Innovation Studies Utrecht (ISU)

Working Paper Series

The role of TA in Systemic Innovation Policy

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ISU Working Paper #08.01

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Abstract:
Starting from the perception of innovation as a multi actor, multi level strategic game, this paper addresses the role of strategic intelligence, more in particular of TA, in systemic innovation policies. First the history of TA in the US and Europe over the last 4 decades are described and its role in innovation policies discussed. Hereafter the role and (possible) impact of strategic intelligence and systemic innovation policies is analysed. Two recent cases of Constructive TA are used to illustrate how this role is operationalised. The paper is concluded with conclusions on how strategic intelligence may further reinforce systemic innovation policies. Special attention is paid to the role of strategic intelligence in empowering users and other non traditional actors in innovation processes.

1. Introduction

This volume conceives of innovation as a non-linear, multi-level, and multi-actor game with many interactions or feedbacks among those actors. We assume that innovation theory, practice, and intervention develop by interactions among the worlds of science, policy, and practice [see chapter Kuhlmann et al, Teubel et al]. According to this view, we can no longer see innovation as a given thing – as an invention. Instead, innovation is a systemic process involving a heterogeneous set of actors who are inspired by both the potential that science and technology offer and by the context in which they have to function. These actors are involved in a complex decision making process that leads to innovative activity.

In this chapter, we will examine an important consequence of this shared conception: the need of actors for information that enables them to engage in innovative activities in an adequate and effective way. We call this information Strategic Intelligence (SI) [see also chapter Polt], and actors involved in innovation require it to develop their visions, strategies, and plans of action. Apart from this 'instrumental' role, SI helps to reflect on the development, interaction and effectiveness of innovation theory, practice, and intervention. By this, SI provides an important input in the further development of these three concepts.

There are many types of strategic intelligence [Kuhlmann et al, 1999; Tübke et al, 2004]. In this chapter we will focus on one particular strand: technology assessment (TA). TA emerged in the US in the late 1960's and developed along multiple paths. In this chapter, we focus only

* To be published in: Smits R, & S. Kuhlmann & P. Shapira (2008) "International handbook of innovation policy", Edward Elgar, London. Concept, not for quotation. Comments are welcomed.
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on TA in the public sector specifically related to knowledge-based innovation on one hand, and social implications on the other. This view necessarily excludes aspects of TA in the private sector, foresight, and other TA-like activities in the public sector, such as environmental impact assessment. This focus is of necessity somewhat arbitrary, but it is through public sector innovation policies that, in our view, the interactions between TA as a form of strategic intelligence and innovation theory, practice, and policy are most clearly visible. We will begin the chapter with a brief overview of the development of TA, in the United States and Europe, over the last four decades, and discuss some aspects of its institutional and intellectual diversity. The next section will elaborate our concept of SI and of TA as a type of SI. We will then develop a framework that allows for a more differentiated evaluation of the role of SI in policy-making. We will conclude with two detailed case studies of more contemporary TA: real-time technology assessment and constructive technology assessment, both focusing on emerging nanotechnologies. From the earlier history and the recent examples, we will explore the (possible) role of TA in systemic innovation polices and whether a 'dominant design' for TA is in place. Finally, we draw conclusions about improving the impact of TA as a major form of SI in systemic innovation theory, practice, and policy.

2. Technology Assessment

A moving target

TA originated in the US at the end of the 1960s as a reaction to many unexpected negative effects of new technologies and the problems encountered in 'making technology work' in the way users intended. These two factors were important, although partial, rationales for the proposal in US Congress to establish an early warning system for possible effects of new technologies. TA was initially positioned – to use the terminology of Smits and Leyten [1991] – mainly as a 'watchdog'. Founded as a scientific discipline that would systematically identify and evaluate science and technology for their consequences for social, cultural, political, economic, and environmental systems, TA has since become more of a 'tracker' – in which it is not so much an outcome of scientific analysis as an ongoing process of analysing developments in science, technology, and innovation, their consequences, and the discussions about them. In table 2 these two types of TA are characterized further.

Table 2: Watchdog- and Tracker TA characterized

Watchdog[3]	**Tracker**
Technology (impact) analysis	Trans-disciplinary analysis
Project oriented	Process oriented
Actors not heavily involved	Actors involved
Problem definition often implicit	Emphasis on developing problem definition
Early warning	Support actors in innovation processes
Only research	Research and discussion
Centralized TA-capacity	Pluriform, de-centralized TA-capacity

[3] Vary Coates [1975] provides a definition that reflects the watchdog type of TA: *TA is the systematic identification and evaluation of the potential secondary consequences (whether beneficial or detrimental) of technology in terms of its impact on social, cultural, political, economic and environmental systems and processes. TA is intended to provide a neutral, factual input into the decision-making process.*

Nowadays, at least in Europe, TA is primarily expected to supply information that enables people involved in decision-making about innovation to determine appropriate strategies. TA thus aims to support decision-making; contribute to the socialisation of decision-making on science, technology, and innovation; and improve the social utilisation of science, technology, and innovation. Many of the participatory approaches developed within TA attempt to give a say to citizens who formerly had little or no voice in decision-making on science, technology, and innovation, but nevertheless bring important perspectives to the discussion. Indeed, the participation of stakeholders and users has been appearing more prominently on the agenda of the development of TA [Smits & Weijers, 1991; Decker et al, 2004; Sclove, 1990].

This development, principally over the last 15 years, has also included the formulation of constructive technology assessment (CTA) [Rip et al, 1995] and other initiatives that reinforce the process character of TA, involve users more effectively, and enhance the link with policy [Grin et al, 1997; Guston and Sarewitz, 2002]. Although much progress has been made, the integration of TA in innovation policies remains a problem. This conclusion could, however, be phrased the other way round: Until now, policy-makers have paid but little attention to the lessons learned by TA about strategic intelligence in innovation.

In hindsight this shift in TA can be conceived as an ongoing learning process driven by interactions between science, policy and practice. From practice it became clear that the impact oriented, R&D and project-based type of TA with its heavy influences of the linear model of innovation was not very effective. The watchdog TA showed many traces of the rational but rather optimistic rational planning theories from the 1960s [Simon, 1976; van Vught, 1980] demonstrating a great trust in the potential of scientific research to 'know' the future. The TA community drew the conclusion that TA should not focus so much on R&D but on the innovation process as a whole and organize its work as a complementary process carried out in close interaction with all relevant actors. This approach was supported and influenced by developments in innovation theory. The TA community learned from the emergence of the innovation systems approach with its emphasis on process with many, interlinked heterogeneous actors [Freeman, 1987; Lundvall, 1992], research in the role of users [von Hippel, 1988 & 2005; Akrich, 1995; Oudshoorn and Pinch, 2003] and evolutionary approaches like the Social Construction of Technology [Bijker, 1995], evolutionary economics [Nelson & Winter, 1982; Dosi, 1988] and Technology Dynamics [van de Belt & Rip, 1987].

