Dirk Meissner
Leonid Gokhberg
Alexander Sokolov *Editors*

Science, Technology and Innovation Policy for the Future

Potentials and Limits of Foresight Studies

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ISBN 978-3-642-31826-9 ISBN 978-3-642-31827-6 (eBook)
DOI 10.1007/978-3-642-31827-6
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013940189

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

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Chapter 1
The Meaning of Foresight for Science, Technology and Innovation Policy

Dirk Meissner, Leonid Gokhberg, and Alexander Sokolov

Science, technology and innovation (STI) policies are topics that has been much written about in the last decades. However until today no common understanding has been articulated on what these policy fields are and how they are correlated in daily practice of policy making. The book thus pursuits a completely new approach, which goes much beyond existing practices. For the first time the concept of evidence based science, technology and innovation policy making is elaborated and put into context with Foresight studies. Foresight studies are commonly understood as a measure supporting governments, public agencies and companies in designing future oriented strategies. The editorial book brings together contributions from leading international scientists, representatives of national governments and international organisations like the Organisation for Economic Co-operation and Development.

The book gives practical guidance for policy makers, analysts and researchers on how to leverage the use of Foresight studies, which are common practice in many countries for future STI policy. The book outlines approaches and experiences of integrating such Foresight studies in the elaboration and implementation of STI policies at different levels. It delivers insights into practical approaches of developing policy measures oriented towards future societal and technological challenges based on evidence drawn from experiences available worldwide. The book is a valuable resource for policy makers, researchers, analysts and Foresight practitioners. It gives real checklists and guidelines for making more value of Foresight studies and leveraging the potential impact of STI policies.

The book consists of four major sections. The first section introduces new or improved methodologies which are used in Foresight studies, the second section looks at new and emerging markets followed by a section on country experiences and national Foresight studies. The book is complemented by a section on the

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D. Meissner et al. (eds.), *Science, Technology and Innovation Policy for the Future*,
DOI 10.1007/978-3-642-31827-6_1,

potentials and role of Foresight studies as tools for innovation policy and on the future potentials of Foresight studies for STI policy.

In the following section (**Section I**) new instruments and concepts for Foresight studies are introduced.

Anna Sokolova and Ekaterina Makarova develop an evaluation model to ensure the comparability of the different Foresight studies. Their analysis shows that Foresight studies can have a clear effect on the process of defining research, technology and innovation policies.

Dirk Meissner finds that conducting national Foresight studies has become common in many countries. However the impact of such studies on the performance of the national innovation system remains unclear. In the short term, it can be concluded that national Foresight studies contribute significantly to the design and – in some countries – reshaping of the innovation system structure and framework conditions. A direct quantitative measurement of the impact and thus the value of Foresight studies can not yet be done in a statistically reliable fashion. However the changes these studies have caused within the national innovation systems may have an indirect impact on the future national innovation performance.

Dirk Meissner introduces indicators applicable for Foresight studies. Due to the nature and characteristics of Foresight studies, there is no 'one indicator that fits all' – different types of Foresight studies have different motivations, and objectives. These features determine the approach and the selection of methodology within the Foresight framework. Given different possible methodologies and techniques available, outcomes, and hence the indicators, vary significantly, and can be qualitative or quantitative in nature. Even quantitative indicators offer sufficient space for interpretation, and, in the course of Foresight studies, these indicators are usually based on quantitative near-time data, which are extrapolated forward to future values. However, such extrapolation requires assumptions that are either drawn from the analysis of statistical trends, by individual assumptions, or both. Eventually, the resulting data are not quantitative but semi-quantitative, with a respectable degree of uncertainty resulting from the inclusion of semi-objective data, and information. Other indicators are needed when evaluating Foresight studies. Again, the evaluation of Foresight studies has many different objectives, goals and motivations and therefore there are a number of different evaluation techniques and indicators that can, and should, be used. In conclusion, indicators developed and used in the course of Foresight studies serve different purposes; thus, indicators are usually tailor-made for each Foresight study and are not necessarily fully comparable between different studies. However, these indicators might eventually be used as input for other Foresight studies.

Ian Miles argues that Foresight activities take many forms; they can be internal to organizations or performed, to various degrees, by external contractors. They may engage many members of the client organization, many participants from outside the client, and – related loosely to this – be more designed to shape the organization itself or to influence actors in a wider environment. They may be more focused on producing formal reports and recommendations, or on establishing networks or cognitive alignment among stakeholders. The achievements of the

activity may be more or less in line with those set out in the original objectives (which themselves may have been more or less explicated by the client).

