Chapter 4
Instruments to measure Foresight

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4.1 Features and Characteristics of Foresight

Foresight studies have demonstrated a positive and lasting impact on the capacity of many countries for innovation. In most countries, this lasting impact is due to the interaction of the initiators of Foresight at the highest level, with actors directly involved in innovation. Within a Foresight process, a top-down approach is complemented by a bottom-up approach. Still as long as the Foresight practitioners and initiators ensure that the top-down and bottom up approach are not conflicting in its aims and directions the necessary acceptance of the results is ensured from the outset. In a wider sense, Foresight is a combination of a wide range of approaches and methodologies that aim to improve future-oriented decision making by the early detection and assessment of emerging trends and drivers of change (Roveda and Vecchiato 2008; Georghiou 2001; Martin 1995). Thus, Foresight studies exist in a variety of shapes, at the national (Grupp and Linstone 1999; Gavigan and Scapolo 1999), and regional level, in the public sector, and the private sector (Schwartz 1991; Ruff 2004; Burmsteir and Neef 2005). However, Foresight studies are always different; there is no typical Foresight study. This holds especially true for public Foresight studies, which aim at national or regional levels and thus require a careful selection and tailoring of methodologies and processes if they hope to bring about notable benefits to national actors, and especially to local firms (Roveda and Vecchiato 2008). The management of Foresight requires an ambitious and sophisticated model, which includes features of an integrated and holistic approach. Such an integrated model is considered a core competence (Major et al. 2001; Alsan and Oner 2004).

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The Foresight results from one country are only partially transferable to another, because each country has specific strengths and weaknesses. Conducting a country's own Foresight is worthwhile also because the resulting processes and discussions are at least as important as the direct output. Foresight studies intend to improve communication and cooperation between actors from different sectors of industry and society; thus interdisciplinary thinking will be strengthened. In addition, a vision of the future that provides for new innovations and educational measures will be developed. It should be noted here that Foresight is also a political process, in the old property claims made under the circumstances in question. In addition, it should be added that Foresight should be seen as a continuous process that extends from the initial target definition through to implementation. The implementation of preparatory decisions must be made following the conclusions reached through Foresight. Foresight is a process that is meant to be repeated anew, following the implementation of its conclusions. Moreover, the learning process involved in Foresight is substantial, and is necessary in order for Foresight studies to be effective, and deliver solid, high-quality results. On the one hand, this substantial learning process is necessary to balance conflictual factors, while on the other hand, it is needed because the stakeholders involved often lack a systematic understanding of Foresight studies.

Foresight can impact the innovativeness of a country through different channels. In the present context of globalization in the developed countries, the view prevails that an explicit and coherent innovation and technology policy/plan/strategy/system is essential to economic and social development. Foresight studies affect the priorities and decisions of these countries. But they also create significant networks and interactions between actors in the national innovation system and thus contribute to the acceptance of new developments and exploitation of technological potential.

Eventually, initiators and stakeholders of Foresight studies have ambitions to seek numerous benefits from such studies, such as dealing with problems at their early stages, believing that problems are easier to solve; improving the perception of opportunities and options; clarifying vision- or mission-focused objectives; and monitoring the future to check approve ad or adjust existing strategies (Bezold 2010). Given such ambitions, Foresight studies generally raise expectations among stakeholders. However, in most cases the framework conditions, and also the organizations initiating the study, are not fully prepared for, nor do they anticipate, the outcomes of Foresight studies. The outcomes are generally considered challenging with major impacts on organizations and systems if implemented properly. Hence, these studies eventually present a substantial risk of failure in meeting the aims and expectations of the initiators and stakeholders in the long run. The analysis of trends is an important issue for businesses, the science community, and also policy makers; however, such analysis is only useful and valuable when coherence between the trends analysed, and the strategic orientation of the actors, is guaranteed (Huss 1987).

An individual's psychological features strongly shape how she or he views Foresight (Bezold 2010). Three basic features are assumed to determine an individual's attitude towards perceiving future events and developments. These

Table 4.1 Behavioural features

Feature	Determination	
Perception	Concrete/specific (Sensing) – S	Intuition – N
Judgement	Objectively (thinking) – T	Subjectively by feeling – F
Focus energy	More by the external world of people, experience, and activity (extroversion) – E	Internal world of ideas, memories, and emotions (introversion) – I

Source: Adapted from Bezold (2010)

are the individual's style of future perception, the basis for judging potential developments, and the sources of energy used for the previous two (Table 4.1).