The lack of impact on policy making stimulated many changes in the conception and practices of TA and was one of the major driving forces behind the shift from watchdog to tracker. The impact of these changes on policy, however, has not been clear. We suggest two reasons for this persistent lack of apparent impact: first, policy discourse continued to be dominated by linear accounts of innovation, so policy makers were not asking questions that TA could answer [Smits & Weijers, 1991]; and second, a persistent tension existed between the world of TA with its societal, sometimes technology-critical orientation, and the world of innovation policy with its heavy emphasis on economic goals. In the US, the absence of a centralised innovation policy complicates the issue even further. These factors over the years proved to be important barriers to the development of a fruitful interaction between TA and policy.

The hypothesis in this chapter is that the gap between TA and policy practice is beginning to narrow, due predominantly to recent developments in, and interactions between, research, policy and practice, in particular the growing influence of evolutionary and systemic approaches to understanding innovation. To explore this hypothesis further we first will dive deeper in the development of TA in the US and Europe over the last 40 years.

40 years TA in the US

From 1974 to 1995, it was said that TA in the US was whatever the Office of Technology Assessment happened to be doing. While OTA existed, that formulation avoided a number of complications, among them the sheer diversity of OTA's activities, the role of TA in the US innovation system, and the role of the US Congress as the monopsonistic consumer of OTA's work.

The general arc of OTA's history is well known: There was a significant but under-recognized and widely distributed TA capacity in the executive branch of the US federal government [Coates, 1975]. Congress, which had been grappling with its authority over S&T through the 1960s, began to consider its own role in TA [Stine, 1986]. Caught in a wider battle with President Nixon over the institutional bases of political power, Congress augmented its own status through a host of innovations, including OTA [Bimber, 1996; Bimber and Guston, 1997]. OTA evolved from a troubled start-up to a respected collection of brokers and analysts of technical analysis. The Republicans, who gained the majority in the House of Representatives in 1995 for the first time in two generations, targeted OTA as both partisan and redundant and cancelled appropriations for the office.

This story, however, neglects at least four crucial issues: First, OTA had external critics all along, particularly those [e.g., Bereano, 1997; Sclove, 1995] who disparaged its technocratic orientation. Even Harvey Brooks, who helped craft OTA's chartering legislation, was by the mid-1980s arguing for a TA that was both more engaged with the public and with researchers. Second, OTA strayed far from the foresight capacity that the original legislation contemplated, and conceived of its work more as policy analysis than as TA in that original sense. Third, OTA had internal critics who helped it establish a modest but perceptive reflexive capacity and who, had the office not been de-funded, might have succeeded in reorienting it. Fourth, OTA's policy impact was not easily apparent, thus helping to create the environment in which congressional Republicans found themselves able to close the office (we will expand on this below).

<u>Reconstituting TA in the US</u>

Immediately after OTA's demise, the consensus (or hope) among many of its former analysts was that the Republican ascendancy would quickly wane and OTA could be revived. These analysts, together with other friends of the office, constituted the private, non-profit Institute for Technology Assessment as a holding pen of sorts. Intertwined with this effort was XOTA, a loosely knit but formally incorporated group of former OTA employees who lobbied for OTA's re-establishment. XOTA has a board of directors and other officers but has done little more than maintain a directory of OTA alumni and a list serve, and host an annual social function.

Granger Morgan and John Peha, both of Carnegie Mellon University, began a larger effort in 2001 with a conference on S&T policy advice to Congress, funded by the Heinz and MacArthur Foundations and supported by 18 professional and academic science policy groups. Well-coordinated with congressional staff and members, the meeting was ostensibly a bi-partisan activity, allied with a bill introduced in Congress to re-establish a TA capacity. But Republican involvement was largely limited to moderate, Eastern Republicans with long tenures on the committees that dealt with science and technology issues. Morgan and Peha

[2003] published a book from the conference, and congressional advocates made a tiny incremental step – authorization for a pilot technology assessment by the GAO (then, the General Accounting Office; now the Government Accountability Office) on biometrics [GAO 2002; also see Fri, Morgan and Stiles 2002]. Most observers agree that TA for Congress will remain moribund at least until another partisan realignment, and thus some [e.g., Sarewitz 1996] have called for a more widely distributed TA capacity.

<u>Other tools</u>

The focus on OTA neglects other efforts in the US that can reasonably be considered as TA, e.g., the forecasting and environmental impact assessments mentioned above. One approach with a significant impact is road mapping, especially as developed by SEMATECH, a public-private partnership aimed at restoring US pre-eminence in the semiconductor industry. SEMATECH pioneered the use of roadmaps to identify future goals and bottlenecks for semiconductor R&D, for example, what kinds of innovations were necessary, and when, to remain on the trajectory described by Moore's Law. A key feature of the roadmaps was their dynamic nature: They evolved through time both to integrate technological advances and to include increasing detail on benchmarks and obstacles. While the value of such roadmaps has not been fully assessed, some in the industry give them credit for catalyzing the renaissance of US semiconductor technologies. Public sponsors of research in the US, particularly the Department of Energy and more recently the National Institutes of Health, have begun crafting roadmaps as well, although it is not clear whether these achieve the methodological sophistication or the level of detail of SEMATECH's.

Variations on TA also found a home in "futurism," a loosely defined practice aiming to illuminate potential technological and social trajectories to support present-day decision-making. In particular, a number of small consulting groups, started in the 1980s, support the strategic decision processes of private and public sector institutional clients dealing with rapid technological change. By seeking to inform decision-making based on scenarios of the future, these groups occupied the intellectual ground abandoned by OTA shortly after its inception. These groups also tended toward technological optimism, although such groups as the Club of Rome and the WorldWatch Institute could be construed as engaged in future-oriented TA with a more pessimistic view.

Persistent tensions surrounding knowledge-based innovation have led, more recently, to government support of research on the "ethical, legal, and social implications" (ELSI) of major S&T initiatives. The first major ELSI program in the US was an add-on to the Human Genome Project. Its goal was to conduct ethics research on genomics, rather than to influence or support decision-making or policy. More recently, the US Congress passed legislation mandating a societal implications program for nanotechnology [Fisher and Mahajan 2006], specifying that the program should help improve the societal value of nanotechnology research by involving both the nanotechnology researchers and the public. The legislation neglected to specify particular mechanisms for such involvement [Bennett and Sarewitz, in press].

Research on the social dynamics of knowledge-based innovation suggest that the decentralized approaches encouraged by such legislation might be more feasible and desirable than a single, national-level effort. Given the magnitude, diversity, and scope of the US innovation system, approaches rooted in the organization of R&D institutions themselves make sense. Melding cutting-edge innovation with ELSI research to enable more reflexive institutions farther upstream in the innovation process could be a more effective way to encourage the anticipatory governance of emerging technologies. One such approach has been described as “real-time technology assessment” [Guston and Sarewitz, 2002]. A new effort to test this integrated approach, described in more detail below, has recently begun at the Center for Nanotechnology in Society at Arizona State University.