Given such a variety of experiences, some aspects of which can be illustrated using available data sets on Foresight practices, it is only to be expected that assessment of the impacts of Foresight is challenging. But the situation is further complicated by the fact that Foresight activities are services provided by practitioners to clients. Services are known to involve greater or lesser degrees of coproduction, in which service users also contribute inputs to service production (and also often to design and delivery) and that these inputs are critical to the final product, its quality and its influences. Indeed "impact" is a problematic term, since the client is unlikely to be a passive of service inputs. Other stakeholders, too, may be important contributors to the process, rather than recipients of formal products.

It is also important to recognize that services are extended over time, and that the interactive impacts are not confined to just one moment. There is exchange of information and knowledge, in different fora and formats, across the various stages of the Foresight activity. These also fit into the various decision-making and other processes underway in the client and stakeholder contexts. While Foresight activity may be intended to feed into an early stage in a policy cycle, often there are multiple policies, and heritage policies, to be interacted with, as well. The influences can thus be multiple – from different stages of Foresight, into and from different points in various policy cycles and related processes.

Using the methods of service system analysis, this essay will set out ways, in which we can think about these issues, and use these ideas to frame better approaches to design and evaluation of Foresight activities.

Ozcan Saritas introduces the Systemic Foresight Methodology (SFM). Based on the ideas of systems thinking, the SFM aims at proposing a conceptual framework for designing and implementing Foresight activities. The framework recognises the complexities involved both in real world systems and in idea creation, which emerge due to multifaceted interplays between the Social, Technological, Economic, Ecological, Political and Value (STEEPV) systems. Conducting Foresight systemically involves a set of 'systemic' thought experiments, which is about how systems (e.g. human and social systems, industrial/sectoral systems, and innovation systems) are understood, modelled and intervened for a successful change programme.

Section II discusses the new innovative markets, which have been detected and described using Foresight instruments. *Oleg Karasev and Anastasia Edelkina* argue that Foresight studies aimed at identifying promising STI development areas have become a major component of government policy-making during the last decades. Such studies enable policy makers to create a basis for government S&T programmes, specific support initiatives and other complementary policy tools. Among the emerging technologies, which are the objects of Foresight studies and targeted by relevant S&T policies, nanotechnology plays a particular role. In leading countries, e.g. the USA, the EU, Japan and others, the nanoindustry development is considered as a national S&T priority. Different policy instruments should be used to support each nanoindustry segment, depending on its specific conditions and characteristics (e.g. existing S&T results, production and market

potential, etc.). The successful development of any nanoindustry will largely depend on the extent, to which interests of the key stakeholders in this process – the government, business and research communities – are matched.

Oleg Karasev and Konstantin Vishnevskiy study the challenge of clean water supply as one of the major challenges societies around the world are facing. Thus far water treatment for general public and industrial purposes and wastewater treatment remains an insufficiently resolved technological challenge. These challenges increasingly raise the awareness of a wide range of technology specialists and policy-makers. The article focuses on elaboration of a new approach to roadmapping for the sphere of emerging technologies, including nanotechnologies providing special routes R&D-technologies-products-markets for the given field. The integrated roadmap determines a set of strategic goals for markets of nanotechnologies, develops measures to achieve them taking into account alternative ways, to fix up the points of efforts' application and to make a choice of the most effective alternative way. Roadmap is also aimed at implementation of coordination mechanism of stakeholders' actions for achievement of strategic goals.

Philip Shapira, Jan Youtie and Sanja y K. Arora discuss the commercialization of graphene, a novel nanomaterial consisting of a single layer of carbon atoms, has attracted significant attention due to its distinctive properties and potential benefits for diverse applications. Electronics has been suggested as the leading application for graphene. There are also potential applications in energy (e.g., solar cells, batteries) and composite materials. The commercialization of scientific discoveries such as graphene is inherently uncertain, with the lag time between the scientific development of a new technology and its adoption by corporate actors revealing the extent to which firms are able to absorb knowledge and readily implement products based on the new technology.

From this perspective, the paper tests for the existence of three different commercialization patterns: (1) a linear process where commercialization follows scientific discovery; (2) the double-boom phenomenon where corporate (patenting) activity is first concentrated in technological improvements and then followed by a period of technology productization; and (3) a concurrent model where scientific discovery occurs in parallel with commercialization.

