory (PIT)[5]

In the last three decades, there have been major changes in the thinking about the nature of innovation and innovation processes, innovation theory, and innovation policy and intervention strategies (see e.g. Barré et al., 1997, Kuhlmann, 2001a, Lundvall and Borras, 1998, the Economist, 2001, Bartzokas, 2001).

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[4] Smits and Leyten (1991) use the terms 'awareness technology assessment' or ATA (awareness and identifying problems), 'strategic technology assessment' or STA (phrasing questions and developing strategy), and 'constructive technology assessment' or CTA (implementation).

[5] This idea has been described extensively in Smits and Kuhlmann (2002) and, in a more condensed form, in Smits and Kuhlmann (2004). This chapter is based, to a large extent, on these two publications.

The linear innovation model has been abandoned in favour of interactive innovation models. Technological changes are increasingly described as complex processes of variation and selection in which technological change and, more broadly, innovation, are, to a large extent, socially constructed. Concepts such as path-dependence, the cumulative nature of technological change, paradigms, and regimes have been used to indicate that these changes are not achieved by random search and selection processes. They also seem to point to a need for new forms of innovation management (e.g. transition or strategic niche management). In innovation practice, the image of the heroic inventor in his laboratory or garage has faded, and has been replaced by the image of innovation as an interplay of actors jointly bringing about innovation in a process that is actively steered and managed. Network and chain management have become indispensable ingredients. There is a growing awareness that it is not sufficient to look only at the 'hard' or technological side of innovation, nut that its non-technological or 'soft' side deserves attention as well.

Innovation policy is no longer limited to correcting market imperfections and stimulating R&D by individual players. Innovation policy is being defined in increasingly broader terms. Just like innovation management has become a complex management task at the level of the individual enterprise or organisation, innovation policy is increasingly about putting together a smart national or sector-specific policy mix that is conducive to innovation. In addition to specific innovation policy, this too demands mutual gearing of different forms of non-innovation policy that could be influential in creating the framework conditions for innovation processes. Specific departments are also increasingly viewing innovation as an area for dealing with broadly felt social problems. The reflection on the arrangement and the role of the knowledge infrastructure is also subject to change.

In different places in the reflection on and practice of innovation, the role of users in innovation, or, more broadly, in the development of science and technology, has come to the fore. Manufacturers are learning to see users as a source of information, and sometimes even of innovation. Policymakers are increasingly realising that innovation policy in its ultimate form can benefit not just companies, but can also serve other social goals. This requires that users are involved in innovations and the development of science and technology in different capacities, i.e., not just as technology critics that need to be refuted, but as contributors to shaping the technological culture in which we live.

This non-exhaustive sketch illustrates that the development of innovation practice, innovation policy, and intervention and innovation theory are strongly interrelated and interwoven. Indeed, they learn from one another and inspire one another. Innovation researchers offer concepts that are used in innovation policy (a good example is the notion of innovation systems). Innovation researchers learn from the ways innovation processes are implemented in practice. Policy interventions affect innovation systems and give rise to learning about the development of innovation processes and how this development could possibly be facilitated. In other words, there is an exchange of knowledge and experience and of learning processes between these three communities (practitioners, policymakers, and researchers), and a co-evolution of practice, intervention, and theory (PIT).

A concept discussed in another context is the so-called 'triple helix' of academe, industry, and government, which develop in interaction and can be viewed as the central axis in innovation systems (see Etzkowitz and Leydesdorff, 2000). If we apply this terminology to the co-evolution of PIT, we could speak of the triple helix of innovation practice (or processes), intervention, and theory, or the triple PIT Helix. What this notion emphasises is the fact that there are very many different actors involved in innovation processes, that all kinds of learning play an important part in such innovation processes, and that this presupposes that all these actors have need for and access to knowledge. Here are three examples to illustrate this:

- Policymakers learn from interventions in practice ('learning by doing'), e.g. because they assess the effect of their interventions in innovation practice. For instance, this could consist of comparing the effects of a particular measure on the performance of users of that measure with the performance of 'non-users'. Policymakers learn from feedback from users of their measures. Naturally, policymakers also interact in many other ways with various other actors (companies, knowledge institutions, intermediary organisations, legislative bodies, etc.) in the innovation system, and this helps them to design policy interventions that are geared to the perceived bottlenecks in that innovation system.
- People in innovation practice can benefit from the insight of innovation researchers into innovation management or network steering, or because they supply frameworks that come in handy in innovation practice. This learning can take the form of formal learning, use of basic concepts, interviews, participation in workshops, or participation in other forums where knowledge is exchanged.[6]
- Policymakers can also turn to innovation researchers to learn about new innovation models and innovation concepts, about new trends in innovation management, and for ideas about steering innovation, ways of shaping instruments, but also, for instance, various ways of monitoring or assessing instruments, or ways in which users can be involved in shaping innovation policy.

In practice, the exchange is two-way rather than one-way. In fact, several concepts in current innovation theory are very much products of the interaction described above and of learning in the triple PIT helix. The innovation systems concept originated in innovation theory, but is now being used and refined by innovation policymakers as a framework for analysis and reflection. The concept of strategic intelligence, used as a collective noun embracing various disciplines such as forecasting, evaluation, and technology assessment, is a concept that is being applied and interpreted by people in innovation practice, policymakers involved in innovation, and innovation theorists (see also paragraph 2.6 below). Likewise, the various forms of TA can essentially be seen as co-produced by the three groups indicated above.

2.4 The triple PIT helix concept applied to the Netherlands

When we look at the development of innovation policy in the Netherlands, we see it reflects the changing insights of innovation practice and innovation theory. This indicates, at least, that there is no such thing as an independent, isolated development of theory, or of practice, or of policy. On the contrary, they seem to be increasingly mutually interconnected in a process of co-evolution. Smits (1994, 2000) and Smits and Kuhlmann (2002, 2004) have summarised this development in a somewhat stylised diagram on the basis of the development of Dutch innovation policy (see figure 2.1) and its shifting emphases. They distinguish four components: the supply side (S), or the knowledge providers, in which they place both the public and the private knowledge providers; the demand side (D), comprising consumers, companies, and authorities, as well as other types of organisations that can be considered users of knowledge and knowledge-based

[6] There are also forums where the three types of actors meet one another with the aim of engaging in an exchange of knowledge. An example is the so-called 'Six Countries Programme' (www.6cp.net), an international innovation network and a forum for discussing new developments in innovation theory, practice, and policy.

products; the intermediary infrastructure (II), aimed at bringing together demand and supply; and finally, the supportive infrastructure (SI), which comprises, for instance, the education system, the material and immaterial infrastructures, the availability of risk capital, strategic intelligence (see paragraph 2.6), and the quality of industrial relations.

As shown in figure 2.1, the history of the development of Dutch innovation policy has been characterised by a growth both of the number of 'compartments' and of the relations involved. Roughly four successive stages of this development can be distinguished:

- Phase A, starting at the end of the 1970s, marks the onset of an explicit innovation policy. In this early stage, the emphasis was on gathering knowledge, and the policy portfolio consisted mainly of financial instruments (subsidies, tax measures) aimed at individual actors on the knowledge supply side. The way in which knowledge was distributed and 'absorbed' was of little or no concern.
- In Phase B, the policy shifted towards a more diffusion-oriented innovation policy, which emerged around the middle of the 1980s. Typical of this phase were various knowledge transfer instruments as well as the foundation of innovation centres (now grouped in the Syntens innovation network for enterpreneurs). An institution such as TNO[7] was more explicitly called upon to perform a bridging function. Measures to promote the mobility or researchers were also characteristic of this phase.
- In the course of phase C, as a complement to the measures typical of phases A and B, policy increasingly paid more attention to giving organisational support to innovation processes, primarily to companies. Suppliers and users were also considered in connection, for instance in experiments involving cluster policy and a programme such as *Toeleveren en Uitbesteden* (Contracting and Outsourcing).[8] Gradually, the policy focus shifted to include the supporting infrastructure and the framework conditions that are essential to innovation. Examples are initiatives in the area of the electronic highway, the availability of risk capital, and technology explorations. In short, this phase was the start of a more integral approach to stimulating innovation, and innovation policy became broader and more comprehensive.
- In phase D, this integral approach has been further developed and a systemic perspective has emerged. Instead of stimulating individual actors or individual relations, the focus of innovation policy has become to optimise the innovation system as a whole, with a portfolio geared to that system. In addition, the notion is gaining ground that innovation policy does not necessarily equate with financial encouragement, but draws on other capacities of the government and individual policymakers as well. In this context, innovation policy is seen as an intermediary and link. Another trend in this phase is the increasingly explicit use of innovation systems theory as a framework of analysis. Strategic technology areas such as life sciences, ICT, and nanotechnology are increasingly 'packaged' into measured policy packages.[9] There is a renewed attention for the steering of intermediary parties (e.g. the current

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[7] TNO: *Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek* (Dutch Organisation for Applied Scientific Research).

[8] The trend towards instruments aimed at supporting companies not only with the absorption of new technologies but also with translating this knowledge into new and successful products and services was described in 1995 by Bessant and Rush in their article entitled 'Building Bridges for Innovation: the Role of Consultants in Technology Transfer'. In the article, they emphasise that innovation does not stop once a new technology has been 'absorbed' by a potential user. One consequence of this observation is that policy instruments have been developed with the purpose of what Bessant and Rush call 'bridging the managerial gap'.

[9] In fact, the IS concept has already been put into practice in the area of breakthrough technologies.

evaluation of the whole intermediary knowledge infrastructure). The influential study 'Interdepartementaal Beleidsonderzoek Technologiebeleid' from 2002 also refers to the concept of IS. It presents an integrated analysis of the set of policy instruments (targeted at companies) of a total of seven departments. Nevertheless, here too, we see that the majority of the instruments (in terms of budget) are still geared to knowledge generation by individual players.

As remarked above, this is a somewhat stylised picture of reality. In everyday practice, policy accents may be added, but an existing policy is rarely if ever radically abolished or drastically changed. As a result, many current instruments, if not most, are typical of phase A or B. In that sense, there would seem to be a phase difference between analysis and policy. Nevertheless, the rise of what we will call 'systemic instruments' in paragraph 4.3 would seem to be unmistakable.[10]

Boekholt et al. (2001) conclude, in an international comparative study of the innovation policy portfolios in nine countries, that, in practice, support to the R&D of individual enterprises is still the most important goal of innovation policy. Likewise, Van der Meulen and Rip (1998) arrive at the conclusion that the main trends in Dutch innovation policy are not essentially different from policy developments in other countries. They emphasise the rise of ever more complex intermediary structures which eventually play a role in what they refer to as the negotiation process between society and science. This negotiation process is becoming increasingly resistant to being directed from the top down.

In short: the development of Dutch innovation policy illustrates that it is a matter of an exchange of insights from theory, practice, and policy, and that, in fact, the three parties involved (policy, practice, and research) generate new insights in their mutual interaction. Their interaction and co-evolution are represented as a diagram in figure 2.2. Learning, experimentation, and evaluation are essential elements in this process.

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[10] This is shown by analyses of, amongst others, Jacobsson and Johnson (2000). Also the IRCE Report published in the beginning of 2003 ('Benchmarking National Research Policies. The Impact of RTD on Competitiveness and Employment') of the Strata-ETAN Expert Working Group, published by the DG Research of the European Commission, points to the trend towards and the need for arriving at more systemic policies. Also Kemp (2000), in his analysis of the set of policy instruments in the field of the environment and innovation, concludes that traditional instruments must be complemented with others, for instance with strategic niche management and socio-technical scenarios, both of which are examples of systemic instruments.

Figure 2.1:

Development of Dutch innovation policy (Smits, 1994)

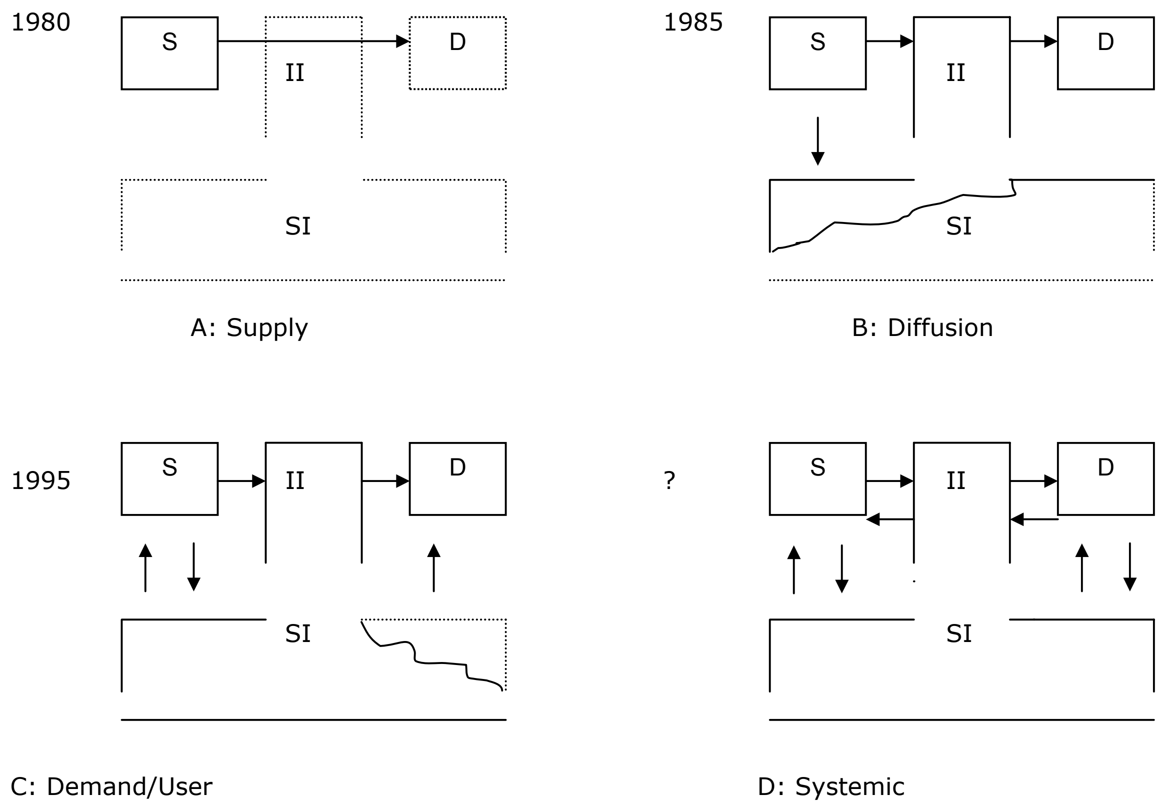

Figure 2.2: The Triple PIT helix applied to the development of Dutch innovation policy (based on Smits, 2003b)