To wind up, OTA started as a rather lame watchdog and over the years turned into an efficient policy analysis institute with some qualities of a tracker. Lack of visible impact and a well developed innovation policy, not to mention raw politics, in the end caused its demise. Attempts to resuscitate the agency have not been very successful. At the same time outside OTA the development of formal and informal TA went on, resulting in a number of promising approaches integrating different perspectives on new technologies and better linked to major actors involved in innovation processes.

40 years TA in Europe

As in the US, we can characterize the first wave of TA in Europe in the 1970s as the rise of the watchdog. Fear of the negative effects of technology acted as a major driving force. Other important aspects in the early days were links with environmental movements, a societal anti-technology attitude, and student revolts. In retrospect, we can conclude that in this period, the institutionalisation of TA in Europe failed because of the lack of interest of politicians and a too-naïve concept of TA [Smits & Leyten, 1991, Smits, Leyten & Den Hertog, 1995].

Unlike in the US, a second wave of TA in Europe broke in the 1980s, characterised by the emergence of the tracker. TA was viewed in a broader and more sophisticated way, not simply avoiding negative effects but pursuing a better integration of science and technology in society. The anti-technology attitude faded, and TA received the opportunity to play a role in innovation as seen from an economic as well as a broader societal perspective (health, environment, well being). The interest in TA grew in policy circles at national and supra national level as was demonstrated by two European TA congresses organized by the EC; in 1987 in Amsterdam, [De Hoo et al, 1987], and and 1991 in Milan, [Smits & Weijers, 1991]. In the same period, due to the heavy economic recession, innovation policy came on the political agenda. TA developed into a more policy-oriented instrument, geared to support actors involved in innovation processes. By this, the gap between the societal and economic approach of innovations slowly narrowed. An illustration of the impact of this narrowing gap is the TA on the impact of what in those days was called micro-electronics (ICT). In the Rathenau report [Adviesgroep micro-electronika, 1980] not only the economic impact of ICT, but also the societal impact was addressed. The same accounted for a TA on genetic engineering [Brede DNA Cie, 1983]. This development is reflected in the rise of a new concept of TA as “…consisting of analysis of technological developments and their consequences and discussions about them. The aim of TA is to provide information that will help the parties involved to determine their strategy and enables them to define new objects for TA-research” [Smits & Leyten, 1991]. In this period, also a number of TA organisations were established of which most of them were linked to national parliaments [Vig & Paschen, 2000]. However it should be noted that this ‘second wave’ by far went smoothly. Long and difficult political debates as for instance in Germany often preceded the establishment of the various TA organizations. Moreover their mandates and resources often were very limited. Apart from political struggles one of the major reasons for this troublesome birth was related to the fact that in those days innovation policy in most European countries still carried many elements of the linear model as was demonstrated by its strongly supply side (R&D) orientation (see also section 3). As a result, the impact of TA on policy still was rather meagre.

Continuing its distinction from the US, European TA experienced in the early 1990s a third wave that focused on the further development of the toolkit of the tracker dog and attempts to strengthen links with policy. Keywords here are participation, demand articulation, TA as a process. TA more and more was viewed as a source of Strategic Intelligence, supporting actors involved in innovation processes to better handle the interface between supply of and demand for technology. Despite these intentions, TA in Europe still was in a rather isolated and sub-critical position. The already mentioned 2nd European TA Congress, organized by the European Commission, in Milan in 1990 took stock of the state-of-the-art of TA in Europe. Although a number of TA institutions were in place, the world of TA remained fragmented and the institutions themselves were sub-critical and often fell short of required quality standards and expectations for impact on policy. These shortcomings, in combination with the ever-growing importance of innovation, induced a debate on how to improve the link between TA and innovation policy, including discussions on quality and methodology. From such discussions emerged experimentation with TA approaches like 'interactive TA,' 'participatory TA,' and 'constructive TA' to improve the quality, impact, and interactivity of TA. As a sign of further institutionalisation, the European parliamentary TA (EPTA) organization consolidated and expanded its reach; EPTA nowadays involves 16 members and associates.

We have mainly focused on the development of TA, but over this period, innovation policies in most OECD countries were evolving, too. Whereas, in the early 1980s innovation policies were still very much supply driven – in line with the linear model of innovation – diffusion policies, the demand side (users), and even systemic elements of innovation began to receive more attention. The almost exclusive focus on new inventions faded away, and it became clear that meeting broader societal goals as part of an innovation policy made sense from an economic perspective too. As a consequence, more actors and perspectives were included in innovation policies. This development confronted policy makers – who meanwhile had adopted the systems of innovation approach as the basis of their policies but struggled with the implementation – with the problem how to involve non-traditional actors, as for instance users, in an effective and efficient way in their policies. In the US, such policies included the Bayh-Dole and Stevenson-Wydler Acts, as well as manufacturing extension, policies for pre-competitive technologies such as the Advanced Technology Program, the rise of state and regional S&T policies, and the coordination of national initiatives in climate change, information technology, genomics, and nanotechnology. In Europe the integration of TA in the European Commissions Framework Program (the R&D program of the EC), the EC-Targeted Socio-Economic Research program concentrating on TA-like research and striving after improving the link with policy, the recent establishment of the EC Technology Platforms and the establishment of the Institute for Prospective Technological Studies, an EC Joint Research Centre, intended to provide Strategic Intelligence on innovation to the EC, are important examples. On national level, in the Netherlands, linking TA to 'big' science programs in the area of nanotechnology, climate change, carbon storage and genomics, as well as big scale research and practices programs that should improve the links between science and application in areas as agriculture (see chapter: Teubal et al), water management and mobility are more recent examples of this trend. The core characteristic of all these activities is attention to the needs, wishes and constraints of users and other societal actors (including policy-makers) in an early stage of the development of a new technology. Also the UK Foresight Program and the German Futur Program (see chapter: Teubal et al) are manifestations of this new type of TA. In the UK Foresight program panels of scientists, policy makers and industrialists in a process combining research and debate designed scenarios for the future development of some 10 sectors of the British society ranging from transport to chemistry, maybe seen as a manifestation. The German Futur Program strived after starting a broad societal debate on the future of science and technology.

This combination of policy change and development of TA in the 1990s opened up opportunities for TA to better link with, and have influence on, innovation policies. But here too stubborn problems in the relation between TA and policy circles, as well as the still marginal position of TA till now prevented a substantial impact of TA on policy (and other actors).

User involvement
In innovation systems many heterogeneous actors play a role. From recent research it has become clear that users are of special importance here, as confirmed by the U.S. and European TA experience. In the following we will focus on the role of TA and users in innovation processes to further illustrate the development and potential of TA and the resulting consequences for policy. Before we explore two more recent examples of TA developments that elaborate user involvement, we first dig a little deeper into the reasons why it is important to involve users.