It turns out that that Foresight practitioners often follow an "STE" approach by systematically designing, and structuring Foresight studies so that they are heavily dependent on the attitudes, experiences, and knowledge of external actors, e.g. stakeholders. In turn, external experts and knowledge holders are frequently applying the "NFE" or "NFI" modus operandi, which is strongly based on their personal perception, and trust in the Foresight practitioners to convert the opinions and assessments of numerous knowledge holders into an aggregated summary for deriving conclusions.

Eventually, organizations that are either directly involved in the Foresight studies, or are affected by the outcomes of Foresight studies, find themselves confronted with a compromise between short term manufacturing and production, and long-term adaptation conflicts. The challenge for any organization is "to step outside itself and examine its own adaptive capacity in order to recognize when brittleness is on the rise as the organization struggles to meet faster, better, cheaper pressures" (Woods 2009). Consequently, Foresight in a broader sense needs to take into account the organizational behaviour of institutions, which in turn strongly impacts the interactions and linkages between the different organizations in the overarching innovation system.

Foresight studies have broadened their scope from pure technology forecasting to a wider social process (Georghiou et al. 2010; Saritas and Nugroho 2012). This is mainly due to experiences from the corporate sector, the recognition of the benefits of stakeholder and end-user involvement in the overarching process, as well as consideration of a broad range of policy fields (De Moor et al. 2010). Consequently, Foresight practitioners put great emphasis on understanding the behaviour of individuals in the course of Foresight (Saritas and Nugroho 2012). The outcomes of Foresight are well-suited to act as inputs, and foundations, for technology roadmaps because they focus on alternative futures, and determine the likelihood of the appearance and the application of technologies in light of varying social, economic, and environmental framework conditions (Saritas and Aylen 2010). In this manner, Foresight studies do contribute to the growth of the knowledge base, which in turn is necessary to any understanding, or definition of innovation (Metcalfe and De Liso 1998). Thus as a matter of fact, Foresight and technology roadmaps are closely connected, since Foresight studies usually result in scenarios that are the basis for technology roadmaps (Erdmann and Behrendt 2006;

Lizaso and Reger 2004; Drew 2006). Eventually, as technology-impact assessments are included in the development of concrete scenarios, a wide range of technological trajectories with differing long-term consequences are integrated into the framework as part of Foresight studies (Berkhout and Green 2002).

Thus, the core issues of Foresight are related to the changeability, and adaptability of organizations; the ability of organizations to adapt to changing environments whose impact has been long underestimated; the ability to detect and quantify actual sources of resilience; the development, and implementation of systems that detect and manage such reliance; and finally the ability to establish and maintain change management processes, which are the result of learning processes as well as the actual Foresight process (Woods 2009).

Foresight studies are typically implemented in two ways: either as policy outcomes for national science and technology, or social programs, depending on the objective functions set for the program; and/or as concrete outcomes for companies in all sectors in the form of market trends, products, processes, and underpinning science and technology to facilitate the development of a company's business (Saritas and Oner 2004).

Different types of knowledge are reflected in different modes of learning and innovation which impact Foresight studies in a way that these studies are strongly based on the knowledge and assessments of individual experts. In this respect, technology should be "understood as involving both a body of practice, manifest in the artefacts and techniques that are produced and used, and a body of understanding, which supports, surrounds and rationalises the former" (Nelson 2004, p. 457). Eventually the most powerful technologies combine knowledge derived from different fields of science (Jensen et al. 2007).

4.2 Foresight Methodologies

With the increasing use and application of Foresight studies for different purposes, a broad range of methodologies have been developed or adapted. These methods are used to varying extents at various stages of Foresight moreover, these methodologies are used in different shapes and combinations – in most cases a bundle of different methodologies is used instead of selected a single one. The choice depends on the specific objectives, context, target audience, resources, and the existing innovation culture. Furthermore, some methods are only suitable for specific phases of a Foresight study. The Foresight methods are explained according to their use in the course of Foresight studies. It is thus shown in which phase the instruments are designed.