	Phase A	**Phase B**	**Phase C**	**Phase D**
Practice	Isolated R&D	Increasing attention for interfaces	Innovation starts with market strategy of individual enterprise	Innovation in networks
Intervention /policy	R&D subsidies	Innovation centres and mobility programmes	Role of management consultants and awareness of social dimension of innovation	Cluster policy
Theory	Linear innovation model	Diffusion (Rogers, Havelock) and paths (Nelson and Winter, Dosi)	User-producer relations, social construction of technology (Pinch, Bijker), TA, and start of IS approach (Freeman & co)	Value chain (Porter) and importance of learning in innovation systems (Lundvall)

2.5 The innovation systems approach

The second concept that is central to our analytical framework is the concept of innovation systems, also known as the IS approach. This concept originated in the late 1980s and was initially applied mainly at the national level. Freeman (1987), in an analysis of the Japanese economy, was one of the first to describe national innovation systems. He defined these as 'the network of institutions in public and private sectors whose activities and interconnections initiate, import and diffuse new technologies.' The basic idea behind the system approach is that innovation is a systemic activity (see e.g. OECD, 2001; den Hertog et al., 2003; Edquist 1997; Nelson, 1993, Smits and Kuhlmann, 2004). Innovation is the result of the interplay between interdependent actors, who, in the course of their interaction, jointly arrive at new solutions. These interactions among companies and between companies and other actors refer to both market and non-market transactions and the institutional framework conditions under which these various interactions take place. The latter are of crucial importance for the development of those innovation systems. It is important to realise that these systemic interactions are dynamic and that they can concern commerce, knowledge development, the sharing of a joint knowledge base, or factor conditions. In the economic sense, the return on knowledge investments depends in part on the way the underlying system of knowledge creation, knowledge diffusion, and knowledge demand is organised and embedded in the social and economic system.

Figure 2.3 below visualises the idea of innovation systems. The first three main building blocks are the industrial system, the education and research system, the intermediary structures aimed at bringing knowledge demand and supply together and gearing them to one another, the demand system (intermediary demand and end user demand), and the infrastructure in the broad sense of the word, together with the other framework conditions that play a part in the innovation process. The latter are represented separately in figure 2.1, but they are often lumped together. Another feature of figure 2.1 in which it deviates from many other IS diagrams is its explicit mention of the political and government system that affects many systems relations. This calls attention to the fact that policy aimed at facilitating innovation has many starting points and does not restrict itself to stimulating R&D in companies or steering the knowledge infrastructure. This also implies that innovation policy must be defined much more broadly, and even that many forms of government policy, and ways in which institutions function – even in domains that seem unrelated on the face of it – have an influence on the performance of an innovation system.[11]

Over the years, the concept of IS has been applied and further developed in different ways and at different levels by various innovation scientists and innovation policymakers. In addition to national innovation systems, European, regional (e.g. Braczyk, Cooke and Heidenreich, 1996), and local innovation systems have been described. Other authors have written about technological innovation systems or about the innovation systems in and surrounding broad (and generally newly emerging) technologies.[12] In addition, there have been publications on sectoral innovation systems (e.g. Brechi and Malerba, 1997) and clusters which have been characterised as 'reduced-form' innovation systems (e.g. OECD 1999; OECD, 2001). What these innovation systems have in common is that they can be

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[11] In this context, one might use the concept of 'meta-steering', and a concept that has recently cropped up frequently is 'innovation governance', although the exact scope of this second concept is unclear as yet.

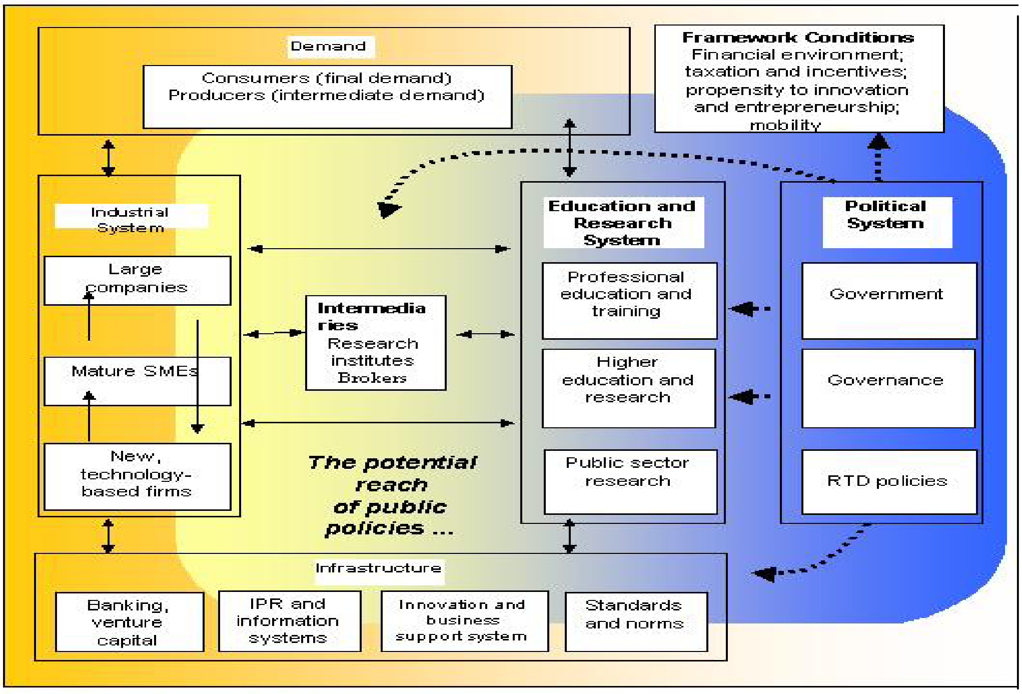
[12] Following an older tradition of analysis of so-called 'technological' systems (see, amongst others, Carlsson and Stankiewicz, 1991).

seen as environments of selection and variation in which enterprises and other actors such as knowledge institutions, intermediaries, users, and authorities operate and innovate. An essential point is that the IS approach abandons the idea of an ideal or optimal innovation system. Innovation systems are very diverse. The history of its development, the relevant types of knowledge, the stages of its development, the forms of its interaction, and the way in which various institutions are set up and function, and consequently, its attendant governance and innovation culture, are often essentially unique to a particular system. As a result, innovation systems are often incommensurable, and different countries, regions, clusters, etc., can be said to have their own specific innovation 'styles'.

The IS approach is a key concept in this study for several reasons. In the first place, because the IS approach offers a good organisational and conceptual framework for policymakers, people in innovation practice, and innovation scientists.[13] That is not to claim that the IS approach is complete or beyond criticism. However, it is a model that brings together many of the concepts that have been developed in innovation theory during the past two or three decades in a way that is workable for policymakers. That is what makes it a very central concept, at least for the time being. The second reason, very much connected with the first, is that the IS approach is a heuristics that offers an overview and insight into the relevant actors and their mutual relations. In that sense, the IS approach can be seen as an innovation management tool that can be used as an analysis tool for identifying obstacles in innovation processes and as a means of gaining insight into the required action, or the policy mix, required to resolve the bottlenecks, which are different in every innovation system. A third associated reason is that the IS framework complements the still valid market failure argument with the argument of system failure. Thereby, the systems approach opens the door for other and new, more indirect forms of innovation encouragement, such as facilitating networks, reconsidering the mission of central players in the innovation system, or investigating the extent to which laws and regulations encourage innovation or, on the contrary, inhibit it. The IS approach challenges to think about a new type of instruments in the innovation policy portfolio that is primarily aimed at improving the operation of the innovation system as a whole. As we will argue below, these 'systemic' instruments offer more room for experimentation and learning. Precisely in these areas, we believe that TA can make a major contribution. In short, the IS approach is generic, while also offering starting points for arriving at a tailor-made innovation policy.

[13] In itself, this already makes the concept of innovation systems an interesting one, as it is, itself, the result of a co-evolution of practice, intervention, and theory.

Figure 2.1: The innovation system and the reach of public policy (Source: Technopolis 2000, adapted and complemented by S. Kuhlmann, ISI (Smits and Kuhlmann, 2004)



2.6 Learning and experimentation and the role of strategic intelligence

Innovations ('*neue Kombinationen'* or 'new combinations') and processes of innovation demand, almost by definition, a willingness to learn, to experiment, to change, to make choices, to assess the possible consequences of an action as accurately as possible, and to anticipate on them, if possible. Innovation also demands a willingness on the part of the actors involved to negotiate and reflect on desirable futures and applications. It is not for nothing that discussions of the knowledge society and the knowledge economy often stress the importance of continuous learning, even to the extent that some experts refer to the 'learning economy' or the 'learning society' (e.g. Lundvall and Borras, 1998).

This learning takes place at many different levels. Individuals must learn to develop in an increasingly complex knowledge society. Companies must learn to keep abreast with the latest insights in their branch of trade or industry and stand out from the competition, if possible. Policymakers must learn to set up economic and social learning processes as efficiently and effectively as possible, and learn from earlier policy interventions, both their own and those of other policymakers (in this context, this is referred to as policy learning). In the decision-making on science and technology and the innovations based on their developments – whether they involve companies, policymakers, or users – good information on these subjects is crucial. There are various well-established research traditions that are geared towards facilitating the decision-making on science and technology and on their applications and possible impact, such as technology forecasting, technology foresight, and technology assessment. These traditions, which are growing towards one another, are increasingly collectively referred to as the 'strategic intelligence'[14] required in an innovation system to provide decision-makers with information and insights on science and technology in the broadest sense of the word. Strategic intelligence is aimed at supporting decision-makers with developing a science and technology or innovation strategy, policy, or intervention. In the words of Smits (2002, p. 12): 'Strategic intelligence provides insight into the potential of new technologies for the economy and society, its appreciation by several different parties, the consequences that result from realising these potentials. In addition, it provides more room for interaction for those involved. Strategic intelligence not only focuses on the technical side of innovation processes in innovation systems.' A summary of the main characteristics of the contents and the process – the course of the process may even be said to be more important than the actual contents in strategic intelligence – is shown in table 2.1 below.

Table 2.1 Characteristics of strategic intelligence (Smits, 2002, p. 12)

Content	Process
Tailor-made	Articulation of demand
Hard and soft sides	Mobilising creativity
Distributed character	Elucidating 'tacit knowledge'
- scale effects	Assessment of the technological potential
- facilitating learning	Facilitating processes
- mix between specific and generic	Optimal link with decision-making
- enlarging accessibility	

As indicated in paragraph 2.2, TA can map knowledge with regard to the demand side of technology and innovation and the way in which demand and supply technology and innovation can be geared to each other in social innovation and learning processes. TA thus facilitates social innovation and learning processes by articulating demand, developing strategies, formulating social requirements of technologies, and indicating the way in which technology and innovation can contribute to solving social problems.[15] This way, TA can be a major support for users involved in innovation processes who are to decide what they want and do not want, and what price they are willing to pay for it.

[14] See e.g. IPTS (2001).

[15] See footnote 4.

3 State-of-the-art innovation theory

Question 2: How has the thinking on innovation and innovation processes developed in the past few decades, in general outlines?

3.1 Introduction

In the last decades of the twentieth century, people began to take much more notice of innovation in general. Companies realised that innovation is a major distinguishing feature in the international competitive struggle. Innovation scientists showed, amongst other things, that technological change and innovation are important elements in the development of productivity (and differences in productivity between countries), and that they are factors underlying economic growth. Policymakers gradually opened up technological change and innovation as a separate policy domain. Over the years, they acquired a large set of direct and indirect policy measures for encouraging innovation.

Technology and innovation are considered less and less as a 'black box' or as 'manna from heaven'. Innovations and the underlying innovation processes are no longer seen as autonomous developments that come over us just like that (in 'ready-made' packages) and which we can only adopt, as societies, organisations, and individuals. Science, industry, social organisations, citizens, and governments in their different capacities, all contribute in their own way to shaping the current knowledge society.

Innovation and innovation policy keep on increasing their scope. For instance, there is increasing attention for the non-technological aspects of innovation besides its more obvious technological aspects, and there is a growing awareness that innovations and innovation processes differ across branches of trade or industry and across regions and countries, that organisations have different ways of dealing with innovation, and finally, that our innovations contribute to shaping the kind of society we live in. Innovation and innovation management – both at the micro level and at the level of society as a whole – is thus becoming an increasingly complex field.

It is not surprising then that the recognition of the importance of innovation has led to a strong increase in the development of theories on innovation. Different disciplines[16] have produced a wide range of more and less elaborate theories and concepts and outlooks on innovation and the role of science and technology. One of the ways in which these approaches differ is their understanding of the concept of innovation. Below, we will briefly discuss a few of these different definitions of innovation (3.2). Next, we will describe a few key concepts of modern innovation theory in a nutshell (3.3). Although we are well aware that there are very different traditions, we believe that the innovation systems approach – one of the three key concept for this study – unites a number of central notions and views which are a fair reflection of the essence of modern innovation theory. One of the points on which the IS approach is less clear is the way in which the user is conceptualised. Because too many studies still pay no more than lip service to the user, we will devote a separate discussion to several views on the role of the user in technology development and innovation, as they are known from innovation literature (3.4).

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[16] Think of various schools of thought in economics, the history of technology, sociology and philosophy (in particular when applied to technology), industrial design, management and business administration, and finally, the strongly multidisciplinary approach of the innovation sciences.