As is clear from the above discussions, the selection, generation, introduction, and application of scientific and technological knowledge increasingly demands a two-way learning process. A fruitful interaction between producers and users benefits both parties [von Hippel, 1988; Smits, 2002; Akrich, 1995]. Smits and Den Hertog [2007] articulate five reasons to justify such interaction: 1) Interaction provides for more effective articulation of social needs in the face of market failures and other limits of private initiatives. 2) Interaction can increase the competitive strength of enterprises by helping to equilibrate the innovative process and its products with public expectations. 3) Interaction can improve acceptance and social embedding of knowledge and technologies by tailoring innovations at an earlier stage. 4) Interaction can improve the learning capacity of society as a whole, but increasing the ability of users to articulate their needs and of producers to become more open and responsive to them. And 5), interaction can enhance democracy by allowing for citizens to influence the course of science and technology.

Each of these reasons could be sufficient in itself to justify greater user involvement in innovation processes. All of them tend to increase the democratic and rational quality of decision-making because more perspectives are considered. These rationales also appeal to actors across multiple sectors, as private firms will find the second and third reasons critical to the bottom line, and governments will find a better articulation of needs and demands (the first), an enhanced learning capacity of society as a whole (the fourth), and greater citizen participation in innovation processes (the fifth) important for succeeding in achieving policy goals and in maintaining legitimacy.

In these interactions, expanded TA activities thus converge with, or take on the characteristics of, the broader category of Strategic Intelligence with which we started. In the following section, we return to SI and elaborate its role in systemic innovation policies.

3. Strategic Intelligence and Systemic Innovation Policies

In this section we discuss the nature of SI and the role it could play in systemic innovation policy. We start with recent insights from innovation studies and policy concepts based on these insights. We then turn to explaining the different dimensions and types of SI and conclude the section by further explicating TA as a specific strand of SI.

Trends in innovation policy

To put this discussion in a better perspective we first will go a little bit further in major developments in innovation policy in OECD countries.[4] In decades following World War II, most OECD countries had nothing in place that resembled an explicit innovation policy. Propelled by the economic recession, innovation policy started to develop in the late 1970s. It became clear that OECD economies no longer could compete on prices and wages, but had to shift to added value embodied in new or advanced products and services. First attempts to develop an innovation policy, inspired by the linear model, were strongly supply-oriented and dominated by financial instruments stimulating R&D. This policy was not very successful because firms did not incorporate R&D results. Roobeek [1990], pointed out that almost all OECD countries were facing the same type of problems.

The solution to this problem was sought in strengthening the intermediary infrastructure in order to better be able to ensure that new technologies also reached the firms. This resulted in the development of policy instruments stimulating mobility of researchers from academia to private enterprise and in many technology transfer programs. Without doubt, these activities improved the utilization of new technologies, but in the early 1990s it became clear that policy could not be restricted to measures that only encouraged the production and diffusion of knowledge. A considerable mismatch between the needs of private firms and the knowledge produced was apparent all too often. A better interaction between the producers and the suppliers of knowledge was essential to be able to cope with this problem. This awareness was the start of the next phase in innovation policy: the user-oriented approach. In this phase it was not only the interface between the users and the producers that was improved, but also the supportive infrastructure was expanded by introducing new or improved forms of strategic intelligence, more advanced risk capital schemes, a high-level electronic infrastructure, changes in educational systems, and other conditions that facilitated innovation in networks and systems. Furthermore we see in this phase the addition of policy instruments to support companies at an organizational level in innovation processes (management advice and support) and instruments that enhance the interface between users and producers in both directions. The trend towards such instruments helped companies not only to absorb new technologies, but also to turn them into new and successful products and services. Bessant and Rush [1995] argued that innovation does not stop when a new technology is adopted by the potential user and that it is necessary to develop approaches that help to bridge the managerial gap. However, in the 1990s, firms were still very inwardly focused, or at best focused on bilateral relations, while financial instruments still heavily dominated the policy portfolio [Boekholt et al, 2001].

The developments as sketched in the foregoing imply that more and more actors were getting involved in the development and implementation of innovation policies. Through this evolution, the need for system-level thinking and intervention increased; we term this the systemic phase of innovation policy. Policy makers were discovering the concept of innovation systems (IS), which in turn was leading to a variety of richer visualizations, such as the rise of the so-called ‘cluster approach’ adopted by many OECD countries [OECD, 2002]. This great interest in the IS approach however does not imply that policy makers have been able to put the IS to work in their daily practice. In the context of this chapter, the most relevant problems attendant on a systems approach include the involvement of more relevant

[4] For more in depth analysis of the development of innovation policies see: Kuhlmann, 2003; Edler et al, 2003, and Arnold et al, 2003.

actors, broadening the scope of innovation policies, the empowerment of actors, organizing learning and experimenting, the set up of an integrated infrastructure for SI and the orchestration of instruments in order to realize goals defined on a systemic level and prevent unwanted interaction. In the following we will focus on one of these problems: the development of a SI infrastructure.

Strategic Intelligence: theory and policy

Strategic intelligence deals with the questions *who* needs *what* kind of information in order to let actors maximise their innovation efforts and how can this information be produced? The answers to these questions depend on which innovation model one adheres to. In a linear model, the technology is more or less given and only needs 'unveiling'. No strong distinction is made between invention and innovation, the problem definition is rather clear and simple from the beginning, the major audiences are policy makers and firms, and the most important goal is to inform actors on emerging technologies and their possible impacts. The production of SI thus proceeds along the lines of 'normal' science, the broad array of societal actors are hardly involved in this process, and the interface with them is limited to providing (some) input in the problem definition and to providing reports. Watchdog TA is in line with this perception of innovation processes.

In a systemic model of innovation policy, the nature and role of SI are far more complex. We may understand this complexity by looking at recent insights from innovation studies and characteristics of innovation policies based on these concepts, as summarized by Smits & Den Hertog [2007]: 1) Innovation is an interactive search process that takes place under uncertainty. 2) Innovation and technological change are endogenous processes and the result of co-evolution of technology and society. 3) Learning and creating learning environments are crucial to innovation. 4) Innovation and technological change are increasingly linked directly to scientific knowledge and involve a variety of transfer mechanisms. 5) In addition to knowledge creation, knowledge diffusion and knowledge utilization are crucial. 6) Innovation also demands knowledge and understanding of organizational innovation, services, and other "soft" aspects of innovation.From this overview, and particularly from points 1, 3 and 6, it is clear that many aspects related to innovation processes ask for SI. SI may help actors involved to develop their visions and strategies and to turn these into concrete plans of action. Innovation policy concepts and instruments basing themselves on these theoretical insights also reflect this need. In the chapter of Teubal, Smits & Kuhlmann a number of so called systemic instruments are proposed of which at least two explicitly refer to the need for learning and an adequate infrastructure for SI. This point may further be emphasised by referring to the plea for new types of governance in innovation polices, as stated in the so called 'Karlsruhe Principles', formulated by Edler et al [2003].