Foresight studies can employ various methodologies, depending on their goals. Critical technology lists are useful in the transfer of technologies, generally in the intermediate stages of their life cycle, from one sector to another. For the detection of more radical innovation, and technologies, other methodologies like scenarios are more appropriate. However, these alternative methods are definitely more complex, expensive, and time-consuming, requiring a wider, and more active, participation of many stakeholders. Still, the advantage is that these approaches consider an organic, and comprehensive analysis of the long-term evolution of the economic, social, and cultural framework, especially in light of global competition (Roveda and Vecchiato 2008).

A common starting point for the majority of Foresight is desk research. Information obtained through literature, and Internet research is used to gain an overview of existing work, analyse international experiences, and design a national context for the best possible Foresight. While prior research is incorporated into feasibility studies, and design proposals, the results of this research may feed back and generate more inputs over the course of the literature and media analysis. Surveys are a very efficient and effective tool, and are used in various forms in virtually all Foresight studies. As such, they provide an important foundation for the preparation of future scenarios, and can be combined with almost any Foresight methods. Brainstorming is also a widespread methodology, but is not often considered as a stand-alone method; rather, it is used in conjunction with other methods, such as the scenario building workshops. The main objective of these techniques is to collect the ideas of the participants in a structured fashion, and to promote creative thinking.

SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis' identifies and structures internal and external factors that influence a country (or a region or company) and are likely to have a future impact. Often, the results of SWOT analysis will take into account the needs and requirements of different stakeholders, and develop lists of strengths and weaknesses, as well as risks and opportunities. SWOT analysis focuses on information that allows for optimized adaptation of resources and capabilities to the environment, thereby improving competitiveness. Brainstorming techniques can be used to complement SWOT analysis. Based on the knowledge gained, future actions will be aligned so that the strengths are consistent with opportunities, risks can be avoided, and weaknesses overcome. SWOT analysis can therefore provide a good starting point for a focused analysis of Delphi or scenarios. To carry out a SWOT analysis, experts with sector-specific or country-specific knowledge, as well as stakeholders from different sectors, are involved at multiple levels. The advantages of this approach are its simplicity (requiring no technical skills) and its flexibility in application, as well as its systematical processing of information. It should be noted, however, that due to many factors, the resulting lists are not always clear, nor are the items prioritized.

The STEEPV (Social, Technological, Economic, Environmental, Political, and Values) method is a technique of structured brainstorming that focuses on initial assessments of key issues. Accordingly, the topics that STEEPV stands for will be the topics discussed in panels, workshops, or via online platforms along these six thematic priorities. Since individual issues can't be assigned exclusively to one category (social, technological, economic, environmental, or political), the category with the highest relevance to an issue is selected. The STEEPV method is suitable as input for the SWOT analysis, which is more target oriented. The structured consideration of future trends and factors in addition to the agenda-setting is suitable for panels and for the Foresight study as a whole, as well as for the development of scenarios.

For the identification of factors, and perspectives based on a precise question, a combination of desk research, workshops, and expert interviews are most important, as well as an analysis of their interaction, and mutual influence. The most important and uncertain factors can then be used when influencing the development of scenarios. It is also important in the development of prospects that no trend analysis is performed based on historical data; instead, potential new factors should be involved in the development of prospects. The morphological box/analysis and relevance tree methods were derived from strategic planning. In these methods, actions and technologies are identified on the basis of future needs and goals with the involvement of relevant stakeholders. The goal is to break up a vast subject into increasingly smaller subtopics, and identify possible paths of development with the involvement of the cost, duration, and probability. The interactions of the various elements are simultaneously considered by means of a detailed illustration. Similarly, the morphological box is designed using a multi-dimensional matrix from the (normative) organization, and stepwise refinement of information, and proposes ways to solve problems, and stimulate new ways of thinking. The starting points for this method are potential or occuring structural problems, which can be solved by means of graphic dimensions and related hypotheses.

The method of critical technologies has been developed in connection with early detection technology to prioritize short-term research and development policy objectives. The long term is also assessed in Foresight studies by a series of standardized criteria in specific technologies for their future importance. For the assessment of funding and action, experts use technology benchmarking with other countries. The goal of international comparison is to identify weaknesses, and assess possible future developments in the country of study. Discursive methods are particularly effective in looking at the technological development in social and economic factors further.