3.2 Definition of innovation

Innovation is a concept that is used by many, and is consequently given many different interpretations and definitions. The small selection of definitions collected in the box below is a good illustration of this variety.

BOX 1: A FEW DEFINITIONS OF INNOVATION

'Innovation is the carrying our of new combinations of the means of production; this can include: the introduction of a new good (1); the introduction of new methods of production (2); the opening of a new market (3); the conquest of a new source of supply of raw material or half-manufactured goods (4); and the carrying out out of a new organization of any industry.' (Schumpeter, 1911)

Innovation is 'an idea, practice, or object that is perceived as new by an individual or other unit of adoption'. (Everett Rogers 1995, originally 1983, p. 11)

'Industrial innovation includes the technical design, manufacturing, management and commercial activities involved in the marketing of a new (or improved) product or the first commercial use of a new (or improved) process or equipment.' (*Freeman, 1982)*

'Innovation is the creative process through which additional economic value is extracted from knowledge. The additional economic value is obtained through the transformation of knowledge into new products, processes and services.' (OECD, 1997, as quoted by Tony Weir in a presentation on designing an innovation survey, May 2003)[17]

'An (TPP) innovation[18] is a new or significantly improved product (good or service) introduced to the market or the introduction within your enterprise of a new or improved process. The innovation is based on the results of new technological developments, new combinations of existing technology or utilisation of other knowledge acquired by your enterprise. The innovation need only be new to your enterprise, not necessarily new to the market.' (Definition of innovation used in the most recent Community Innovation Survey, CIS III, which refers to technological innovations among enterprises during the period 1998-2000)

'A successful combination of hardware, software and orgware, viewed from a societal and/or economic point of view.' (Smits, 2002a, p. 865)

De Wilde (2000) rightly remarks that many researchers refer to the standard definition that 'innovation is the successful application of an invention in the market'. Another popular definition is that of Schumpeter, one of the first to define innovation (see the box above). As a matter of fact, in his early work, Schumpeter highlighted the role of the

[17] A definition as used in innovation surveys and also based on the Revised OECD Oslo Manual from 1997 is the following: 'Technological product and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes. A TPP innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). TPP innovations involve a series of scientific, technological, organisational, financial and commercial activities. The TPP innovating firm is one that has implemented technologically new or significantly technologically improved products or processes during the period in review'. The definitions of technological innovation used in the context of the EU are largely the same as those used by OECD.

[18] Abbreviation of 'technological innovation in product and process'.

heroic entrepreneur,[19] and in his later work, the role of R&D departments, mainly those of large companies, which 'mechanise' the innovation process, as it were.[20] The *'Durchsetzung neuer Kombinationen'* (or 'implementation of new combinations'), as Schumpeter describes innovations, sets in motion a process of 'creative destruction' in which old branches of trade or industry are replaced by new ones. Thus, this process contributes to a dynamic development of the economic structure. Another noteworthy aspect of Schumpeter's views is that, in addition to the distinction between product and process innovation, which has lost none of its relevance, he also distinguished other categories of innovation, which became relegated to the background with the lapse of time. Gradually, innovation has been reduced to technological innovation, which has remained dominant to this day.

The notion of innovation has been subdivided and supplemented in a myriad ways. Not just by the distinction, which has become customary, between incremental and radical innovation, but also, for instance, by all kinds of models of the innovation process,[21] the application of the notion of innovation to higher scale levels (technology systems, techno-economic paradigm, all sorts of innovation systems), and by the growing emphasis on the relationship between science and technological innovation. More recently, the concept of innovation has again been applied in a slightly broader sense, and discussions have again turned to non-technological innovation, services innovation, or to what is termed the 'soft side' of innovation (den Hertog et al., 1997). The idea of innovation as an isolated activity (innovation as a 'single act') is increasingly being abandoned in favour of a view of innovation that sees it as the result of interaction between various actors.

Nevertheless, the dominant concept of innovation is still the economic-technological interpretation, although there are plenty of other approaches. Innovation can be considered from a historical, socio-cultural, design, or even an ecological viewpoint. A noteworthy finding – made by de Wilde (2000) – is that, in most definitions, the user is conspicuously absent, or is at most allocated to the role of a passive consumer. The highly influential definition of Rogers is a case in point. Here, users are reduced to 'units of adoption', and in his later work (1995), Rogers mainly looks at the characteristics of innovations that influence speed of adoption.

Many of the non-economic innovation studies have pointed out that not only do we live in a 'technological culture', but that technology, and, more broadly, innovations, are to a great extent socially constructed. This means they are influenced by the expectations that users have of technology and innovation, the promises made by manufacturers, etc. (see, amongst others, Lente, 1993). Rip and Kemp (1998, p. 330 et seq.) distinguish four basic patterns in the way we conceptualise technology and/or technological innovation (see the box below). This indicates that the more economic-technological viewpoints essentially correspond to the first two approaches, and the more socio-technological approaches more clearly correspond with the approaches described in 3 and 4. Essential is that technology – or, rather, innovation, so as not to overlook non-technological innovation – does not

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[19] The so-called Schumpeter 'Mark I' definition features an entrepreneur who is motivated by the 'dream and the will to found a private kingdom', the 'will to conquer: the impulse to fight, to prove oneself superior to others', and the 'joy of creating'.

[20] The so-called Schumpeter 'Mark II' definition of innovation.

[21] From the linear push and the demand-driven pull model to the chain-linked model as introduced by Kline and Rosenberg (1986), a model that is still frequently referred to and that was one of the first to stress the importance of interaction and feedback between various actors in the innovation process.

develop autonomously, but co-evolves with social developments[22] and is really an integral part of those developments. In that sense, technology and/or innovation are endogenous, and also social constructs, and it is only logical that users play a role in their realisation and implementation. We are convinced that TA can play a part in the innovation debate when it succeeds in clarifying demand and supply and bringing them together so that technology is able to make a maximum contribution to solving social problems and meeting social needs and desires. This is possible in the longer term, through contributing to the development of a vision and a political agenda, in the medium term, through developing strategy, and in the short term, through implementation.

BOX 2: FOUR (COMPLEMENTARY) VIEWS ON TECHNOLOGY AS DISTINGUISHED BY RIP AND KEMP (1998)

1. **'Technology as tangible things and skills', or the product approach to technology.** Technology, or the technological product – or more broadly, 'a configuration that works' – is central to this view. This outlook is sometimes dubbed the 'cannonball view' of technology. It sees technology as an exogenous force that penetrates and circulates, and that needs to be facilitated in order to fulfil its function. Besides technology proper, however, it also looks at the 'software' and 'orgware' that 'surround' the product in 'concentric circles', as it were, and in which the product/technology needs to be embedded (as in the socio-technical systems approach, for instance), but it is nevertheless strongly focused on the product or technological system.

2. **'Production technology' or the 'transformer view' of technology.** This is a rather abstract view of the function of technology as a transformer of inputs into outputs. This approach is quite closely related to the neo-classical production function view, but also, at a higher level of abstraction, to the innovation systems approach (e.g., when it addresses the question of what determines the innovation potential of countries). The actual role of technology is hardly specified at all.

3 **'Technology as a key element in socio-cultural or socio-technical landscapes'.** This view sees technology as an element of the direct broader (technological and social) environment in which we live, and technological artefacts as expressions of a comprehensive culture. (For instance, it sees the car not as an isolated technological product, but as an element in a whole system of facilities and rules, and as a cultural phenomenon.) It also sees technology as a component of social change processes, and technologies as technological and social configurations.

4. **'Technology as a symbol and as an ideology'.** Technology is often associated with progress, modernity, and rationality, and for that reason, it has an important symbolic function that is a major force in processes of social change. Our thinking about technology is not neutral, but generally amalgamated with ideas concerning technology and its attendant possibilities and impossibilities.

3.3 Central concepts and insights

The preceding paragraph has already shown that many very different traditions and schools, each using their own concepts and terminology, have their own outlook on technological change and (more broadly) innovation. Some of these concepts are strictly connected to certain traditions, while others are more generic. As indicated above, the IS

[22] A significant concept that is used in this context is that of the 'seamless web', the converging of widely divergent social and technological elements and actors, which come together, for instance, in a technological systeem (Hughes, 1987).

approach is an approach that combines the thinking of many different traditions. Below, we go into a few closely interconnected concepts and insights from interdisciplinary innovation theory and put these in the perspective of an innovation systems approach as introduced in chapter 2. Taken together, they give a first impression of how innovation can be perceived from the point of view of innovation theory.[23]

1. **Innovation is an interactive search process that takes place in uncertainty.** Innovation processes have long been perceived as linear developments in which (to slightly exaggerate) 'ready-made' products and processes can be produced, and therefore managed, almost 'according to plan'. But innovation practice has shown up its inherent uncertainty. Or, to borrow from Dosi (1988, p. 222): 'innovation involves a fundamental element of uncertainty, which is not simply the lack of all relevant information about the occurrence of known events, but more fundamentally, entails (a) the existence of techno-economic problems whose solution procedures are unknown (…) and (b) the impossibility of precisely tracing consequences of actions'. In innovation theory, the linear innovation model has been largely replaced by an interactive innovation model that leaves more room for interaction between the various departments of an enterprise or an organisation, or for different actors, both within and outside the individual enterprise or organisation, involved in achieving an innovation. In OECD (1992, p. 24-26), this switch is described as follows: 'For almost three decades, thinking about science and technology was dominated by a linear research-to-marketing model. In this model, the development, production and marketing of new technologies followed a well-defined time sequence that originated in research activities, involved a product development phase, then led to production and eventual commercialisation (…) Today, however, the innovation process has finally been recognised as characterised by continuing interaction and feedback. Interactive models diverge significantly from the linear approach. They generally emphasise the central role of design, the feedback effects between the downstream and upstream phases of the earlier linear model and the numerous interactions between science, technology and the process of innovation in every phase of the process'. There are not only relations at the level of the enterprise, but there are also various interactions between the different players and the external scientific and technological knowledge base. That already makes it clear that many innovations are the result of a group or systemic process rather than the product of an individual innovator, a fact that also gets strong emphasis in the IS approach.
2. **Innovation is path-dependent, or evolutionary and/or accumulative in nature.** Innovation may well be surrounded by uncertainty, but that does not make it an undirected process. In much innovation literature, this search process is described as a succession of variation and selection phases in well-defined selection environments (Nelson and Winter, 1982), in which the desired characteristics of the innovation gradually become clear. This search process is directed by search rules or heuristics that largely remain implicit, though they indicate how certain problems should be tackled. In this context, some authors speak of 'technological paradigms' ('the definition of relevant problems to be tackled, patterns of inquiry, the tasks to be fulfilled and the type of artefacts to be developed and improved'), which provide the framework within which solutions to problems are sought. The potential and direction of technological innovation depend on the knowledge already available within a company, as well as on the directions of previous searches. Viewed from this perspective, the innovation process is seen to have an evolutionary or accumulative

[23] We emphasise that this is a first impression. A whole library has been written on theoretical and more applied innovation research. Among the key sources are Dosi et al. (1988) and OECD (1992).

character. At the level of technologies or types of solutions, this can mean that certain search directions are not considered. In particular when an innovation is already successful, i.e., when substantial resources have already been invested, when experience has been gained with it both on the side of the manufacturer and on the side of the users, when economies of scale and network effects have been achieved, and when it has already given rise to related innovations, the further development of this innovation tends to continue along the same lines. Above, we have called these processes technological paths. They are path-dependent, and eventually even run the risk of 'lock-in' and irreversibility. This makes it much more difficult to switch to another (and possibly better) solution, merely because a routine has already been established.[24] The reigning paradigm may also display 'rejection symptoms' with regard to radical innovations. Some innovation theorists therefore advocate the creation of protected learning environments (e.g. strategic niche management, see Hoogma, 2000; Hoogma and Schot, 2001), or the transformation of the entire systems of standards and values underlying a particular dominant design or system (one example is transition management, see e.g. Rotmans et al., 2000). Innovation systems at the level of technologies and the operation of actors in these systems are generally geared to accomplishing a particular type of innovation. The Dutch innovation system, for instance, is strongly focused on innovations in the agro and food industry, but is now, gradually and with difficulty, switching over from a predominantly quantity-oriented strategy to a strategy that is more geared to quality and discernment. In other words, the Dutch agro innovation system that was extremely successful for decades[25] has now become an obstacle to innovation. This is a typical example of 'lock-in', a situation that takes large investments and a sustained effort over a long period of time to undo.

3. **Innovation and technological change are endogenous processes and the result of co-evolution of technology and society.** In connection with the conceptualisations of innovation presented in the preceding paragraph, it can be stated that, at present, the dominant view among innovation theorists (probably with the exception of the hardcore neo-classical economists) is that technology and innovation should not only be conceptualised as 'ready-made' artefacts (the so-called 'cannonball view' of the impact of technology). Technology and innovation are endogenous, and therefore their development is not strictly deterministic or linear. In economic terms, they are usually the result of a complex process of interaction and development between demand and supply. In terms of more socio-cultural approaches, they are the result of a co-evolution of technology and society, or of the 'technological culture' (Bijker, 1995) in which we live. The idea that technological changes and innovations are socially embedded and develop in a parallel fashion is also apparent from such notions as 'technology as a seamless web', which was mentioned higher, or, for instance, the idea of 'socio-technical landscapes'.

4. **Innovation as an activity is no longer the prerogative of a genius inventor working in 'splendid isolation', but is a systemic activity to which a variety of actors contribute.** As was already apparent from paragraph 3.2, some people have an almost romantic image of the inventor working in solitude in his or her lab, or (American-style) in the garage and coming up with inventions that lead to innovations. However, in all fairness, the great majority of innovations are achieved by groups of people. The terms 'multi-actor activity' and 'system activity' refer to this aspect. In

[24] Examples are the great efforts it takes to switch over to alternative sources of energy, for instance in the automobile industry (the electric car to replace the regular car).