In **Section III** country Foresight study experiences are introduced. *Alexander Sokolov* presents a description of major Foresight activities in the field of science, technology and innovation in Russia, including identification of National S&T priorities and Critical technologies as well as three cycles of the National S&T Foresight that have been performed during the last decade vis-à-vis developing S&T and innovation policies. The development of more complex and elaborated policy instruments requires a better grounded long-term vision of key trends in S&T, society and economy. The evolution of Foresight in Russia on the way from an information source for S&T and innovation policy towards a full-scale policy instrument addressing key issues of S&T and innovation is discussed.

Kerstin Cuhls gives a comprehensive overview of the German experience with Foresight studies. Since the beginning of the 1990s, Foresight processes have been part of the instruments in the German Federal Ministry of Education and Research

(BMBF) to look into the longer term future and gain insights and recommendations for research and innovation policies. Whereas the first projects aimed at providing information about future topics, the latest Foresight processes were directed to the BMBF and (indirectly) its portfolio. This chapter tries to trace some of the effects of these Foresight processes and discusses why it is so difficult to really have an impact on policy making. The latest "BMBF Foresight Process" illustrates these attempts and shows a tendency towards systemic integration of Foresight results and even provides topics or Future themes for transformation processes.

Jennifer Cassingena Harper's chapter focuses on the experience generated over the last decade in Foresight activity at European level with a view to identifying policy impacts, both formal and informal. European Foresight activity operates at different levels but is primarily implemented through expert groups addressing particular themes and projects implemented by European consortia selected through an open call under the EU Framework Programme for Research and Technological Innovation. The paper identifies the different types of policy impacts generated through these activities based on the design, process and content as well as other factors such as stakeholder consultation and engagement. The potential and early impacts will also be addressed as some of the projects are quite recent and the impacts need more time to materialise. Policy impacts can range from networks generated, change in perspectives and mindsets leading to new policy approaches and a roadmap for action, which leads to the adoption of concrete policy measures. The chapter analyses how the changing rationales for European Foresight have lead to the raising of the level of ambition in terms of the expected results and policy impacts.

Section IV discusses the potentials of Foresight Studies as an instrument for innovation policy. *Luke Georghiou* in his chapter on Challenges for Science and Innovation Policy finds that the content of research and innovation initiatives is increasingly being discussed in terms of thematic content on the one hand, through engagement with Grand or societal challenges, and in terms of clusters of key or critical technologies on the other.

In parallel, the processes of innovation have been changing. A broader-based view of innovation has been emerging, which recognizes the critical importance of the research and innovation ecology, in other words the network of relationships between innovation actors and the environment, which structures those relationships. The ability to use knowledge developed elsewhere or to be a knowledge supplier as captured in the terminology of 'open innovation' has started to transform business models and processes. Finally, it is also increasingly recognised that there is no single innovation model that fits the requirements of all fields of innovation. Greater diversity in research and innovation patterns can be observed, as reflected in the greater attention paid to sectoral and thematic specificities of innovation.

Caught in between changes in societal demands on innovation and changes in research and innovation practices, a substantial reappraisal of innovation policy has been taking place in Europe in the past 5 years. Initially the drive for this was the realisation that efforts to underpin the technological base, though vital, were

insufficient in terms of providing the environment in which innovative firms would flourish and grow. In the meantime, the economic crisis and other pressing challenges have reinforced the urgency to act. It is generally accepted that governments have to take the lead in addressing societal challenges. The chapter asks whether governance structures and processes are ready to cope with this new perspective on innovation policy. This is mainly caused by the multi-level and fragmented governance in public procurement, but also by regulations and sector policies that are often not in concordance with the requirements of stimulating innovation.

Dirk Meissner, Vitaly Roud and Mario Cervantes argue that the contribution of innovation for growing societal welfare is without any doubt an important one. Innovation by itself is a phenomenon known to humankind over centuries. Although much work has been done to understand the process of how innovation is generated the ultimate motivation for people to search for innovation has been neglected in a broader context. Quite recently the term 'innovation policy' became a fashionable expression often used by politicians and administrative bodies to interfere in some way into the sole process. It's certainly wise to design the framework conditions in a society – thus in an economy – which are conducive innovation but as long as designing framework conditions aim at the generation of innovation only and not considering the underlying motivation of society to develop and accept innovation such efforts are very likely to remain at the invention stage where ordinary taxpayers will ask for justification of such activities. Still it seems sufficient to use the terms "innovation" and "innovation policy" to generate awareness and acceptance. In consequence such thinking is likely to lead to promising announcements by whoever to whomever. Their contribution develops a new principle approach towards the governance of innovation on the national level considering the interrelationship between policies at federal and regional levels but also the role and importance of international policy aspects.