Delphi surveys are multi-stage surveys that are characterised by standardized questionnaires, and. several rounds of questioning. The purpose of this type of survey is a consensual evaluation of formulated hypotheses. The topics to be evaluated are compiled by various means, including desk research, brainstorming, workshops, and SWOT analysis. Based on the results of the first questionnaire, a second one is prepared, whith the aim of identifying common opinions, and subsequent re-assessment, and re-organisation of the expert statements, and discussions. By gathering opinions from a number of experts, this procedure can then make assessments on the possibilities, opportunities, and constraints of different topics with a long-term focus. From the results, starting points for further discussion or action can be developed. In addition, this phase of multi-stage surveys is often followed by a scenario process, which develops the acquired information to form future pictures. In some cases, the method is supplemented by a workshop or interim evaluation of the results.

Delphi studies have been conducted in Japan in connection with Foresight since the 1970s, and began to spread to Europe in the 1990s. They are gaining in popularity, especially because of the possibility of electronic surveys. One of the biggest challenges, however, remains the identification of relevant experts. Often, the return drops considerably in the second round, so a strong commitment is needed from the experts. It should also be noted that this method is based on results and has no measurable effect on communication and network building. For the benefit of Foresight, Delphi studies can therefore be combined with other methods, or simply replaced by them. Delphi surveys are mainly used for setting priorities in technological areas. For more complex issues, other methods are more suitable. Finally, it should be noted that Delphi studies promise a high accuracy of results; however, they are time- and labour-intensive, and costly. Instead of two-round expert surveys, forward-looking surveys that take into account society, politics, economics and/or science, may be performed using polling techniques that record the needs and perceived challenges of a wide audience. Such a survey is to be combined with other Foresight methods, in order to facilitate the desired dialogue between actors, and stimulate forward-looking discussion. Group workshops, facilitated by a moderator, for the collection of information and experience are suitable in different phases of a Foresight study. The interaction of the participants can either focus on topic areas, identified strategies, or results.

Often, in the early stages of Foresight, brainstorming techniques and SWOT analyses are used to structure the discussion, and panels consisting of around 10–20 experts are used to compile relevant expertise on a particular subject area. The interdisciplinary nature of this discourse lays the foundation for wider discussions. Here, the panels take different organizational forms. Expert panels are a valuable complement to other methods because they generate inputs, outputs, and direct the use of other methods. According to their use in the course of the Foresight study, the panels generate knowledge and opinions, develop scenarios, prioritize, and make recommendations. Also, specific tasks such as enriching memories of Delphi-statements, can be perceived by expert panels. In addition, the experts involved are used in part as ambassadors of the Foresight study to support the results in the eyes of the public, and to promote follow-up actions. If respected experts can be attracted, the prestige and authority of the Foresight study are increased. Accordingly, the choice of experts must be made transparently, and according to the function of the panel. In contrast to the expert panels, mixed panels of experts, stakeholders, and interested parties are also used. Through the exchange of ideas and opinions of different parties, an overall, broader perspective can be developed, which takes into account specific technical and social knowledge, and related interests. On such a panel, around 20 people are involved, most of whom were chosen based on recommendations and personal reputation. The scenario technique is carried out to assess how the identified factors (which were often identified using Delphi, SWOT and STEEPV techniques) could affect current, and in particular, future developments. Scenarios are particularly suitable in cases where a large number of factors have to be considered, and a significant degree of uncertainty persists. The scenarios therefore aim to assess a range of possible developments, and public reactions. Usually three to five different future scenarios are used to test the robustness of the recommendations. This stimulates strategic and creative thinking, and promotes communication among stakeholders, leading to more robust strategies.

In most Foresight studies, workshops and conferences are common methodological approaches. However, Foresight studies globally show a large variance in complementary methodologies, including impact matrices, multi-criteria analyses, scenario writing, backcasting, expert panels, background studies, and working groups. The differences in approaches reflect the meticulous balance that has to be found between the expertise of scientists and engineers, the interaction between researchers and users (industry, government, society), and the creativity of visions of the future (van der Meulen 1999).