[25] Although the Netherlands is one of the smaller countries of the world, it is the third-largest exporter of agro products, after the US and France.

addition to companies, many knowledge institutions, intermediary organisations and, in some cases, also the government, via various types of policy (including science and innovation policy), play a role in these innovation processes. A special case of interaction is feedback between users and manufacturers. In a number of cases, this too gives rise to innovations or major adaptations of products, processes, or services. The innovation systems approach emphasises precisely this multi-actor character of many innovation processes.

5. **Learning and creating learning environments are crucial to innovation.** An important theme in much innovation research is the way people arrive at innovation and the part that learning processes play in this. Distinctions can be made here between many different types of learning (e.g. learning by searching, learning by doing, learning by using, and learning to learn, Rosenberg, 1976, 1982) and different types of knowledge (e.g. the basic distinction between codified and tacit knowledge). It is not for nothing that some innovation scientists have come to favour the term 'learning economy' or 'learning society' above 'knowledge economy' or 'knowledge society'. For that matter, incremental innovations involve different forms of learning and experiment than radical innovations, where the creation of protected learning environments is mainly necessary to protect the innovation from overly harsh selection processes in the market. In the innovation policy itself, there is a parallel development in the direction of policy learning and policy experiment. Learning by and with users – and in particular learning to articulate the demand – is also important for innovation.

6. **Innovation and technological change are increasingly linked directly to scientific knowledge.** A growing number of industries depend ever more directly on the progress of research (and in particular fundamental research) for innovation. A good example is the area of the life sciences. However, this applies not only to hard technology, but also to the soft aspects of innovation. For instance, research into user behaviour, design of the client interface, and organisational change processes all depend on the scientific knowledge on these matters. One of the constants in innovation research, and in particular in applied research, is the question of how the gap between knowledge suppliers and knowledge demanders can be bridged and how the economic utilisation of the available knowledge potential can be enhanced (the well-known 'European paradox' or the management of industry-science relationships, ISRs for short). For a long time, the general impression was that exchange of knowledge consisted mostly of R&D collaboration and personal mobility. In practice, though, this interface turns out to be much more complex. As scientific knowledge becomes more important for innovation processes, it becomes more important to also have knowledge of the nature and exact operation of those different mechanisms of knowledge transfer (see also Joanneum, 2001; OECD, 2002, Bongers et al., 2003). The main categories of knowledge transfer, apart from the mobility of people mentioned higher, are:

   a) Collaboration in R&D
   b) Contract research and consultancy
   c) Collaboration on education and training
   d) Intellectual property
   e) Spin-offs and entrepreneurship
   f) Sharing facilities
   g) Publications
   h) Participation in conferences and professional networks and boards
   i) Other informal contacts and networks

   A more comprehensive list is given in appendix 1.

7. **In addition to knowledge creation, knowledge diffusion and knowledge utilisation are crucial.** For a long time, innovation has been associated with progress in the knowledge-intensive branches of industry and certain areas of technology. This has led to a preoccupation of sorts with radical innovation and high-tech activity in innovation theory, practice, and policy. However, to use a cycling metaphor, it's not just a matter of where the leaders go, but also, and equally importantly, of whether the pack is following them. To switch back to innovation jargon: both incremental and imitation innovations are involved. In this context, O'Doherty and Arnold (2003, p. 31) note that 'incremental or "imitative" innovations which seek limited improvement of existing products and processes and which are sometimes seen as "diffusing" new technologies, are the numerically and economically dominant variety. While the creation and flow of new knowledge has traditionally had high status and attracted policy attention and funding, the working and reworking of the stock of knowledge is much more important for economic development. Since technological change and economic innovation drive the capitalist economy, creative imitation is the central process in capitalist economic development'. Furthermore, the innovation question is equally important in so-called 'medium-tech' and low-tech branches of industry. These branches too can be knowledge-intensive and/or knowledge-reliant, even though the tacit knowledge component is often greater here.

8. **Role of institutions and different roles and tasks for policymakers**. In the above-mentioned processes of knowledge transfer and, more in general, in the entire process of innovation and in innovation systems, the interaction of institutions (also referred to as the 'institutional set-up' or 'institutional environment') and especially the adaptability of the institutions involved play a major role. Edquist, amongst others, has extensively reflected on institutions in relation to innovations, and defines them as 'sets of common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals and groups' (1997, p. 46). With regard to innovation, Edquist (1997, p. 51-55) distinguishes three functions of institutions: (1) reducing uncertainty by providing information; (2) managing conflicts and collaboration; and (3) providing stimuli. In addition, institutions can focus resources more specifically on innovation, or, on the contrary, act as an obstacle to innovation. Innovation systems theory also reflects more systematically on the operation of individual institutions (especially the weakest links), as well as the degree to which different institutions are geared to one another. Moreover, a system-specific institutional set-up is quite likely, precisely because of differences in history and specific context. In other words, there is no such thing as one optimal innovation system, and what works in one country or region or technology system may well be a failure if it is indiscriminately copied in another institutional context. In an IS approach, a government can intervene in various capacities.[26] It can act as a co-innovator, in different roles, or at least provide the necessary framework conditions for arriving at innovation. Not only market failure, but system failure (the absence of the right institutional set-up or an institutional set-up that does not give the right stimuli to encourage the innovation process) can serve as a starting point for a more broadly defined public innovation policy (see further chapter 4).

9. **Innovation and the steering of innovation act at several system levels.** As mentioned in paragraph 2.4, the innovation systems concept has been applied and

[26] Gilsing (2001, p. 363) mentions various roles in which the government can contribute to innovation processes: as a catalyst/initiator, process manager, intermediary, network connector, financer, and chairman. The roles of legislator and regulator and that of commissioning authority could be added to this list.

developed at different scale levels over the years. What these innovation systems have in common is that they can be considered as environments of selection and variation in which enterprises and other actors such as knowledge institutions, intermediaries, users, and authorities operate and innovate. Steering of innovation can take place at as many levels, and can operate simultaneously at all these levels or at different times. Steering does not necessarily have to operate at the level of the individual actors, but can also take place at the system level (meta-steering).

10. **Innovation also demands knowledge and understanding of the soft aspects of innovation.** As we have already seen in the preceding paragraph, the initial broader Schumpeterian concept of innovation gradually became restricted to technological innovation. Especially since the 1990s, more attention has been paid to services and organisational innovation, or, generally speaking, to the soft side of innovation.[27] Awareness is growing that an exclusive focus on the technological aspects of innovation processes (in particular industrial innovation processes) is one-sided, and that attention should also be paid to the non-technological aspects of innovation. Such a broader view also includes the innovations in the services sector that are so crucial to our Western economies.[28] This is slowly trickling through to the work of statisticians, who are gradually including non-technological aspects in their statistics, including those on innovation. The translation of the soft side of innovation into innovation policy and the pursued policy mix is an important aspect that presents difficulties to many innovation policymakers.

These key concepts and insights lead to the conclusion that innovation (and its steering) cannot be understood otherwise than as a complex (multi-actor, multi-level) management task at different levels ('managing innovation in firms/organisations', 'managing innovation in networks/clusters/systems', 'managing innovation in society'). In the next chapter, we will go into the way the IS approach is increasingly being used as a starting point or a heuristic tool in innovation policy. This is gradually being complemented by a category of policy instruments, the so-called 'systemic instruments'. These systemic instruments should be seen in relation to the other instruments in the innovation policy mix, many of which have been around much longer. Before we proceed to that, we will first sketch the more theoretical views on the role of the user in technology development and innovation.

3.4 Views on the role of the user in innovation

Over the years, different perspectives have arisen on the role of users in technological change and/or innovation processes. They are not mutually exclusive. It is good to look at a few of these views at this stage, before going into innovation policy in general and the role of TA (and parliamentary TA) in particular, in chapters 4 and 5.

First, there are different views on the role of users in technology development and innovation. Users can play a role as more or less active consumers, and modifiers, as

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[27] See e.g. Delaunay et al., 1992; Miles et al., 1995; Gallouj, 2002; Hauknes, 1996 and 1998; den Hertog et al., 1997; den Hertog, 2000; den Hertog et al., 2003, and a relatively large number of edited volumes, such as Metcalfe et al., 1999; Boden et al., 2000, Andersen et al., 2000; and Gadrey and Gallouj, 2002, but also the growing attention for services innovation displayed by OECD and EU.

[28] In the Netherlands, the services sector represents 70% of the total economic activity!

domesticators, as designers, and, in fact, also as opponents of technological innovation.[29] (Oudshoorn and Pinch, 2003, p. 1).

The more economic approaches[30] must mainly be associated with concepts such as user-producer relationships, the role of lead users in innovation processes, and the idea of demanding users, as formulated, for instance, by Porter (1990). Users are potential sources of innovation. However, the position of different types of users during the diffusion of a particular application product can vary considerably.[31] All these different concepts have in common that they recognise that users can play an autonomous role in economic innovation processes, and, more than that, that users can actually be a source of innovation, and that especially the early users can play a part in the articulation of users' wishes and in learning processes (which are often interactive). More and more new products and services are the results of interactive learning processes, and more and more processes of innovation invite users to play a role. The distance between manufacturers and users – physical distance, but also cultural distance – and concerns such as trust and confidence are crucial in this context.[32] User-producer relations and the attendant interactive learning processes are generally considered as constituting the core of the IS approach.

When it comes to learning processes, a distinction is made between different forms of learning, such as learning by doing, learning by using, and learning by interacting, concepts that go back to the work of economists such as Arrow (1962), Rosenberg (1982), and von Hippel (1988). It is not just a matter of providing for feedback of users' experiences to the manufacturer in order to enable a cycle of improvements and adjustments. Actually, the process is one of co-evolution (see Nelson and Winter, 1982) in which users' demands and product characteristics are geared to each other. At the same time, we find a difference on opinion as regards how user-producer relations are to be understood. Are they primarily the relations between manufacturers and end users who arrive, through an interactive process, at the development of new products and services (or to new design criteria for products and services)? Or should they be understood to refer to the relation between manufacturers and more intermediary users, who, as it were, articulate the demand in the well-known network economy, on behalf of the anonymous end users and consumers?[33] Where medical equipment is involved, for instance, intermediary users (the medical professionals themselves) play an important and even vital role (von Hippel, 1988). Conversely, the food industry aims at the mass consumer, and organising a feasible interaction is much more difficult.

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[29] In this context, the characteristics of non-users are also considered. Precisely looking at the reasons why potential users decide to forego using a new technology – or, more broadly, an innovation – can yield an insight into the demands users make on technology and/or innovations.

[30] Which, as a matter of fact, should largely be associated with the work of evolutionary or neo-Schumpeterian economists rather than with the work of mainstream economists. See also Coombs et al. (2001).

[31] Think of the well-known distinction between innovators, early adopters, early majority, late majority, and laggards, as made by Rogers early on in the 1970s. In this view, consumers are mainly perceived as passive users who need to be 'persuaded'.

[32] Many recent economic theories pay much attention to concepts such as trust and social capital. See, for instance, 'Trust' by Fukuyama (1995).

[33] In particular Lundvall has pointed to the possible productivity-enhancing effects of user-producer relationships. He distinguishes between producer-dominated relationships and producer-organised markets in consumer goods; producers dominating professional users; big professional users dominating producers; stubborn user-producer relationships; and situations characterised by the absence of user-producer relationships (Lundvall, 1992).

In addition to these more economics-inspired perspectives, recent decades have seen the rise of various other views on the role of users in technological innovation. Recently, Oudshoorn and Pinch published an overview (2003) of the main non-economic approaches to users. They distinguish four approaches. Three of these approaches largely coincide with historical/sociological traditions, historical/sociological/feminist traditions, and semiotic traditions, respectively, while the fourth approach is associated with cultural and media studies. We give a summary below, mainly indicating how each of these approaches conceptualises the role of the user.

The historically-rooted so-called 'social construction of technology' (SCOT) approach developed since the beginning of the 1980s sees users as one of the social groups that contribute to shaping what is called the 'construction' of technology. This approach emphases that technology development is not autonomous, but to a great extent 'socially constructed'. In the early stages of a technological development, certain social groups attach a particular meaning or content to it, which comes to dominate over time. Users and developers of a technology will gradually come to share a particular technological framework (Bijker, 1995a). One of the criticisms of this approach is that it tends to limit the role of users mainly to the early stages of a technology, and that the variation in the types of users it distinguishes is limited.

The second major non-economic approach identified by Oudshoorn and Pinch is a more sociological approach. It is no longer so much about the interaction between engineers and users who jointly create a new technology (or technological artefact) as about users and the use they make of a technology, and the part played in all this by the power relations between various actors. It focuses on the user as a consumer who consciously chooses between technologies and on the fact that there is a great variety in users and the power structures to which they may or may not belong. Accordingly, this view distinguishes between end users, lay end users, and implicated actors.

The third view on users comes from semiotics and focuses especially on the meaning people attach to things. In this approach, for instance, researchers would study the way designers form themselves a mental image of the user (a process referred to as 'configuring the user'). To this category, they also reckon approaches that look at the relations between people and machines, and in particular at how relations between people and between man and machine are already implied, as it were, in the design of machine. In this context, reference is made to 'scripts' and 'scenarios'.

The fourth approach comes from cultural and media studies and focuses mainly on users and consumers and they way technology is 'appropriated', as it were, and becomes functional in a particular culture. In the words of Oudshoorn and Pinch (2003, p. 12) 'material things can act as sources and markers of social relations and shape and create social identities'. Consequently, consumption is an activity that is related to status and identity. Consumers/users themselves are largely responsible for shaping the way they deal with technology and for the meaning they attach to it. Another important concept is that of the 'domestication' of technology, a two-way process in which both technological objects and people are changed. 'New technologies have to be transformed from being "unfamiliar, exciting, and possible threatening things" to familiar objects embedded in the culture and society and the practices and routines of everyday life' (Oudshoorn and Pinch, 2003, p. 14).