Dimensions of strategic intelligence

The foregoing not only points at the importance of SI for systemic innovation policies, but it also has consequences for the content and the nature of SI. With regard to content, it will be clear that the systemic approach emphasises that although technology (the invention) may be given, the way in which technologies end up in our societies (the innovation) certainly is not. Moreover, it is often not clear which questions actors have to ask when confronted with a new technology. As a consequence, problem definition takes real effort, including identifying the broad and heterogeneous set of actors that should be involved and providing insight into their positions, goals and interests. But a useful problem definition is only the first step in articulating the demands of the involved actors and in the remaining, complex and highly interactive learning process. Hence, SI has to be conceived as a process that transcends the scientific arena to involve non-technical actors and non-technical information. In order to manage such a process, much attention has to be paid to (facilitation of) the various interfaces between actors with different backgrounds and expertises. SI also includes more than only providing knowledge, but also intervenes in, and partly shapes this decision-making process. This makes the question of how SI is institutionalised in the innovation system very important. Questions like: who will get involved, which questions will be addressed, and how will the results of SI impact upon decision-making, are influenced by the institutional position of SI.

We can thus characterize SI along the dimensions of process and content [Smits, 2001] (Table 2):

Table 2: dimensions of SI.

Content	Process
♦ Tailor-made ♦ Hard- and softside ♦ Distributed character: ⇨ scale effects ⇨ facilitating learning ⇨ mix between specific and generic ⇨ enlarging accessibility ⇨ insights from interaction	♦ Articulation of demand ♦ Mobilising creativity ♦ Elucidating 'tacit knowledge' ♦ Assessment of the technological potential ♦ Facilitating activities ♦ Optimal link with decision-making ♦ User involvement

TA as a Type of SI

We have mentioned that over the years multiple types of SI, each with their own goals and methodologies, have developed. Following Tübke et al. [2001], we can distinguish between five types of SI: Technology Forecasting, Technology Foresight, Technology Assessment, Evaluation, and Road Mapping. Each type is distinguished by its major task or goal, its field of application, and the kind of political or policy issues it addresses. Each type also has its own unique focus on different aspects of the process and content dimensions. Seen from the needs of innovation policy, one often has to combine these different types of SI.

TA distinguishes itself from other forms of SI by its task focus on support for decision makers in national parliaments, and actors directly involved in innovation processes, as opposed to forecasting and road mapping, which concern concrete technological developments. It also distinguishes itself by addressing developing technologies in a problem-orientation, as opposed to foresight, which addresses a broader scope of early-warning functions, or evaluation, which addresses innovation policies retrospectively. TA also distinguishes itself through its concern for identifying options, its heavy emphasis on process (but not to the exclusion of content), and as a consequence, its extensive and intensive interaction with a wide variety of actors. These characteristics show much overlap with the tracker type of TA. For the remainder of this chapter, we will deal with TA as a prime example of SI.

4. Impact of TA and Systemic Innovation Policy

Introduction

A major issue regarding SI in general and TA in particular is impact: How should the impact of TA be conceived? And how can impact be measured?
If we consider TA, or for that matter SI itself, to be a kind of policy analysis, we might look to the scholarship on the impact of policy analysis for some initial guidance. The Anglo-American version of this literature, however, is long on attempts and short on findings, as it often concentrates too much on impact on "the decision" rather than on other aspects of policy making. Bimber's study of OTA, for example, demonstrated few instances of spontaneous acknowledgement of OTA's influence on a policy decision made by Congress or by individual members of Congress. Similarly, Bimber found relatively few mentions of OTA in the *Congressional Record* of debates on issues. OTA, less than other congressional agencies like the Congressional Budget Office, was not part of the vocabulary with which members of Congress justified their actions. There were, however, instances in which OTA's work was absolutely critical to a particular policy outcome. Indeed, to understand the hostility of congressional Republicans to OTA one must also understand, for example, OTA's impact on the debate over the Strategic Defence Initiative and other defence policy questions in the 1980s. Morgan and Peha [2003] document further concrete impacts of OTA as well.

Mostly, however, OTA was a facilitator of communication around an issue. OTA was usually one node in an issue network that contributed to congressional information on that issue (Whiteman 1986). In many issues, OTA was simply one among many nodes. In some, it was a critical node. Sometimes, for example, in its assessment of potential human genome projects (Cook-Deegan 1995), OTA played an important role in assembling the network. Even though OTA was not broadly participatory, it became expert in conducting stakeholder analysis and stakeholders' meetings, thus smoothing the policy waters until a time that Congress might decide to wade in. The impact of such efforts on problem definition and framing and on broader strategic intelligence are, however, hard to discern, and methods for identifying them, which would include detailed ethnographies of issues and information, are lacking.

Another reason why OTA's policy impacts may appear to be minimal is that the arena of US innovation policy is not usually geared to such input. There is no basic policy for science and technology, nor for innovation, that OTA could have helped construct. OTA's 1991 report, *Federally Funded Research: Decisions for a Decade*, is a detailed and sophisticated assessment – particularly when compared to post-OTA S&T policy documents like the 1998 report issued by the House Science Committee chairman Vernon Ehlers – but there was little legislative opportunity to apply such analysis. To talk about OTA's influence on innovation policy is to talk about its impact on little, rather than its little impact. In Europe too, policy makers often did not (or were not able to) formulate questions TAs that TA could answer.

The previous OTA story shows that strategic intelligence, and TA in particular, needs a set of tools to assess its impact that can focus on learning across a broad swath of society. Such a learning focus is especially important for more participatory activities in which framing (set of relevant actors and problem definition) and learning are at least as important goals as immediate influence in any event (Guston 1999a). In the following we explore a framework to evaluate the impact of a TA. We first discuss that every TA has its own environment in which it operates, i.e. TA's are constrained by context and institutionalisation. Second, assessing impact should follow the general dimensions of SI: content and process.

Environment of a TA: context and institutionalization

TAs are never carried out in isolation. As the TAMI [2004] project noted, the process and impact of TAs are dependent on their context and institutionalisation. Context means the current situation of the technological field or problem at hand. Typical contextual questions include: How developed is the technology currently? Which actors are already involved and which only potentially? What governance arrangements have emerged around the technology to date?

Institutionalisation is a less clear concept. Following TAMI [2004], institutionalisation involves five factors: problem selection and definition, the relation and involvement of important actors, the composition of the toolkit or choice of methods; the modes of project management and interaction; and the style and freedom of communication.

Both context and institutionalisation can vary considerable from case to case and, moreover, can change during the course of a TA process, e.g., institutionalisation is (partly) shaped through problem definition as existing TA institutions and resources constrain actors in their attempts to institutionalise a TA. Both also imply that impact must be addressed case-by-case, because the environment strongly determines which impacts are sought and what can be expected.

Assessing impact: content and process

In assessing impact, we can talk about the role of a TA in influencing both the content and process of innovation policy. Again, the first of the pair is relatively straightforward. Typical content-related impacts will include improved understanding among decision-makers, stakeholders, and other publics of the TA issues involved, substantive analyses and recommendations regarding choices in innovation policy, and the manifestation of such understanding, analyses, and recommendations in new policy.