4.3 Foresight Indicators

Meanwhile, it is common practice to evaluate the Foresight study itself. Such Foresight study evaluations are commonly done using different indicators, such as leading, lagging, and real time indicators, as well as input-, output-, and process-related indicators. However, despite the fact that these evaluation approaches have been developed quite thoroughly, evaluations of the longevity of the impact of Foresight studies are still lacking. Moreover, it has been shown that the effects of Foresight studies can hardly contribute to the long-term performance of a country in any respect. First, indicators are needed to evaluate the contributions of Foresight studies to the development, and the eventual impact of today's strategic decisions. Foresight studies typically cover a long time frame – 10 years or more – during which strategic policy decisions are usually revised several times, making it impossible to measure the impact of previous strategic decisions. Second, neither the direct nor the indirect impact of science and innovation on the economic performance and societal welfare of a country, region, or the world can be measured reliably. Although economic theory thus far recognises the contribution of technological progress to economic welfare and growth, there is no reliable quantitative measure for the contribution of technological progress, and thus innovation. Moreover, innovation per se is more than technology; it includes soft skills, which are not generally encompassed in the definition of technology.

Typically, such evaluations are based on indicators of the potential value, and contribution of Foresight studies. However, such contributions are measured by the achievements of specific goals, rather than the overall global context of the Foresight study (for example, relevant institutions, and linkages between institutions). One special feature of Foresight studies is the resulting impact through learning, understood here as the awareness of potential future developments; for example, broadening the horizons of institutions and actors, and helping them learn to design future-oriented policy and strategy in all fields related to innovation (van der Steen and van der Duin 2012). Hence indicators used for the evaluation of Foresight studies need to reflect the learning effects of Foresight studies. Moreover, softer impacts of Foresight studies such as the creation of trust between stakeholders form an essential part of the outcome, although these effects might be counterproductive as well. As most evaluations of Foresight studies are ex post evaluations, the broad spectrum of learning effects is barely considered; thus, misleading interpretations producing unfavourable consequences are highly likely to occur. In this light, evaluations of Foresight studies should also be used to contribute to learning the effects of the purpose, potentials, and limitations of Foresight studies; thus, the expectations, ambitions, and goals of stakeholders need appropriate reflection. A possible way to evaluate the output of Foresight studies is the analysis of the resulting scenarios' internal coherence, or the verification of the consistence of the developed vision (Boaventura and Fischmann 2008). The challenge, however, lies in determining the relationship of a company's or country's strategic STI direction (vision and products) to trends and megatrends in science and in the industry to which the organisation belongs (Battistella and Toni 2011).

From a learning perspective, it becomes evident that the established Foresight evaluation models need to be complemented by indicators that evaluate the learning potential, and, later on, its success. In other words, the related indicators have to reflect the Foresight study process, the impact achieved, etc., but also take advantage of the respective learning and improvement achieved at different levels. Such a requirement is especially challenging since it does not only affect the correlation between selected indicators, but also the causality dimension (van der Steen and van der Duin 2012). The established dimensions of Foresight study evaluation, namely quality, impact, and success, thus have to be complemented by the dimension of learning. Moreover, the Foresight evaluation process should be adjusted to these new requirements: it should be modified from the rather static approach towards a dynamic one that involves several learning and feedback loops; towards an interactive, exchange-oriented process. An evaluation process designed as an interactive process also has the potential to improve the trust and confidence of the stakeholders and participants in the Foresight process. As such it will render the decision-makers more inclined to implement the recommendations of the Foresight studies. This approach also enables Foresight practitioners to build a stronger bridge with the decision-makers, who are confronted with the challenges of operational daily management, and whose decisions are being more strongly determined by future considerations.

One of the main objectives of Foresight studies is to detect trends in science and technology. Detection and monitoring of such trends is often done using patent and/or bibliometric indicators (Gokhberg et al. 2013; Moed et al. 2004). These indicators are suitable for comparisons between different scientific and technological fields, countries, and organisations, and allow for studies of the life cycle of science and technology. Traditionally, it is assumed that publication statistics mirror basic research trends, whereas patent statistics reflect applied research trends