Although there are considerable differences between these approaches, they are similar in the extent to which they ascribe a role to users in the development, shaping, and application of technology and innovation. They make it clear that it is impossible to speak of 'the' user, but that we must distinguish between several types of users. Finally, it has become clear that the relation between technology/innovation and the user is to be considered as a two-way relationship. It is not just about how technology or innovation influences the user, but also how users influence the realisation of technology or innovation and help to shape that technology or innovation through the actual use they make of the product or innovation (which can be quite different from its intended use). These insights can also have consequences for the role of the government and for how it deals with technological change and innovation (see box 3).

BOX 3: TECHNOLOGICAL CHANGE, INTERACTION BETWEEN DEMAND AND SUPPLY, AND POSSIBLE ROLES OF GOVERNMENT

In an analysis of changing outlooks on technological change and possible roles that can be played by the government, one of the conclusions of Rip and Kemp (1998, p. 390-391) is that: 'The multifactor processes of technical and social adaptation in which problems and conflicts are gradually overcome can be understood as processes of co-evolution of technology and society, or, when focusing on markets, as the co-evolution of technological supply and demand, which interact which each other. Suppliers learn from user experiences and benefit from economies of scale, and users develop a better understanding of the technology, how they may use it for their own benefit, and what they want from it. In the interaction process, misfits between the technology and the social environment are accommodated through processes of learning, coercion, and negotiation. Because demand is articulated in interactions with supply, policymakers should avoid too-easy recourse to demand stimulation policies. Rather they should stimulate learning and articulation of demand, especially when users do not have precise requirements for novel technologies. (…) Governments might intervene to change the processes involved in technology development: facilitating communication, broadening the scope of inquiry, supporting participants that might not otherwise be heard, providing resources for research unlikely to yield short-term results, and stimulating cooperative activities in a novelty-seeking industrial environment. For example, government can secure a future market for a new product. Or, in the case of technological controversies, government can facilitate discussions among interested parties, to generate better understanding of the issues, and guide technology developers in their decisions. Thus, the role of the government is that of an alignment actor and facilitator of change rather than that of a regulator'

4 Modern innovation policy based on the IS approach

Question 3: Given the development towards a knowledge economy and society, how has the thinking on innovation policy developed? Three sub-questions: a. What are the main developments in the knowledge economy and society? b. What are the starting points of an innovation policy based on the IS approach? c. What can we learn from the confrontation of innovation theory with innovation practice?

4.1 Introduction

In this chapter, we shift our attention from theory to the main developments in the thinking about innovation policy, again starting from the IS approach. First, we describe the major trends in the knowledge economy and society that provide the context of this innovation policy. Next, we look at the possible starting points of innovation policy and at how it can be developed. We will also discuss a few more recent developments in the thinking about innovation policy, in particular the development towards an integral or horizontal innovation policy, also called a 'multi-purpose' or 'third-generation' innovation policy. Finally, we confront innovation theory with the practice of innovation policy, and sketch the need for a new type of innovation policy instruments, the so-called 'systemic' innovation instruments.

4.2 Main trends in the knowledge economy

What are the main developments in the knowledge economy and society? (sub-question 3a)

The popular notions of the current knowledge economy and society would make one wonder whether we used to live in a society and economy that was not to a large extent based on knowledge. In this regard, Cowan and van de Paal (2000) remark that the main difference is that, since the middle of the 1990s, it has become clearer that knowledge is in fact not so much the basis of our economy as one of the main driving forces of the economic dynamic. Therefore, they prefer to call our economy 'knowledge-driven'. They distinguish three major changes in this regard (p. 2):

1. 'Knowledge is increasingly considered to be a commodity. It is packaged, bought and sold in ways and to extents never seen before.
2. Information and Communication Technologies (ICTs) lower the costs of various aspects of knowledge activities, such as knowledge gathering and diffusion.
3. The degree of connectivity among knowledge agents has increased dramatically.'

Following on from that, they distinguish four major knowledge-related innovation themes (p. 3):

1. 'Diffusion of knowledge throughout the system of innovation is a key element of innovation and technical change.
2. Innovation without research deserves attention as an important source of technical advance.
3. The complexity of the knowledge base has increased, for all firms, in all industries and in all service sectors.
4. Humans are central as holders of (vital) knowledge assets.'

Comparable studies [34] into the characteristics and challenges of the knowledge or knowledge-driven economy or society look at comparable developments, in different mixes. Recurrent themes and issues include:

- the globalisation of the economy in relation to the liberalisation of markets and/or to deregulation (including how it leads to new forms of regulation, or 're-regulation') and the related forms of increased competition;
- new forms of organisation which are facilitated – partly through the massive utilisation of ICT – and lead to far-reaching collaboration among enterprises and between enterprises and, for instance, knowledge institutions;
- the acceleration of learning processes at all levels and the need for constant learning and adapting ('learning to learn capabilities'). Where policy is involved, explicit mention is made of policy learning, the ability to draw lessons from earlier interventions through a systematic process of reflection, explorations, monitoring, benchmarking, and evaluation (strategic intelligence);
- the changing role of science in relation to trade and industry and the related changing view on the role of national knowledge infrastructures;[35]
- the facilitating roles of mainly knowledge-intensive (business) services in facilitating the above-mentioned processes of change, including the acquisition, diffusion, and absorption of knowledge;
- in addition to policy learning, attention is being called, in the ever more broadly defined innovation policy, to the mutual gearing of the different policy levels, the explicit coordination of science and technology policy, and the importance of all sorts of framework conditions that affect the innovation process (such as policy in the area of

[34] There are many studies on innovation and innovation policy that start with listing the characteristics of the knowledge economy and society. A few good summaries and overview studies (including the accompanying sets of indicators, which are very similar to one another) are OECD STI Outlook 2002 of OECD STI Scoreboard 2003, CEC 2003 European Innovation Scoreboard (CEC, 2003, Brussels), Lundvall and Borras (1998), Cowan and van der Paal (2000), Archibugi and Lundvall (2001), Louis Lengrand and Associés et al. (2002), Rodrigues (2002, IPTS/p. 10), and STRATA-ETAN Expert Working Group (2002). It lies outside the scope of this report to paint an exhaustive picture of the knowledge economy and society. Instead, a few characterisations will have to suffice to give an idea of the nature and scope of the change processes in which we find ourselves and which make up the background against which innovation policy is developed.

[35] E.g. the distinction between so-called 'mode 1' and 'mode 2' science (see Gibbons et al., 1994), the greater direct dependence of trade and industry on fundamental knowledge, and new questions related to the subject of the exchange of knowledge. This last subject is addressed particularly in analyses that show that the switch from knowledge generation to (economic) knowledge implementation is a problematical process in many EU countries.

intellectual property, the administrative burden, financing, and the accessibility of public-financed research).

In short, fundamental changes are emerging in the role of knowledge and the way knowledge is acquired, disseminated, and eventually applied, as well as in the way these processes are controlled. These developments are posing major new questions for innovation researchers, innovation practitioners, and innovation policymakers alike. In relation to the management of innovation processes, Smits (2002a) sees three central developments: (1) structural changes in the economic system (including the rise of the service economy and service innovation); (2) changes in the dominant 'strategy and management paradigm'; and (3) changes in the knowledge infrastructure, such as the distinction between the transition from 'mode 1' to 'mode 2' science (see Gibbons et al., 1994) and the rise of the second, officious and private knowledge infrastructure that plays a role in knowledge diffusion alongside the first, formal and public knowledge infrastructure (see den Hertog, 2000).

Especially the developments in the second category are important in relation to this study, as they are directly connected with what has been called the broadening of the decision-making (as regards both actors and aspects) on innovation processes. On this subject, Smits (2002, p. 869-870) notes that 'an increasing number of players wish to become involved in the way innovation processes progress, and – partly because of this – this decision-making is starting to involve an increasing number of different aspects. This trend is typical of a much wider development known in public administration circles as the emergence of "meta-management". Reliance on the old institutions continues to decrease. Not only are a constantly higher number of *neue Kombinationen* formed, but the boundaries between the institutions and organisations are also becoming less significant. One important characteristic of this process is the transition from "weakly-linked systems consisting of discrete components" to "strongly-linked systems consisting of fuzzy components".[36] (…) The management of societal change processes is taking place more and more in complex networks, in which it is impossible to pinpoint an absolutely dominant player, and in which success and failure are strongly associated with the ability of all parties concerned to form wise alliances and – partly thanks to this – to mobilise the creative potential of users (...) Numerous problems with dot com firms, failing automation projects, discussion on life sciences related products (food, drugs) demonstrate the dependence of innovation processes on the acceptance by users and – perhaps more importantly – on the ability to mobilise and use the creative potential of users to improve the innovation process. Other laws apply in this "network society" or "knowledge economy" than in the hierarchical variant. More and more often do we see the main goal being the optimisation of chains or systems of organisations, rather than a maximisation of the performance of components (e.g. companies). (...) Encouraging effective alliances, bringing players with often totally different interests into one and the same line, and acting as the intermediary are becoming increasingly more important tasks for administrators in both the public and private domain. (...) Flexibility and the ability to eliminate (institutional) barriers and to stimulate initiatives that promote interaction between organisations and the networks within which they operate thus become crucial characteristics of the players involved in the innovation processes. (...) This flexibility is sometimes difficult to detect in today's structures. (...) Seemingly, today's politics and the policy machinery are unable to muster up to the flexibility needed to form – by way of *neue Kombinationen* – institutional structures, and thus make it possible to pursue a horizontal and flexible policy. All of this is a huge problem for innovation management.'

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[36] In this connection, Gibbons (2001) introduced the concept of the 'porous society'.

In short, management of innovation processes in a knowledge-driven network economy is no sinecure. However, it is becoming clear that 'users' are acquiring an important role in these processes as part of the socialisation of the decision-making in these matters. Involving users in science and technology, and more specifically in innovation processes, can contribute to a society that is structured in a way that does not arouse resistance, in which the innovation potential of users is optimally tapped, and in which innovation contributes to solving 'major social issues' and eventually, to the well-being of society. We will go into this in chapter 5. First, in the rest of this chapter, we will sketch the characteristics and challenges of an innovation policy based on the IS approach, as well as the sort of measures that can be envisaged with such a policy.

4.3 The IS approach as a heuristic in innovation policy

What are the starting points of an innovation policy based on the IS approach? (sub-question 3b)

At present, the IS approach is becoming the de facto standard in the world of innovation policy, even though its application can be, and is, very diverse.[37] Why is this model so attractive and what are the current developments in the policy thinking on the IS approach?

The attraction of the IS approach, in our opinion, has to do with several factors. In the first place, the IS concept seems to fit in with the idea of an economy as a comprehensive system of actors between which flow and feedback is possible[38] and where interventions on one of the relations have consequences for other actors and relations in the system. The IS approach is a recognition of the fact that innovation (and its stimulation!) is no longer a 'single act', but the result of a complex interplay of sometimes very diverse actors, who arrive at innovation in interaction. Innovation is no longer the result of individual actors who innovate on their own accord and through a purely rational process, but rather, a multi-actor activity. Besides thinking in terms of market failure (which is strongly based on neo-classical economic theory), the failure of the broader innovation system is increasingly recognised as a basis for government intervention (see box 4). This too implies a more normative and integrated framework for innovation policy. Usually, the weakest links in the innovation system – which are different in each country or region or technological system – will be the most logical starting point for new policy initiatives. However, this presupposes that the policymakers have the necessary strategic intelligence for identifying these weakest links, as well as a good insight into the effectiveness and application possibilities of the instruments they employ (see also Guy and Nauwelaers, 2003, p. 21).

A second factor that may explain the attraction of the IS approach is the finding that the IS approach offers both a flexible heuristic that is sufficiently malleable to be practicable for many different policymakers and an idiom that indicates a contemporary understanding of innovation.[39] For instance, the IS approach recognises the roles played by different institutions in the innovation process, allows a broader interpretation of innovation as such (more than just technological innovation), and can be operationalised at different policy

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[37] Lundvall and Freeman are both credited with coining the term 'national innovation systems'. In the 1990s, the IS approach found more and more support in policy circles (see e.g. OECD, 1997; OECD, 2002 and 'The First Innovation Action Plan for Europe' published in 1997), not in the least with Soete and Arundel (1993 Maastricht Memorandum).

[38] This is also referred to as the 'plumber's version' of the economy.

[39] The IS approach offers an idiom that is familiar to innovation practitioners, policymakers, and theorists.

levels (supranational, national, regional/local, at the level of complex technological systems, clusters/sectors).

BOX 4: SYSTEM FAILURE FROM THE PERSPECTIVE OF THE IS APPROACH

O'Doherty and Arnold (2003, p. 32) identify five categories of obstacles that may impede the operation of innovation systems and thereby frustrate the process of economic growth, and which can give rise to policy interventions. They are:

- *Market failures*. When markets to not function optimally, there is an under-investment in R&D. This is the traditional argument for an intervention, which is widely accepted. The idea is that, due to that spill-over effects of private investments in R&D, private investors are precluded from reaping the benefits of these investments, and are therefore making less investments in R&D than would be socially desirable. In order to 'correct' this 'under-investment', instruments are often established to stimulate private R&D investments.
- *Capability failures*. Inadequacies in the ability of potential innovators to act in their own best interests where innovation is concerned.
- *Failures in institutions.* Flaws in the design or failures in the adjustment of institutions which preclude their optimal functioning in the innovation system.
- *Network failures*. Deficiencies and problems connected with the interaction and/or collaboration between the different actors in an innovation system.
- *Framework failures*. The operation of innovation systems partly depends on the framework of rules and regulations and on other framework conditions such as the characteristics of the demand brought to bear, the innovation culture, as well as all kinds of values and standards that influence the operation of an innovation system.

Finally, O'Doherty and Arnold (2003, p. 32) remark that policymakers can only respond to these different forms of system failures, or, preferably, anticipate on them, if a form of intelligence is built into the policy system. This strategic intelligence serves to identify the various barriers in the system and indicates how to proceed and to which action. That makes strategic intelligence (and therefore, parliamentary TA) into a crucial element of a strategic and anticipatory innovation policy.