Leonid Gokhberg discusses indicators for STI policy and Foresight studies. He argues that the current STI indicators system is well suited to describe the configuration of STI systems ex post but need to be broadened by the innovation dimension beyond research and development. Also Foresight is considered as a future oriented instrument, which takes advantage of different STI indicators. Given this background he finds that Foresight studies have a major impact on STI policy and significant contributions to the design and implementation of STI governance schemes.

In the concluding chapter *Leonid Gokhberg and Alexander Sokolov* discuss the potentials to adapt policy to future thinking and derive conclusions. They find that Foresight studies show an ever increasing potential to serve as a general basis for S&T strategy building at different levels. The outcomes of Foresight studies' evaluations contain valuable learnings and information, which should be included in the design of further Foresight activities. Hence a systemic approach towards the preparation and design of Foresight becomes ever more needed in order to ease the preceding phase and to limit the repetition of failures and mistakes done in the preparation and design of Foresight studies. The preparation of such tender process and the subsequent

assessments and selection of tenders are a complex process, which is critical already for the quality and validity of the subsequent Foresight study. Hence guidelines for the design and preparation, e.g. the tendering procedure, are valuable instruments for prospective Foresight studies. Foresight not only should take into account potential technological or societal developments but also aim at assessing the need for and the design of potential STI policy measures. Here a new field for forward-looking activities is likely to arise in the near future.

Part I
Instruments and Tools for Foresight Studies

Chapter 2
Integrated Framework for Evaluation of National Foresight Studies

Anna Sokolova and Ekaterina Makarova

2.1 Introduction

The number of Foresight projects has increased significantly over the past few years, growing twofold from 2005 to 2009 (Popper 2009); as a result, the evaluation of such Foresight studies has become increasingly important. The monitoring and identification of probable mistakes occuring through Foresight design and implementation are therefore crucial: strong evaluation procedures are necessary for the success of Foresight, and according to Georghiou there are "three basic tests for Foresight evaluation: accountability, justification and learning" (Georghiou 2003).

Issues concerning the evaluation of Foresight studies have formed a separate field of research. The most widespread problems investigated in this regard are the following: factors of Foresight success, areas of Foresight impact, and evaluation of different aspects of the Foresight process.

Scholars presenting the first research area focus on defining Foresight success and identifying factors that lead to such success. Foresight is considered to be successful if it provides more effective learning and more creativity in developing strategies and initiatives (Bezold 2010). Several factors of Foresight success have been determined: strong interconnections between public, private, and academic sectors; inclusion of different stakeholders; links to the current policy agenda; development of novel methodologies, creativity and lateral thinking; proactive public work; and taking previous experience into account (Calof and Smith 2008; Meissner and Cervantes 2008; Habegger 2010).

The impact of Foresight activities, being the main reason for Foresight intervention, is a principal indicator of evaluation as well. Four types of Foresight impacts – including awareness raising, informing, enabling, and influencing – form a Foresight

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D. Meissner et al. (eds.), *Science, Technology and Innovation Policy for the Future*,
DOI 10.1007/978-3-642-31827-6_2,

impact schema (Johnston 2012). For the purpose of impact evaluation, researchers have determined several areas of the most considerable Foresight influence. These areas include: knowledge society emergence; science, technology, and innovation (STI) system; business; policy-making, and decision-making processes; and public understanding of science and technology (e.g. Popper et al. 2010; Havas et al. 2010; Rollwagen et al. 2008). Some scholars suggest analysing internal criteria (such as those related to actors, processes, objectives, and inputs/outputs), as well as wider environmental factors, and external factors for the purpose of a qualitative evaluation of Foresight impact (Amanatidou and Guy 2008). In accordance with the close interconnection between STI system and Foresight, the impact of the latter is assessed from the national innovation performance perspective (Meissner and Cervantes 2008).

Issues devoted to the evaluation process include choosing optimal methods and criteria, identifying evaluation topics, and elaborating evaluation algorithm. The following criteria are considered to be the most important: appropriateness, efficiency (input–output, input-effects, and input-impact relations), effectiveness (objectives-output, objectives-results, and objectives-impact relations), sufficiency, value added, usefulness, importance, and relevance (Georghiou et al. 2004a; Georghiou and Keenan 2006; Meissner and Cervantes 2008; Popper et al. 2010; Destatte 2007; Dursun et al. 2011; Rijkens-Klomp and van der Duin 2011). The most "economic" criterion – value for money – is assessed through the evaluation of the funding mechanisms' performance and is characterised mainly in qualitative terms (Popper et al. 2010). The specificity of the "behavioural additionality"[1] criterion is widely investigated by researchers in regard to the evaluation of Foresight impact. Many other criteria can be applied for the evaluation of different aspects of the Foresight process, such as the appropriateness of objectives and the experience of the project team (e.g. Georghiou et al. 2004a; Yoda 2011; Calof 2011).