Typical procedural impacts include: identifying and empowering actors in such a way that they can play their roles effectively, e.g., by enabling actors to identify and meet their information needs; bridging the gaps of information and influence among actors;[5] and contributing to the acceptance and use of TA results in decision-making. Such procedural impacts not only contribute to the quality and usefulness in a more restricted way by facilitating the provision of useful content, but they also will enhance the quality of participation and empowerment in and impact of decision-making.

In the long run, the latter result, although less visible than the provision of (in particular instrumental) knowledge or content, often turns out to be a very important type of impact. One consequence of this process orientation is the need for continuous monitoring – to evaluate intermediate results, plan for any indicated redesign of the process, and appropriately attune expectations.

There are many concepts that can be used to fill in the content and process measures of impact. One perspective that fits particularly well with the vision of TA as SI is conceiving of impact as the ability of actors to engage in substantive, procedural, and reflexive learning (Guston, 1999a). Learning is a necessary step prior to behavioural change, i.e., acting differently within

[5] Geurts [1993] distinguishes between four types of gaps between: practical policy processes and science, different (scientific) disciplines, administrators and citizens and between experts and laymen, between the producers and the users of knowledge. Bridging the gap however does not imply consensus. It only points at enabling a fruitful dialogue between actors with different frames of reference and interests.

the innovation process. Collective or social learning is of special interest, because a change in the so-called 'shared frame of reference' can occur. Such change means that actors position themselves differently when making up their mind about a particular issue related to the innovation process. An example would be when scientists make it a common practice take societal and ethical concerns into account in their work.

Others include the instrumental and conceptual use of TA-results (Caplan, 1979), seven standards of utilization (Dunn, 1980), anticipation, reflection, and learning (Schot and Rip, 1997), and timing of receiving and using information (Caplan, 1979). While we do not claim to know which conception of impact on content and process is the best – and it may be that different conceptions are appropriate for different contexts and institutionalisations of TA – we do claim that both the content and process dimensions are necessary components in every TA evaluation. TAs conceived as simple research projects will not be able to meet these conditions.

In the next section we will explore how TA developed over the last 40 years from a 'research project' like activity into a 'process-oriented activity' by focusing on two recent developments in TA – Real Time TA and Constructive TA.

5. Two cases of recent TA approaches: Real Time TA and Constructive TA

TA approaches in the US and in Europe are under discussion in this section: (1) Real Time TA activities at the Center for Nanotechnology in Society at Arizona State University, and (2) Constructive TA activities in the Dutch TA NanoNed program carried out in the Innovation Studies Group at Utrecht University. We start by giving the context, institutionalisation, and setups of both approaches. Second, we discuss the impact along the dimensions of content and process. We do have to make two remarks; first, the RTTA example plays at a higher level than the CTA example. This means that the latter is much more detailed, but on the other hand also of smaller scope. Second, in the case of RTTA, we can only discuss intended impact as the program is still unfolding towards its full capacity and activities are just starting. For the CTA example, activities have been rounded up, and impacts are assessed and known.

Real-Time TA in the US

Real-time Technology Assessment (RTTA) has a lineage of multiple strands. Guston and Sarewitz [2002] conceive of it as: 1) an incremental alteration of CTA for local consumption in the U.S.; 2) a response to the specific failings of the ELSI model; 3) a synthetic enterprise built on the analytic findings of science studies and innovation studies; and 4) an intellectual and social response to the challenges that knowledge-based innovation poses both to governance and to the social sciences. The test-bed for RTTA has become the Center for Nanotechnology in Society at Arizona State University, which was created in October 2005 under a $US 6.2 million grant from the National Science Foundation. As implemented at CNS-ASU, RTTA is somewhat evolved from its initial description in the literature, but its impulse, first, to conduct fundamental and applied social science and humanistic research alongside natural science and engineering research, and, second, to push attention to questions of the value of knowledge-based innovations further upstream, remains the same.

CNS-ASU maintains four program activities within RTTA:[6]

1) Research and Innovation System Assessment (RISA), which provides surveillance of nano-scale research activities through a variety of (mostly quantitative) methods. In particular, RISA activities at CNS-ASU map the ongoing research dynamics of nanotechnology through bibliometric and patent analysis, evaluate the public value of nanotechnology by understanding the relationship between promises on its behalf and emerging societal impacts, and assess the nanotechnology workforce needs of regions by conducting supply-and-demand analyses for regional nano-workforces.

2) Public Opinion and Values (POV), which gathers both broad-brush and fine-grained data about knowledge of and attitudes toward nanotechnology and its societal implications from both researchers and lay-citizens. In particular, POV activities poll a large sample of the US public about their knowledge of and attitudes toward nanotechnology in a longitudinal and comparative perspective, study in a quasi-experimental fashion the impact of media reports on how the public conceptualizes nanotechnology, and survey a large sample of nano-scale science and engineering researchers about their perspectives on nanotechnology, for comparison to both the public poll and other data drawn from scientists.

3) Deliberation and Participation (DP), which elicits input on technical and societal issues through deliberative and participatory exercises. In particular, DP activities create "naïve" but technically validated nanotechnological scenarios for analysis and assessment by other CNS activities, propose responsible nanotechnological products through a trans-disciplinary undergraduate education module called "InnovationSpace", critique the scenarios and other visions of nanotechnological futures with the tools of critical theory and critical analysis, and involve scores of lay-citizens in the assessment of nanotechnological issues through a National Citizens' Technology Forum.

4) Reflexivity Assessment and Evaluation (RAE), which scrutinizes the activities and impacts of CNS-ASU at the micro- and macro-level. In particular, RAE activities examine the changing identity, knowledge, and practice among nano-scale science and engineering researchers with whom we interact, attempting to identify changes attributable to our influence, and reflect on CNS-ASU through international and other comparisons.
CNS-ASU also addresses two crosscutting areas of substantive inquiry: Freedom, Privacy, and Security, in which researchers are particularly concerned with how the design of nano-sensors may or may not build in important capacities for data acquisition and management; and Human Identity, Enhancement, and Biology, in which researchers are particularly concerned with the place of nanotechnology in a long history of questions about the relationship between human biology and novel technologies, e.g., nanotechnological enhancements.

Interaction between nano-scale science and engineering researchers on one hand, and CNS researchers on the other, is a crucial aspect of the activities. Interaction among the various elements of RTTA is another. To address the former challenge, we design CNS-ASU intentionally as a boundary organization [Guston 1999b], to provide concrete benefits to participating researchers as well as to facilitate social research and spur societal capacities for anticipatory governance. To address the latter challenge, we focus on the central role of activities like mapping the nanotechnology enterprise and generating technologically

[6] Details on the research activities and outcomes of CNS-ASU can be found in its first annual report to the National Science Foundation, on-line at http://cns.asu.edu/about/sitevisit.htm.

plausible scenarios of nano-technological futures in informing our other research (RTTA thus incorporates aspects of evaluation and forecasting into TA work). We also interweave research, educational, and outreach activities across CNS to enhance interactivity and opportunities for substantive, procedural, and reflexive learning.