The third attractive aspect of the IS approach is its integrated character and the fact that this provides for an organisational framework (analytical, but also very practical) for innovation policy in practice. It offers a framework not only for visualising the main (perceived) problems surrounding innovation, but also for designing a mix of policy instruments to solve the problems once they have been identified. In other words, the IS approach makes it possible to take an integrated portfolio approach to innovation policy measures or to a particular carefully considered policy mix.[40]

In this context, Guy and Nauwelaers (2003, p. 22-23) once presented a strongly simplified innovation system (see tables 4.1 and 4.2). They start by describing a simple science, technology and innovation system (table 4.1), distinguishing knowledge providers and

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[40] On this topic, it should be noted that there is an important phase difference between perceived problems and the instruments employed (as regards nature and, especially, scope). For instance, at present, there are many good analyses of the flaws and obstacles of innovation systems, but they are generally still not followed up with an intelligent mix of old and new innovation instruments (see e.g. den Hertog et al., 2004).

knowledge users on the one hand, and the private and public sectors on the other. The four resulting cells each have their own innovation problems.

Table 4.1: Issues, actors, and activities in a simplified sciences, technology and innovation system (Source: Guy and Nauwelaers, 2003, p. 22)

	Public sector	**Private sector**
Knowledge users	*Social and human capital* ▪ Universities ▪ Science and technology training and education	*Absorptive capacity* ▪ 'Follower' firms; inter-mediate and end consumers, and professional users ▪ Market for goods and services
Knowledge creators	*Research capacity* ▪ Universities; government laboratories ▪ Basic scientific research	*Technology and Innovation Performance* ▪ 'Creative' firms ▪ Applied RTD and product/process development

However, from an IS approach, it is important to look not only at the functioning of individual actors, but also at their interaction. Translated into policy instruments, it is a matter of – to use the terms of Guy and Nauwelaers – not only 'reinforcement policies' (aimed at reinforcing individual actors), but also about instruments bearing on the relation between the different actors, which they call 'bridging policies'. The underlying idea is that innovation policy should aim not only at generating knowledge, but to a great extent also at the smart application and dissemination of existing knowledge. Table 4.2 shows an overview, based on the strongly simplified IS diagram in table 4.1, of possible innovation policy measures. Appendix 2 contains a more extensive version of this table that incorporates individual policy measures taken from the EU trendchart.[41]

Table 4.2: Overview of STI policy measures as used in the EU (Source: Guy and Nauwelaers, 2003, p. 23)

Reinforcement policies for public sector knowledge users	**Bridging initiatives between public and private sector knowledge users**	**Reinforcement policies for private sector knowledge users**
Bridging initiatives between public sector knowledge users and knowledge creators	Bridging initiatives between public sector knowledge users and knowledge creators	Bridging initiatives between private sector knowledge users and creators
Reinforcement policies for public sector knowledge creators	Bridging initiatives between public and private sector knowledge creators	Reinforcement policies for private sector knowledge creators

The relatively strong focus on sciences, technology and industry policy could be cause for criticism. In many IS approaches, a broader variety of policy measures is coming to be considered as belonging to the domain of innovation policy. Another aspect that could be criticised is the fact that, for each innovation system, the main point is the mix, the specific

[41] See: http://trendchart.cordis.lu/.

selection of measures employed to tackle problems. This is precisely where there are obstacles between branches of trade or industry and between countries. Guy and Nauwelaers are certainly aware of this. Even on the basis of this simplified diagram, they have made a number of interesting observations. In the first place, they find that, although the IS approach assumes that every country has its specific instruments and mix of instruments, there is still – probably as a result of the increasingly widespread phenomenon of benchmarking – a certain standardisation to be seen both at the level of the instruments and at the level of the policy mix. They also find that a relatively large portion of the instruments are aimed at bridging the gap between private and public creators of knowledge. Most innovation and diffusion instruments are concentrated in the upper right corner of table 4.2, an area where innovation policy and enterprise policy (starters, entrepreneurship, etc.) meet one another. Finally, one other observation touches upon a development in IS-based policy which we consider to be crucial, to wit, the rise of what is called 'systemic' policies (alongside reinforcement and bridging policies). These are policy measures that focus on the operation of the innovation system as a whole, or, in the words of Guy and Nauwelaers: 'these instruments encourage wider sets of actors to interact witch each other in ways which allow a variety of user needs to influence knowledge production and, conversely, knowledge production capabilities to shape user expectations and strategies' (2003, p. 24). We will go more deeply into these systemic instruments in paragraph 4.4.

Next, if we look at the evolution of the policy thinking that is based on the IS approach, we see several major developments. In the first place, the rise of the systemic instruments we have just mentioned. However, as is common in the policy process, we also see a certain delay here, in the sense that the problem definition tends to be quite a long way ahead of the actual instrumentation. Even in countries that are associated with a modern innovation policy, a majority of the instruments and the greater part of the budget are utilised to stimulate knowledge creation and technological R&D, generally by individual actors. Not infrequently, one of the reasons for this bias is that such forms of intervention, for which the rationale is based on the customary argument of market failure, are approved by the ministry of finance (see box 5).

In the second place, we see that, as more aspects are involved in innovation, innovation policy becomes broader in scope. Certainly when we look at the different types of policy that create the background conditions for innovation (e.g. education policy, competition policy, public contract policy, science policy, and all kinds of legal framework conditions) and take them into consideration in the actual structure of innovation policy, one can speak of an integrated or broadened innovation policy. It should be clear that many forms of non-innovation policy can still play a major role in encouraging innovation. In the Netherlands, for instance, environmental planning policy, combined with the act on shop opening hours, has contributed to innovations in retail. Other policies that are likely to have a stimulating effect on innovation are e.g. environmental policy (by setting strict requirements) and competition policy (counteracting monopolies and breaking cartels).

Closely related to this, there is a trend towards a multi-purpose or horizontal innovation policy. This is innovation policy that does not just stick to its traditional task of contributing to the innovation and competitive strength of trade and industry, but has other aims besides. It sees innovation not just as an aspect of the economy, but as a way of addressing a variety of social problems, such as the lack of innovations and innovative methods in healthcare or education. The extent to which various fields of policy are connected with – some would probably say subordinated to – the innovation objective is largely a matter of degree. In this respect, the study 'Innovation Tomorrow' (Lengrand et al., 2002), that was recently carried out on behalf of the European Commission, even speaks of a third-generation innovation policy. In this view, an IS approach will even tend to be categories as a second-generation innovation policy. For a summary of what are considered the first, second, and third generations of innovation policy, please refer to box 6.

BOX 5: THE IS APPROACH IN PRACTICE - THE RELATION BETWEEN PERCEIVED INNOVATION PROBLEMS AND THE UTILISED INNOVATION POLICY MIX

One of the aspects covered by an extensive international research project on innovation governance that ran to the end of 2004, which explicitly builds on the OECD National Innovation Systems study (see, amongst others, OECD, 2002), is how the mix of innovation policy instruments is developing. How do the innovation policy mix, the specific structure of a national innovation system, and the perceived dominant problems in an innovation system relate to each other? A total of 12 countries show what they consider, in an NIS context, to be their main innovation problems, and what policy mix they use to try and solve them. A similar analysis has also been done for the Netherlands (see den Hertog et al., 2004). One of the findings of this study was that, although the number of 'problems' indicated was large, the actual policy agenda – and, more importantly, the actual instruments of innovation policy – were, in fact, dominated by a small number of stable problems (interaction between companies and knowledge institutions, too little private R&D, too few innovative companies, and too few innovative starters). Apparently, there is a considerably delay in the translation of a change in innovation policy philosophy, into a change in the actual policy mix.

To give an example: the interdepartmental policy study of technology policy conducted in 2002 showed that the set of instruments aimed at knowledge creation by individual actors was still by far the dominant one, dwarfing, for instance, the proportion of the instruments aimed at collaboration.[42] This is corroborated by the figures in table 4.3 below.

Table 4.3: Development of the budget for technology policy (sum of the budgets of the 7 most closely involved ministries) in the period 1994-2002, in current prices (IBO, 2002, p. 38)

	1994	1998	2002
I. Company incentives	308 (36%)	621(48%)	787 (51%)
- Fiscal	95	281	357
- Subsidies and credits	130	143	215
- Subsidies for collaboration	84	197	117
II. Collaboration	51 (6%)	164 (13%)	269 (18%)
III. Public knowledge institutions	396 (46%)	405 (31%)	411 (28%)
Iv. Diffusion	104 (12%)	103 (8%)	101 (7%)
Total	859	1292	1536

[42] In this regard, it should also be noted that a systemic policy actually costs less than the old instruments, in financial terms. Achieving collaboration, or building an SI infrastructure, costs considerably less than stimulating research that is to lead to a new chip. However, this also points to a difficult aspect of systemic policy: it is no longer about the 'simple' allocation of R&D funds, but about developing visions, mobilising parties, and other even less tangible activities.

BOX 6: FIRST-, SECOND-, AND THIRD-GENERATION INNOVATION POLICY

A study by Louis Lengrand et al. conducted on behalf of the European Commission introduced the distinction between three generations of innovation policy (2002, p. 10-11) that surfaces regularly in discussions on innovation policy. The authors defined third-generation innovation policy as follows:

'The first generation of innovation policy was based on the idea of a linear process for the development of innovations. This process begins with laboratory science and moves through successive stages till the new knowledge is built into commercial applications that diffuse in the economic system. The emphasis of policy was on fostering critical directions of scientific and technological advance, and enhancing the flow of knowledge down along the innovation chain. Second-generation policy recognises the complexity of the innovation system, with many feedback loops between the different 'stages' of the process as outlined in the first-generation model. It also gives more recognition to the generation and diffusion of what have become known as "innovation systems" (national, regional, sectoral, etc.). Policy seeks to enhance two-way communication across different points in the innovation "chain", and to improve innovation systems in ways that can better inform decisions about research, commercialisation, technology adoption and implementation, etc.

Even though second-generation innovation policies still have to be embedded in many agencies, the contours of a new generation of innovation policy are now becoming apparent. Such a new generation of policy would emphasise the benefits of co-ordination actions in policy areas, and making innovation-friendly policies – one of the core principles of this.

This "third-generation innovation policy" would place innovation at the heart of each policy area.' (p. 10-11)

'Elements of this third-generation policy are visible, but further development of the key ideas should be a strategic goal. The third-generation innovation policy will result in innovation concepts being embedded in many policy areas. This requires much more than the issuing of pronouncements about a new policy. It will be necessary to identify and involve key stakeholders in the process, and to develop interfaces that allow for pooling of knowledge, learning from experience and evidence, and further co-ordination of policy initiatives. Though the third generation innovation policy will need to be developed interactively, rather than imposed from on high, this process will require leadership and vision, with high-profile and high-level innovation "champions" sustaining it.' (p. 12)

Next, the study zooms in on two forms of policy reform, i.e., regulatory reform and institutional reform (What are the implications of all kinds of policy for innovation in market and non-market sectors? What kind of intelligence systems need to be created for this?) and on governance.

The fourth development is that – also in IS-approach-inspired policy – a matter that is becoming increasingly pressing is the question of which activities are to be organised at which scale level. For instance, creating a good research infrastructure is clearly a matter for the EU rather than the national governments, and a discussion on European research had therefore probably best be conducted at that level.[43] Policy aimed at innovation diffusion and network policy are probably best tackled at the level of the regions and local networks. In short, how scalable is innovation policy?

[43] For a discussion of the internationalisation of innovation policy, see AWT (2004).

The fifth current development is the trend towards new forms of stimulating players in the innovation system and the emphasis that is laid on formulating clear objectives on the one hand, and on accountability on the other. This trend, which is often referred to with the badly defined term 'innovation governance' or, even more broadly, 'new public management', is to be applauded in itself. Innovation, and therefore, stimulating innovation, cannot be noncommittal. Policymakers and politicians demand that the utilisation of resources for innovation and innovation policy is based on clearly formulated policy objectives and that the effectiveness of the resources utilised can be proven. This is understandable, in view of the large sums that are sometimes involved in innovation stimulation, but it also implies a danger of being left with only 'tried and tested' instruments and a 'safe' innovation policy.[44]

This could possibly endanger the sixth development of modern innovation policy, which is the trend towards an innovation policy that offers enough room for learning and experimentation in uncertainty. This is all the more the case for innovation policy in which civil servants can play different roles in encouraging innovation processes. Many of these roles do not involve giving financial support to innovation. If new approaches are to be explored, room should be made for new policy experiments, and for learning by experience. This requires a system of monitoring and evaluation, feeding back the results to policy, and a certain form of reflection on the effects of policy actions taken, if there is to be any real policy learning.

Finally, another subject currently under discussion is the question of where the user (in the broad sense of the citizen) fits into the IS approach. So far, the user or citizen has been conspicuously absent from modern innovation policy, that is to say, from IS-based innovation policy. Socialisation of the decision-making on science and technology and, more broadly, innovation, is hardly being considered. Louis Lengrand et al. (2002, p. 91) rightly remark that 'informed public opinion about broad classes of innovation must be nurtured. One element in achieving this will be the improvement of systems of communication about RTD and innovation programmes – their design, rationale, evaluation, etc. – with public, greater public involvement in decision-making as to priorities, etc. Furthermore, potential areas of social or ethical concern [need to be] identified and addressed. Trust in regulatory agencies must be earned (and seen to be earned), not assumed. Thus openness and participation are important, and multiple methods to achieve these ends will need to be institutionalised.' It is precisely here that strategic intelligence can play a part, and in particular TA (and parliamentary TA). In the final analysis, innovation policy is too important to be left to technologists. Innovation policy is primarily about the question of how to organise learning processes in society so that the possibilities offered by technological developments contribute optimally to solving social problems and bringing prosperity and well-being.

[44] In practice, it is no sinecure to prove the effects – which are, moreover, generally derived – of even the most direct stimulating measures, such as R&D stimulation, let alone to ascertain what would have happened if a particular measure had not been taken (the 'counterfactual'). See e.g. the recent evaluation of the biggest Dutch innovation-stimulating system, WBSO (Brouwer et al., 2002; Poot et al., 2003).