A review of the literature has revealed that there is no consensus among scholars about Foresight evaluation frameworks. Georghiou and Keenan (2006) argue that an evaluation framework should depend on the rationale for the specific Foresight study (the authors identify three main rationales for Foresight: providing policy advice, building advocacy coalitions, and providing social forums). Other researchers propose that evaluation should be based on normative, strategic, and operational levels of management, as well as three basic elements: people, system, and organization[2] (Alsan and Öner 2004).

Foresight evaluation theory has developed in parallel with the formation of practical Foresight appraisal. The first evaluation initiatives appeared in the late 1990s. Nowadays a great number of Foresight evaluation projects are being implemented. Large-scale national programmes are assessed, as well as separate elements of Foresight studies. Evaluation procedures are conducted through all stages of the Foresight process (ex post, ex ante, mid-term, ongoing evaluation); external and internal experts can be engaged. The chronology and classification

[1] Behavioural additionality is the difference in actors' behaviour resulting from the Foresight intervention (Georghiou et al. 2004b).

[2] It is a framework of the adjusted integrated Foresight management model.

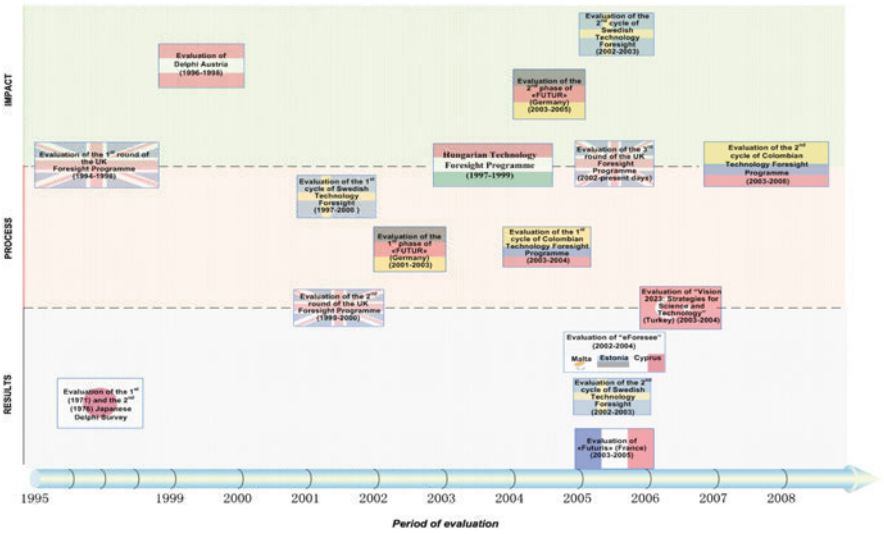

Fig. 2.1 Foresight evaluation projects: chronology and focus of analysis

according to the focus of analysis of the most remarkable Foresight evaluation projects are presented below (Fig. 2.1).

For the majority of projects presented in Fig. 2.1, the period of time between Foresight implementation and evaluation usually doesn't exceed a year. Moreover, in many cases the evaluation procedures are realised during the Foresight, which allows correct decisions to be made with regard to the following stage (e.g. FUTUR and the first round of the UK Foresight) or project (e.g. Hungarian programme).

International expert panels were formed to conduct evaluation procedures in the majority of the cases. Evaluation projects were sometimes initiated by the responsible ministry or department (e.g. Delphi Austria and the second round of the UK Foresight), as well as by members of the Foresight programme's team (e.g. "eForesee"). The results of evaluation projects have a significant importance for a wide range of stakeholders from different levels of management all over the world. Notwithstanding increasing activity in the sphere of Foresight evaluation, only individual examples of methodology for appraisal have been constructed by scholars and implemented during projects (e.g. Alsan and Öner 2004; Popper et al. 2010; Georghiou et al. 2006). The lack of a commonly applied framework impedes the development of Foresight evaluation theory and decreases the effectiveness of practical procedures. Moreover, it limits the possibilities for spreading the experience of successful evaluation.

The intent of this research therefore is to form a framework for the development of a complex national Foresight evaluation methodology. It includes identifying the key criteria and the main stages of the evaluation process on the basis of analysis and systematisation of accumulated practical and theoretical experience.