Through this complex of RTTA activity, CNS-ASU hopes to build a greater societal capacity to engage in anticipatory governance of nanotechnology: from increasing public understanding of and engagement in nanotechnology, to rendering nano-scale science and engineering researchers more reflexive about their own work and its consequences for society. Decision-makers are one among many target groups for dissemination of RTTA findings, but scientists and engineers themselves are the critical target group, as RTTA aspires to cultivate a more reflexive, more anticipatory, and more engaged scientific disposition. CNS-ASU can thus provide descriptive and analytic information for scholars and decision makers, but it can also potentially seed a cultural change in science that will make knowledge-based innovation and the people who do it more familiar with, and receptive to, governance.

New TA in the Netherlands: CTA, bypassing the Collingridge Dilemma

As we saw above, participatory TA projects are well founded in the Dutch/EU style of doing TA. More recently we see that TA projects are also linked up with ‘big science and technology’ projects and sometimes even incorporated in them. In the case of nanotechnology in The Netherlands this is done through NanoNed, a nation wide consortium for nanotechnology. TA practices are embedded in and funded by this scientific endeavour. Projects are carried out at universities around the Netherlands. Here, we discuss one of these projects executed at the Innovation Studies Group at the Utrecht University. A reason for TA practitioners to choose this setup is a tendency among TA practitioners to “be there” as early as possible, to ‘get the chance to do it right from the start’. When these two points merge we end up with participatory TA approaches, for emerging technologies. Taking the well-known Collingridge dilemma [Collingridge, 1980] into consideration, in early stage technologies, chances for improvement are richest, but directions for improvement and further development hard to find; this project strives to bypass this dilemma.

Since nanotechnology is an awkward bundle of exotic technologies simply defined by scale, a choice for the subject still has to be made. Here, we choose Lab-on-a-chip for medical applications technology that, in contrast to most other nanotechnology applications, has a few applications on the market and is used in practice. Therefore, although still being an emerging technology, the relevant actors can more easily be identified, because some structure is in place. We find another issue of interest when we look at the technological field itself. In the case of Lab-on-a-chip technology, not completely, but to some extent accidentally, we found a field that “longed” for CTA kind of activities [in terms of de Bruijn et al, [2002] there is a ‘sense of urgency’). This was revealed by interviews with the science and business community.

Which actors to include in the CTA when applications are almost non-existent, and taking into account there is a clear lack of visibility outside the scientific and pioneering business arena? CTA strives to incorporate all relevant actors in the process. Looking at which actors will have a say in the development and use of the technology sooner or later gives anchor points to find the actors. Heuristics as the innovation chain, innovation systems, and social maps provide the necessary intellectual tools to do this. The actors where invited iteratively, meaning feedback from the actors was used in the course of the project. This assumes an important point of TA, which is that TA is an ongoing process where steering along-the-way is a necessity.

The approach consisted of the following 3 steps: (1) providing information to the participants, (2) constructing individual scenarios, and (3) dialogue workshops. Follow-up interviews are used as part of the data on which the impacts of the approach can be assessed. The project recognizes the interface between insiders and outsiders [21], where insiders work towards the realization of the technology and are committed to its success (e.g., science and business), and outsiders are selectors in the sense of having multiple options to solve their problem of which the technology under discussion is just one (e.g., professional users and ministries).

We thus managed to perform a CTA on an emerging technology. The impact that is aimed for was, among others, seen in terms of increased anticipation, reflection, and learning. This in turn creates awareness of how socio-technical dynamics work and broadening of perspectives of the involved actors. Both are necessary for actors to change their actions, the only way real influence on innovation processes can be expected.

Impact assessment of both approaches
RTTA at CNS-ASU, as of this writing just one year old, is still too young to have concrete impacts that can be easily measured – especially given the difficulty of identifying such impacts. Yet there are some early indications of the kind of impacts that RTTA might have, particularly on the target audience of nanotechnology researchers.

In terms of impact on content, CNS-ASU has begun to educate through coursework modest numbers of undergraduates in the societal implications of nanotechnology and provide opportunities for the engineering, design, and business students in InnovationSpace to create new nanotechnological product concepts. At the graduate level, CNS-ASU has begun to 'cross-train' several nano-science doctoral students to enable them to include research on societal questions about their own nano-science in their dissertations. By the account of one laboratory director, engagement with CNS-ASU has resulted in the success of a large grant proposal, which was more socially aware and problem-oriented than the first version of the proposal, which had been rejected. We have also begun to generate substantive knowledge in a variety of areas, in particular an operationalisable, social science definition of nanotechnology (Porter, Youtie, and Shapira, 2006).

At the procedural level, we have influenced Mike Roco (2006), the principal policy entrepreneur of the US National Nanotechnology Initiative, to adopt CNS-ASU's terminology of "anticipatory governance" as a goal for addressing the societal implications of emerging nanotechnologies. We have also argued for a greater attention, in the area of human nanotechnological enhancement, to a frame that includes attention to democratic political values (Parsi, Tosi and Guston, forthcoming) and to the role and particular needs of persons with disabilities (Wolbring, 2006).

The impact of the CTA example is discussed now. An important effect in terms of *content* is that most actors realized the value of discussing views and applications with different actors early in the development of the technology, i.e. their thinking about the future of the technology, reflected in their work, changed. Some even said their assessment for cooperation is now broader. There is a strong wish to have more events that also include a wide variety of actors. This is an important learning point that, due to the collective effect, can also be seen as a small change in the frame of reference of the participants. At the same time, actual changes

in action are marginal. It can be the case that this is a longer-term effect (as some participants indicated), although this remains to be seen. Having more than one workshop would probably also be beneficiary on this point, which can be taken as a lesson for other TAs.
The *process* dimension focuses on three questions: did we succeed in getting the ‘right' user involvement, did we succeed in providing effective support to participate in the discussion, and did we succeed in facilitating the interface between insiders and outsiders? The involved actors originated from science, business (SMEs and large firms), professional users (general practitioners and hospital care), ministries, financial institutions, and health care insurers. Listening to the participants during the follow-up interviews, this actor involvement was just about right. The participants indicated they were content with the process and the support (making the scenarios which prepared them for the workshop) given to them. The workshop itself was stimulating and generally (besides some comments) found useful. Since the discussions were enlightened both by insiders as well as outsiders, the interface was successfully facilitated.

6. Conclusions

In this final section we want to highlight the implications of our foregoing discussion on three aspects of TA that are central to our concerns: its development; its impacts and its role as SI in innovation policy.

Development of TA
Did TA actually develop from a watchdog functon into a tracker function, or are we, over the years, more and more looking at TA through a different analytic lens? If, as we argue, the former is the case, can we go even further to conclude that a ‘dominant TA design' has evolved?