4.4 Confronting theory and practice: systemic functions and systemic instruments[45]

What do we learn from the confrontation of innovation theory with innovation practice? (sub-question 3c)

In this concluding paragraph, we confront innovation theory with innovation policy and practice and briefly describe the need for a new type of innovation policy instruments that are known as 'systemic' innovation instruments.

The analysis of both innovation theory and modern innovation policy shows that innovation is not an isolated activity of individual actors, but a systemic activity in which different actors arrive at innovation in interaction. In other word, innovation is a systemic activity (see also Guy and Nauwelaers, 2003, and O'Doherty and Arnold, 2003). One of the consequences of this finding is that actors involved in innovation have a need not only for instruments aimed at individual actors (e.g., at present, many of the financial and management instruments) or at the relation between organisations (e.g. many of the diffusion instruments and instruments to encourage the mobility of individuals), but also need instruments at the systems level. There are already a few examples of such instruments: the use of non-product standards (Tassey, 2000), exploration programmes (Smits, 2002b), and information campaigns of governments and industrial organisations aimed at increasing awareness in the business community or with the general public for the opportunities offered by specific technologies. However, in our opinion, more systemic instruments are required for stimulating innovation. These systemic instruments could support the following innovation systemic functions:

1. **Managing interfaces**. This function is not just aimed at stimulating the exchange of knowledge as such, but also serves to build bridges between different players and stimulating debate between them.
2. **Building and organising (innovation) systems.** This comprises the building (*neue Kombinationen*) and 'creative destruction' of systems (and subsystems), initiating debate, aligning interests, and achieving consensus. Other aspects that belong to this function are managing complex systems, preventing premature lock-in, identifying and facilitating the main driving forces, and ensuring that the main actors effectively participate.[46]
3. **Creating a platform for learning and experimenting.** This includes creating the preconditions for different forms of learning (e.g. learning by doing, learning by using, and learning by interacting, see Rosenberg, 1982; Lundvall, 1992) and creating space for experiments. These could also be policy experiments.[47]
4. **Providing an infrastructure for strategic intelligence.** This means identifying sources (technology assessment, explorations, evaluation research, benchmarking) and connecting them, enhancing accessibility for all relevant actors (the so-called 'clearing house' function), and stimulating the development of a player or a facility that

[45] This paragraph is mainly based on Smits and Kuhlmann (2004).

[46] By way of illustration, we refer to the energy systems case as described by Jacobsson and Johnson (2000).

[47] In the Netherlands, advocated, amongst others, by the *Centraal Planbureau* (2002), and now provided, for instance, in the area of innovation and services.

can meet the need for strategic information geared to the requirements of the players involved (Kuhlmann et al., 1999).

5. **Stimulating the articulation of demand and the development of strategy and vision.** This comes down stimulating and facilitating the search for possible applications and developing instruments that can support the broader debate and the development of strategy and vision. This also demands knowledge of the role of users in innovation processes and of the growing literature on the subject (Oudshoorn and Pinch, 2003; Smits, Leyten, and den Hertog, 1995).

In the preceding paragraph, we already concluded that there is a certain delay between developments in policy thinking and its translation into practical policy instruments. At present, the dominating instruments – certainly in terms of budget – are those aimed at knowledge creation by individual actors, and, to a slightly lesser extent, knowledge development and diffusion between a few actors. However, the awareness that innovation is a systemic activity is growing, and so is the need for systemic instruments. In order to illustrate the difference between systemic and non-systemic instruments, table 4.4 below compares a few major non-systemic instruments with the archetypal systemic instrument. The characteristics corresponding to the five functions distinguished are italicised.

The table already shows that the different instruments are not mutually exclusive, but complementary. In a few cases, the new systemic instruments could contribute to the effectiveness and efficiency and/or the adaptation of existing, more traditional instruments of technology policy. The effectiveness of many instruments aimed at the diffusion of innovations could be enhanced with the aid of instruments designed to bridge what Howard Rush and John Bessant have called the 'managerial gap' (1995). It is conceivable that systemic instruments would have a positive effect on more management instruments supporting the development of innovation strategies, because they can be helpful in gaining a better insight into the context in which the innovative enterprise has to operate. In fact, we see a similar development occurring with the instrument of technology assessment. TA has evolved from a purely scientific activity aimed at predicting the positive and negative consequences of new technology into an instrument that is much more aimed to policy. It has become geared to supplying actors involved in an innovation process with specific, relevant information, and thus to playing a role in improving the interface between developers, users, and regulating actors. We emphasise once again that the intention is not for systemic instruments to take over the role of other innovation instruments, but to complement these, in order to arrive at a broad portfolio of policy instruments available to policymakers.

Table 4.4: Functions of four types of policy instruments (Smits and Kuhlmann, 2004, p. 11)

	Primary goal	**Client**	**Content**	**Process**	**System**
Financial	Stimulating R&D	One to one; Private firm	R&D subsidy	-	-
Diffusion	Transfer of knowledge and/or technological competence	One to one; Private firm (Public institution)	Science subjects; Formal	Limited to specific technical project	-
Managerial Gap	Support running a business	One to one; One to few (co-makership); Private firm	Social science; Formal; Tacit	Limited to specific consultancy project; *Demand articulation; Strategy dev.*	*Organising small chains and clusters; Management of interfaces*
Systemic	*Facilitating change*	*Chains; Networks; Systems*	*Science, Social science; Formal; Tacit; Strategic intelligence*	*Management complex projects; Strategy and Vision development; Demand articulation; Stimulate learning; Stimulate experimenting*	*System organiser; System builder; Management of interfaces; Identifying, mobilising and involving users; Guarding democratic content; Developing infrastructure strategic intelligence*

Smits and Kuhlmann have analysed experiences with four systemic instruments *avant-la-lettre* in greater detail (2004).[48] Although they indicate that it is still too early to judge the real impact of these instruments – most of them have been introduced quite recently, and the implementation of system changes or adaptations usually takes a relatively long time – they have nevertheless been able to made the following observations (Smits and Kuhlmann, 2004, p. 19-20):

1. 'The four cases demonstrate that there already are developing systemic instruments fulfilling at least three or more of the systemic functions.
2. From the analysis of the four cases it appears that there are strong indications that they are the product of learning processes in which policy, theory and process heavily interact. In other words, they are the result of a co-evolution of intervention, process and theory.

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[48] The four systemic instruments were: the Dutch *Innovatienetwerk Groene Ruimte en Agrocluster* (Innovation Network Green Space and Agro Cluster),n the Dutch *Programma Duurzame Technologische Ontwikkeling* (Sustainable Technological Development Programme), the OECD's Cluster Approach, and the German *Futur* programme.

3. Up to now these instruments have not been analysed thoroughly; there are also hardly any systematic monitoring and evaluation procedures to facilitate this analysis.
4. In consequence, there is a great deal of uncertainty as to the nature and the magnitude and the structural character of the impact of these instruments.
5. Observation 4 also accounts for the many instruments used within the context of the systemic instrument, such as – for instance – techniques for the development of scenarios and visions, back-casting and technology circles.
6. What does seem to be clear, however, is that all systemic instruments analysed in this report have a positive impact on the other instruments in the portfolio. They facilitate the use of these instruments and/or improve their performance.
7. Up to now however this potential to reinforce the efficiency and effectiveness of other instruments in the portfolio has deliberately not been exploited because the focus is generally on individual instruments and not on the portfolio as a whole.
8. Apart from the problems related to monitoring, evaluating and analyzing the impact of these instruments, the most important problems with the further development of systemic instruments concern:
   . how to organise effective learning and experimenting;
   . how to ensure that these instruments achieve structural, long-lasting results;
   . the availability of actors with the right attitude and appropriate skills;
   . creative destruction of systems, institutions and relations that no longer meet the new demands.'

Further development of systemic instruments, their application, and their insertion into the existing innovation policy portfolio will require the necessary earning processes and experiments in the years to come. Naturally, there is a need for a strategic intelligence function, and it is obvious that TA has a role to fulfil in this. In the next chapter, we will go into the importance of user involvement in the development of science, technology, and innovation, and the role of TA in the management of innovation in economy and society, or in shaping future innovation policy.

5 The role of users in innovation policy

Question 4: What roles can users, strategic intelligence, and TA – PTA in particular – play in a modern innovation policy?

5.1 Introduction

In this chapter, we will go into the role of users in innovation and explicitly posit TA as an instrument for shaping management of innovation in society, and in particular, as an element of a strategic intelligence capacity that is preferably a part of the management of a Flemish innovation system. First, we give an outline of the fundamental reasons why users should be involved in innovation (5.2). Next, we sketch how, in our opinion, TA is best understood as an instrument for managing innovation in society (5.3). As indicated in paragraph 2.2, we explicitly consider TA to be an essential element in the broader concept of strategic intelligence. We believe that TA can play an important role in facilitating social innovation and learning processes in various ways, including through demand articulation, strategy development, formulating social demands of technology development, and indicating ways in which technology can contribute to solving social problems and achieving social goals.

5.2 Why involve users in the development of science, technology, and innovation?[49]

The developments of science and technology are undeniably of great influence on the society in which we live. The crops we grow, the cities and houses we inhabit, our energy supply, and our leisure activities have all been through drastic changes in the last few decades as a result of these developments. The same goes for the organisation and contents of our jobs, healthcare, and the ways we communicate with one another. In short, our everyday life is shaped by the products connected with technological changes and scientific developments.

This brings us to the question of whether technological changes and innovations come to us, users, only as 'ready-made' packages of technology, as an inevitable set of choices to which end users can only react passively, i.e., by deciding whether or not to purchase the product in question. For some goods and services, and for some end users, that will indeed be the case. However, there are many instances where society as a whole, or individual end users, or groups of users, feel the need to actively shape the way science and technology, and the innovations based on them, are prioritised, introduced, and applied. This need can arise from a desire to apply the problem-solving capacity of science and technology in a different way, or from the suspicion of negative consequences of the technology or product in question. Other wishes can involve the conditions under which the introduction or implementation of new technologies or of the goods and services based on them should take place. In short, society actively shapes the development of science and technology.

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[49] Largely based on Hertog, P. den and R. Smits (1997).

In our opinion, the selection, generation, introduction, and application of scientific and technological knowledge increasingly demands a two-way learning process. A fruitful interaction between manufacturers and users will benefit both parties. But user participation will also further complicate the development of science and technology, which is not simple to begin with. Nevertheless, at least five valuable positive effects can be identified which are sufficient to justify investing in interactive development paths and a policy development geared to such interaction.

1. *More effective articulation of social needs*

Science and technology need to be harnessed to help solve social problems. There are many social problems to which the market and private initiative do not 'automatically' provide solutions. In those cases, the government has a stimulating role to play. Areas such as healthcare, safety, education, traffic, and transport come to mind. However, science and technology can only help in addressing these issues when the social needs are clearly articulated. Interactive development paths can contribute to this.

2. *Increased competitive strength of private enterprises*

The usefulness of involving users in development paths is not limited to the domains in which the government bears the brunt of the responsibility. On the contrary, companies and institutions that maintain insufficient contact with their end users run the unnecessary risk of launching products or services on the market that fall short of the public's expectations, and therefore flop. User participation that goes further than marketing can enhance the quality of the innovation process and thereby considerably improve the competitive position of industry and services. It is not for nothing that customer focus is one of the main success factors in highly competitive markets.

3. *Improved acceptance and better social embedding of knowledge and technology*

The introduction of results of scientific and technological innovations sometimes requires far-reaching changes in the social, economic, institutional, and cultural context. The active involvement of end users in innovation processes and the realisation of interactive innovation and learning processes increases the chance that the demands made of an innovation are known in an early stage and that changes can be made if necessary. This can contribute to the better social embedding of science and technology and their results. As such, user participation can therefore boost the return on investments in science and technology.

4. *Improved learning capacity of society as a whole*

The growing complexity of society and the increasing speed at which it changes are demanding ever more flexibility and adaptability from citizens and from society as a whole. In our opinion, user involvement is one of the mechanisms for achieving this. Societies in which the exchange of views and outlooks and the articulation of needs is customary or even institutionalised to a certain extent are much more likely to be capable of dealing adequately with the possibilities offered by science and technology. Users will be better able to articulate their needs, and providers will be more open to new users and users' wishes. This 'social learning capacity' can contribute to a better utilisation of science and technology.

5. *Enhanced democracy*

In a democracy, citizens must be able to influence the decision-making on science and technology and the conditions under which the results of scientific and technological research are introduced. The representative parliamentary democracy only has a limited capacity to enable such an influence in practice. Innovative forms of consulting users or mechanisms that enable users to articulate their needs can make the decision-making on science and technology more democratic.

To sum up, it may be stated that each of the effects listed here can be sufficient in itself to urge for user involvement in decisions made about science, technology, and innovation. In all these cases, the quality of the decision-making is increased because of the fact that more aspects, arguments, and perspectives are considered. From the perspective of an enterprise, the second and third effects are probably the most relevant. From the perspective of a parliamentary TA organisation such as viWTA, user involvement will mainly serve to arrive at a better insight into social needs and demands made on science, technology, and innovation, and – if necessary – at a better articulation of these needs and demands itself (effect 1); to enhance the innovation and learning capacity of society as a whole (effect 4); and, of course, to give citizens a real voice in innovation processes and the political decision-making on these matters (effect 5). These are as many reasons for aspiring to a position in the innovation debate as a parliamentary TA organisation (ergo the discussion on the design of the Flemish innovation policy).

5.3 The role of TA in 'management of innovation' in the economy and in society

In most countries, innovation policy has evolved from a strongly supply-oriented policy aimed at knowledge creation into a policy that has gradually made more room for knowledge diffusion, for a clearer orientation of demand, and, more recently, towards a systems approach: how is the interplay of actors and precondition organised to arrive at innovation? Innovation is no longer positioned exclusively in the economic domain (competitive strength) or the scientific domain (pioneering research), but increasingly also in the social domain. Science, technology, and innovation are to contribute to solving broadly felt social problems. This trend will only grow stronger when innovation policy successfully develops towards further horizontalisation, and effectively becomes third-generation innovation policy (see paragraph 4.3). Viewed from the perspective of this development, it is no more than logical that TA will play a more prominent role in the discussion about the design of innovation policy – an observation that was already made years ago (see box 7).