An innovation systems perspective obviously provides an analytical lens for understanding TA that is distinct from the lens provided by the linear model. The history of TA practice, however, clearly shows real and substantial changes in the institutionalization and practice of TA itself. Whereas OTA carried out its TA in the relative isolation of its office and much TA in Europe in the early days was carried out by committees of experts (as for instance the Rathenau committee) and TA institutes were not very well linked to other actors in the innovation systems (as for instance most parliamentary TA organizations in their early days), TA has, since the mid 1990s at least, beome something rather different. TA nowadays is far more process oriented, more inclusive of relevant actors, and better linked to those circles that have a real say in the innovation process.

The explicit goals of TA have also changed from informing a limited set of actors on emerging technologies and their impact, towards identifying involved actors, articulating their information needs, and stimulating and feeding learning processes. TA methodology in the watchdog era hardly paid any attention to working with stakeholders to formulate problem definitions. Indeed, watchdog TA can be understood not as a process, but as an event charcterized by formal methods and techniques carried out by centralised TA institutions with rather simple interfaces with users and policy. Nowadays much attention in TA is paid to defining the problem in a carefully designed participatory process with a focus on learning. While watchdog TA was a multidisciplinary, scientific endeavour, TA now can be characterized as a trans-disciplinary activity carried out in a distributed infrastructure using a mixture of formal and process oriented techniques. The interfaces between the heterogeneous set of actors are carefully designed to serve multiple perspectives to the extent possible. All in all, we may conclude that the tracker drove away the watchdog not only in the perspective of the analyst but also in daily practice.

During this change a sometimes intense interaction between policy, theory and practice has been visible. New insights from innovation studies (innovation systems, evolutionary approaches, the role of users) influenced TA and policy-makers, and experiences with TA in practice served as empirical input for innovation researchers. The interaction between TA and policy however has remained problematic, with policy makers often unwilling or unable to absorb results of tracker TAs. We speculate that this is because the insights of TA do not easily translate to actionable knowledge in the daily work of policy-makers.

Will TA continue to evolve? In innovation theory, innovations go through a process of variation and selection [Utterback, 1994] resulting in what is called a 'dominant design'. Might such an account apply to TA? In answering this question we first have to realize that in this chapter we limit ourselves to a special type of TA: public sector, focusing on knowledge based innovation and social implications. Furthermore it should be obvious that despite some general trends, captured in the notion of the tracker, many different TA approaches are still visible. To speak of a 'dominant design' thus would not acknowledge this richness. Nonetheless, we feel it reasonable to conclude that a class of TA with the characteristics of the tracker may be viewed of as a promising strand of Strategic Intelligence, and an improvement over the watchdog function.

Impact

How should we conceive of the idea of impact of SI, and TA in particular. and how can such impact be measured?

In our overview of attempts to evaluate TAs we argued that impact should not be understood or assessed in terms of influence on particular decisions. For one thing, evaluating TAs in this way does not make much sense as long as policy makers do not ask the questions TA can answer. More importantly, innovation theory is not a theory of decisions but of systems and networks. Thus, regarding OTA it can be concluded that 'To talk about OTA's influence on innovation policy is to talk about its impact on little, rather than its little impact'. Understanding TA's impact thus in part awaits further development of innovation theory (researching implications for policy of the systems of innovation approach, (see Part III) and further development of innovation policies (implementing insights from innovation studies in policy, see chapter Teubal et al). Our view is that TA impact must be understood as a multidimensional phenomenon (content and process) and that determining impact is impossible without consensus on a well defined and shared problem definition, specifying explicitly the type of impacts to be expected, as developed by relevant actors taking into account the context and institutional limits in which the TA should be performed. As a matter for future research, proper evaluation of TA can build on in-depth analysis on a case-by-case basis; past TA projects should be a rich source of information for developing a useful approach to impact assessment.

TA and Policy

In conceptualizing TA as an important strand of SI in systemic innovation policies, what are the barriers to fruitful use of TA in innovation policy, and how can TA more succesfully contribute to such policies in the future?

Our understanding of systemic innovation policy makes it clear that actors involved in innovation processes need SI that support them in developing visions and strategies and turning these strategies into action. We concluded that the characteristics of this type of SI match up well with important characteristics of tracker TA, particularly the support of actors in their learning processes, the commitment to process-based information supply, and the focus on a heterogeneous set of actors engaged in the innovation process rather than the output of R&D activities. Smits and Den Hertog [2007] present a number of possibilities for how TA may aid systemic innovation policies (see table 3), drawing in turn on the five systemic instruments as discussed in the chapter by Teubal et al.

Table 3: The possible role of TA and users in a modern innovation policy (Smits & den Hertog, 2007)

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 ▪ 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 infrastructure) ▪ Develop nationwide innovation strategies in social domains

Yet we are still left with the challenge of barriers between TA and policy makers. Policymakers often do not use insights from TA, sometimes because they are not aware of the results, but more often because the results do not seem relevant to them. Despite great conceptual advances, innovation policy in most OECD countries is largely characterised by [Smits & Kuhlmann, 2003]:

- *a high degree of departmentalisation, sectoralisation of the political administration, and low inter-departmental exchange and cooperation*
- *heterogeneous, non-inter-linked arenas: often corporatist negotiation deadlocks (e.g. health innovation related policy in Germany)*
- *failing attempts at restructuring responsibilities in government because of institutional inertia (e.g. Germany, Netherlands, UK ...)*
- *dominance of "linear model" of innovation in policy approaches (and of related economists as consultants) in many national authorities (e.g. ministries)*
- *conceptualisation of "innovation policy" as a very specific, narrow field focusing closely on introduction of new technologies in SMEs, IPR or VC issues etc.*

Innovation policy itself, that is, still often fails to embrace the known complexities of innovation processes. A key issue of systemic innovation policy, therefore, is the involvement of a "new breed" of innovation policymakers, employed under the rules of a more flexible staff policy (e.g. supporting job rotation with industry or non-governmental organizations), working in a reformed, systemically interlinked institutional setting, fostering experimentation and learning and starting from a nonlinear, more systemic perspective on innovation.

A further development of systemic instruments is necessary to help this new breed of policy makers play their role in an effective and efficient way. Innovation studies may be helpful in this context by taking stock of already existing systemic instruments and, based on this, conducting a thorough analysis of the functions such instruments can fulfill and the situations in which they can be applied. Innovation studies may provide additional help for policy makers by furthering the insight into the dynamics of innovation systems and in the links between learning at the micro level with characteristics of the overarching system. The already mentioned ‘functions approach’ (see chapter Jacobsson et al) appears to be a promising avenue to realize this.

This brings us to the contribution TA researchers and practitioners may provide. Apart from the possible roles as already outlined in table 3, TA researchers and practitioners could also benefit from a greater integration of the insights provided by innovation studies. Until now, TA researchers and innovation scholars often operate in two different and separate environments, hardly referring to each other’s work. The same is true for TA researchers and policy makers. TA researchers need to invest more in matching their problem definition, goals and methods with the needs, possibilities and limitations of policy makers. Institutional innovations that allow for greater cross-fertilization among innovation policy makers and TA practitioners may be a central part of any successful effort to enhance the value of TA for policy making.

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