BOX 7: LESSONS FROM THE TA PAST

At the second European TA congress in Milan in 1990, participants looked back at the developments of TA since the middle of the 1960s. Here are a few of the findings of Smits and Weijers (1990):

- 'During these (25) years the ultimate goal of TA – to stimulate the utilization of technology for the benefit of economy and society and to minimize its negative effects – was never under discussion.'
- 'It was agreed that public participation is a must given that it can help to identify new issues, provide valuable inputs for the TA process, broaden the scope of TA, can help resolve conflicts, it forces technocrats to pay attention to the demand side and can have a positive influence on the utilization of results.'
- 'If European TA organisations are to be successful they will at least have the ambition to want to conquer a place at the heart of where new technology policy is in the making and definitely not allow themselves to be satisfied with playing a role in the margin – as has unfortunately happened far too often in the past.'

Especially this last finding shows that there was already a discussion about the relation between TA and innovation policy in 1990. It is our firm belief that only by giving TA a role in the actual social decision-making about the deployment and use of the results of science, technology, and innovation, and seeing it as an element of a broader strategic intelligence function, TA will be able to play an active and meaningful role.

Innovation policy draws to a great extent on strategic intelligence capacity, which has emerged in practically all countries to a greater or lesser degree. As indicated in paragraph 2.6, the function of this strategic intelligence capacity could be summarised as: to support, with customised intelligence, the decision-making process on science, technology, and innovation, and to facilitate social innovation and learning processes in innovation systems. It could also be called 'the management of innovation in economy and society'. It includes:

- the timely identification of new technologies and areas of application, in order to be better able to anticipate developments in science and technology (technology forecasting/foresight);
- the explicit learning of policy aimed at stimulating science and technology and applying it both at the level of the individual instruments and integrated in the innovation systems[50] (policy evaluation, policy monitoring). An important goal is to stimulate processes of policy learning and the capacity for timely adjustment and/or refinement of the policy mix;
- the introduction of the user perspective when the co-production of innovations is concerned. Innovation is not just the outcome of a process of technological development, but, to a large extent, it is also socially constructed (see the preceding paragraph and chapter 3). TA is, then, a form of 'anticipatory intelligence' (Rip, 2002, p. 4), a policy instrument for shaping the interaction and dialogue between the actors, in particular potential and current users, thereby initiating social innovation and learning processes with regard to the deployment and use of science and technology, and thus facilitating supported innovations.

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[50]E.g. meta-evaluations of innovation systems, analyses of the interaction between companies and knowledge institutions, and analyses of the administrative obstacles to knowledge diffusion.

In practice, these three components are increasingly interwoven. The question is whether TA should be considered a separate discipline, or, rather, as a part of this broader strategic intelligence capacity. We think it is meaningful to make the distinction, because TA is essentially different from other forms of strategic intelligence in several important aspects. Traditionally, TA focuses on the demand side of technology and innovation, and contributes intelligence on the way demand and supply in science, technology, and innovation can be geared to one another in social innovation and learning processes. In other words, TA explicitly presents the perspective of the user and the perspective of social utility, as well as intelligence on the way users can be involved in the decision-making and social learning processes involved in science, technology, and innovation (see also box 8).

TA as an element of a strategic intelligence capacity can thus contribute to a modern innovation policy. Innovation policy is greatly affected whenever there is a change in the dominant strategy and management paradigm (see paragraph 4.2). In the networked society (or the porous society referred to in paragraph 4.2), TA is about creating and facilitating social learning processes in networks and systems. It is important to tap the creative force of users and/or potential users, as they will eventually play a major role in achieving innovations. It is the users who want to be taken seriously, who want innovations to meet their needs (insofar as those needs have been articulated), contribute to solving social problems, and who want to help shape the society in which they function. To a growing extent, modern innovation policy is developing in interaction with new insights from innovation theory and practice, and vice versa (the triple PIT helix discussed in paragraph 2.3).

BOX 8: THE DEVELOPMENT OF TA: FROM 'WATCHDOG' TO 'TRACKER'

TA has had a long history of development. Initially, TA was mainly positioned – to use the terminology of Smits and Leyten (1991) – as a 'watchdog'. TA was originally founded as a scientific discipline that would systematically identify and evaluate the consequences and risks of developments in science and technology in terms of their effects on social, cultural, political, economic, and environmental systems. For some time now, however, the position of TA has shifted to that of a 'tracker' – to use another term coined by Smits and Leyten (1991). In this new outlook, TA is not so much an outcome of scientific analysis as an ongoing process of analysing developments in the domains of science, technology, and innovation, their consequences, and the discussions about them. Nowadays, TA is expected, in the first place, to supply information that enables people involved in decision-making about science, technology, and innovation to determine their strategy on these matters. In this approach, TA supports decision-making, contributes to a socialisation of the decision-making on science, technology, and innovation, and contributes to a better social utilisation of science, technology, and innovation. Many of the methods and approaches that have been developed within TA, ranging from scenario studies and citizen consultations over consensus conferences to social debates, are aimed at giving a say to users who were formerly had little or no voice in the decision-making on science, technology, and innovation.

Higher, we already indicated that a modern innovation policy demands a new type of innovation policy instruments. These policy instruments could support the five innovation system functions distinguished earlier. In table 5.1, we give a few examples (non-exhaustive) of the way TA could contribute to these systemic functions. If the TA community, using the arsenal of methods and techniques already available, succeeds in thus giving the users a stronger position in a few of these functions, TA can make an effective contribution to the development of a modern innovation policy in the years to come.

Table 5.1: The possible role of TA and users in a modern innovation policy

Innovation system functions	**Possible roles of TA and users**
Managing interfaces	▪ Involve users in innovation initiatives in sectors/ fields ▪ Stimulate user-producer relations (per cluster) ▪ Create a TA section in innovation research (*'TA-begleitforschung'*) ▪ Assess intermediaries as 'brokers' between knowledge demand and knowledge supply
Building and organising (innovation) systems	▪ Give users a role in innovation networks and systems with regard to newly emerging technologies. ▪ Collect and concentrate systemic knowledge with regard to the steering of innovation systems ▪ Conduct strategic TA studies in selected sectors / domains ▪ Review the operation of existing innovation systems (e.g. clean-up and/or reorientation of the existing knowledge infrastructure)
Creating forums for learning and experimenting	▪ Involve users as co-developers in innovation experiments. ▪ Develop innovation forums connected to social issues (safety, healthcare quality, administrative innovation) ▪ Experiment with demand-driven innovation (e.g. in the steering of a part of the public knowledge infrastructure) ▪ Experiment with public/private knowledge institutions (along the lines of the *Technologische Topinstituten* in the Netherlands) ▪ Experiment with systemic innovation instruments ▪ Conduct constructive TA studies ▪ Experiment with strategic niche and transition management
Establishing an infrastructure for strategic intelligence	▪ Conduct awareness TA studies ▪ Make use of synergies between exploration communities, TA, and evaluation, and create a central strategic intelligence clearing house ▪ Invest in policy learning on the basis of strategic intelligence studies ▪ Challenge TA researchers to come up with concrete proposals for innovation policy ▪ Contribute to a (distributed) strategic intelligence infrastructure ▪ Give users and/or potential users access to the strategic intelligence function
Stimulating demand articulation and development of strategy and vision	▪ Invest in forms of public participation such as public debates, consensus conferences, constructive TA, scenario workshops, and round-table conferences[51] ▪ Stimulate the parliamentary debate on issues involving science, technology, and innovation ▪ Start a discussion on the structure of the national innovation system or parts of it (the arrangement of the knowledge

[51] There is really a far greater arsenal of instruments to involve the participation of various categories of users and potential users in the decision-making on science, technology, and innovation. See e.g. the distinction between weak and strong forms of democracy as made by Bijker (1995b) or the debating technologies as distinguished by Mayer (1997).

	infrastructure) ▪ Develop nationwide innovation strategies in social domains

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Appendix 1: Classification of knowledge transfer mechanisms[52]

A. Mobility of people • graduates • knowledge institutions (KIs) ➔ companies /organisations • Companies/organisations➔ KIs • [KIs➔KIs] • students on work placement • double appointments • temporary exchange/secondment	F. Spin-offs and entrepreneurship • spin-offs • start-ups • incubators at knowledge institutions • stimulating entrepreneurship
B. Collaboration in R&D • joint R&D projects • presentation of research • guiding students/doctoral students • financing promotion research • research grants via comp./org. • sponsoring of research • [co-patents, see E] • [co-publications, see H]	G. Parts of facilities • joint laboratories • shared use of equipment • shared accommodation (co-location, science parks) • purchase of prototypes
C. Contract research and consultancy • contract research • contract consultancy	H. Publications • scientific publications of companies • co-publications • consulting publications
D. Collaboration in education and training • contract education/training • continuing education of employees • dual learning • guest lectures • informing students • demonstrations • (contributing to) establishing curricula • providing scholarships • sponsoring education	I. Participating in conferences and professional netwoks and boards • participating in conferences • participating in trade fairs • exchanging in professional organisations • directing knowledge institutions • advisory committees/government bodies
E. Intellectual property • applying for patents • information via patents • co-patenting • issuing/obtaining licences • copyright/other forms of IP	J. Other informal contacts and networking • social networks • alumni associations • other boards

[52] Based on Bongers et al., 2003, p. 40.

Appendix 2: Summary of STI policy measures as used in the EU[53]

Reinforcement policies for public sector knowledge users • Public support to education institutions and programmes • Actions to raise awareness on S&T studies (many countries) and technical vocational courses (NL), or awareness of science in the larger public e.g. promotion at primary and secondary schools (SE) • Creation of interdisciplinary graduate schools (DK), graduate schools system (FI, SE) • Modernization of vocational schools (DE) and apprenticeship system (UK) ▪ Increased funding for polytechnics	**Bridging initiatives between public and private sector knowledge users** • Role of polytechnics, technical lyceums to support companies (AU, FR, DE), *Techno* centres (NL) • Training in ICT (many countries) • Lifelong learning initiatives (several countries) e.g. open universities for adult education (FI), retraining of labour force (NL), adult education programmes (SE) • Promoting positions for graduates (several countries) e.g. FR, IT, PT, KIM (NL), TCS (UK) • Innovation and entrepreneurship courses at high schools (most countries) e.g. Science Enterprise Challenge (UK)	**Reinforcement policies for private sector knowledge users** • Innovation-oriented business support structures (most countries) e.g. Syntens (NL), KETA (GR), Luxinnovation (LU), ALMI (SE) • Support for technological development in firms (most countries) • Support to counselling activities in firms (most countries) e.g. national workplace development programme (FI) • Support for training in firms (most countries) e.g. CRECE (ES) • SME specific financial programmes (most countries) e.g. SME innovation programme (BE), Danish growth fund (DK) • Entrepreneurship promotion programmes (many countries) e.g. entrepreneurship training (FI) • Incubators (most countries): space, finance and advice in the same place • Capital and seed investment (most countries) e.g. Sitra (FI)
Bridging initiatives between public sector knowledge users and knowledge creators • Collaborative programmes between universities and high education establishments • IT infrastructure for science, industry and public, e.g. DE	**Bridging initiatives between public sector knowledge users and knowledge creators** • Collaborative programmes between universities and high education establishments • IT infrastructure for science, industry and public, e.g. DE	**Bridging initiatives between private sector knowledge users and creators** • Demonstration activities targeting companies e.g. *TechnoKontakte (*AU) • Mentoring schemes between large and small firms e.g. PLATO (BE) • Support for co-operative R&D projects linking developers and users of new knowledge
Reinforcement policies for public sector knowledge creators • Public support to universities and public research labs (all EU) with focus on 'excellence'	**Bridging initiatives between public and private sector knowledge creators** • Mobility programmes for researchers in industry (most countries) e.g. FIRST (BE), *Torres Quevedo* (ES), CIFRE and	**Reinforcement policies for private sector knowledge creators** • Support for R&D projects in companies: grants, loans, capital investment, guarantee mechanisms

[53] *Guy and Nauwelaers, 2003, p. 23.*

poles • Reform of public research organizations (e.g. DE, IT, GR, SE, UK) and of status/career of researcher (e.g. GR, NL, UK) • New university or research centre creation (ES, GR, LU) • Targeted business-oriented R&D programmes carried out by PRIs (many countries) e.g. PAT (IE) • Support to Young Scientists (many countries) e.g. START (AU), DK, YPER (GR) • Improvement of doctorate and post-doc research (several countries) e.g. ES, FI, PENED (GR), IT, PT • Support for integration of research by various PRI e.g. inter-university attraction poles (BE) • Support for internationalization of research (most countries) • Attraction of foreign researchers: e.g. DE, ENTER (GR)	CORTECHS (FR), PT, Industrial PhD programmes (DK, SE) • Spin-off promotion programmes e.g. A+B (AU), Contest (FR), Exist (DE), Praxe (GR) • Third mission for universities (several countries) e.g. ES, SE • Legal changes in PRIs to promote spin-offs e.g. FR, ES • Liaisons Offices at universities (most countries) • Science parks and 'technopoles' (most countries) • Grants for collaborative research projects (most countries) or networks e.g. large cross-disciplinary research groups (DK), PROFIT (ES), Tekes (FI), FR, *Leitprojecte* (DE), LINK and Faraday Partnerships (UK) • Public-private competence centres e.g. Kplus (AU) and networks (DE), SE • Technology diffusion centres and networks (most countries) e.g. collective research centres (BE), GTS (DK), technological centres (ES), CRITT and RDT (FR), AKMON (GR), institutes of technological development (IE) • Support to R&D in PRIs with potential for commercial exploitation (most countries)	(most countries) e.g. CDTI (ES), ANVAR (FR), ProInno (DE), *Agencia de Innovaçao* (PT), SMART (UK) • Support for R&D programmes conducted by business consortia e.g. IT • Tax incentives for R&D in companies (AU, BE, ES, FR, IE, IT, NL, PT, UK) • Risk and seed capital funds, Business Angel networks (most countries)