(Blind 2004); however, a look at both patenting, and publications reveals a slightly different picture. First, patent statistics are strongly influenced by the strategic and also cultural features of patent applicants and patent holders. Second, the role of patents is not limited to the protection of a market with active use of the underlying technology, but also serves the purpose of hampering the use of competing or substituting technologies for selected applications. Third, patent strategies – especially by large companies who hold the majority of patents – generally aim at filing a larger number of patents in order to protect narrowly defined applications, rather than smaller numbers of patents, which in turn protect a broad range of applications of a certain technology. Consequently, a patent statistics analysis might identify trends that do not necessarily allow for solid and reliable detection of the application of technology; even in the case of the use of property rights for fighting substitution technologies, these indicators evaluate the strength of technologies and the likelihood of substitution. Finally, the analysis of patent statistics is limited by the fact that completely new science and technology fields are usually the subject of patentability at the point when these fields first emerge, and well before they are included in the patent classifications (Blind 2004). However, longevity studies of patent statistics by technology field, or industrial classification enable the identification of technology fields with dynamic features (Schmoch et al. 2003).

Complementary, or even substitutive, indicators can be traced from technical standards released by standard-setting bodies (Blind 2004). The time lag between patent filing and actual commercialisation is considerable, especially for emerging technologies (Blind 2003). Hence, there is considerable risk at the early stages of technology development in emerging and enabling general purpose technology (EEGPT) fields, which in turn is expressed in rather modest patent activities. Furthermore, standards are not being negotiated and set at the very early stages of technology development, and are lagging behind patent applications, even though there is a need for regulation, and standardisation (Blind 2004).

Regulatory action becomes relevant for allowing emerging technologies to grow and establish in the early phases of the technology life cycle. The challenge lies in detecting the concentration of actors holding a critical mass of legal rights, which has the potential to limit, or even stop the development and application of technologies. Such detection can be done by using concentration indices of patents; for example, the share of single patent holders in the overall number of patents for a selected technology field (Blind 2004). Thus Foresight studies, especially broad, national ones, should not only focus on detecting emerging technologies, but should be complemented by a concentration index of technology owners and patent holders. The calculation of such an index is possible using a timeline of patent applications for a given technology, and the respective concentration index over a longer time period. The volatile development expressed by such a concentration index first gives insight into a emerging echnology, and application power of individual actors in the long-term. Eventually, such an indicator provides early detection of the mid- to long-term evolution of new industries around emerging technologies.

Table 4.2 Indicators for measurement of the attractiveness and feasibility of technologies

Attractiveness	Feasibility
The potential capability of a technology to give rise to relevant product and process innovations	The level of knowledge regarding a technology in academic, and public, research centres, and in local industrial systems
The pervasiveness of a technology	The availability of this knowledge in academic, and public, research centres
The potential capability of a technology to give rise to new firms	The number of researchers able to transfer a technology to local firms

The value of Foresight studies lies in its usefulness as a tool for strategic decision making; for example, in raising the awareness of decision makers of potential disturbances that might arise from the evolution of external conditions. Still, Foresight analysis of such trends does not stand alone; rather, it should be integrated into an overall national, regional, or institutional strategy "so that instead of remaining a mere exercise, it becomes actionable" (Battistella and De Toni 2011). Given this background, the outcomes of Foresight studies help decision makers and knowledge holders to understand whether the vision, and measures, of their country or institution are aligned with foreseeable, or possible, trends; additionally, they outline the major weaknesses of existing thinking, and measures, thereby establishing a culture of being "ready in advance" (Battistella and De Toni 2011). Indicators that are suitable for assessing technologies and knowledge are the attractiveness of technologies for a region/cluster, and the feasibility of development of these technologies in that region (Roveda nad Vecchiato 2008). Indicators which are suitable for assessing the feasibility and attractiveness of technologies, technology fields respectively as illustrated in Table 4.2.

Foresight studies typically result in different scenarios that mirror potential future developments. Moreover, such scenarios are quite frequently used as the basis for decisions about concrete measures. Thus, there is reason to introduce and apply an indicator that expresses the degree of materialization of the measures proposed, and implied, by different scenarios; for example, in an ex post assessment of a Foresight study, the indicator "share of realised measures" or "share of partially realised measures" is adequate to assessing the awareness, and plausibility of scenarios developed. These are then expressed in concrete measures. The "joint realisation rate" is the percentage of measures that are derived from Foresight outcomes for a special topic. The share of "not realised" measures indicates how many topics have not been put into practice to date, thus raising concerns about the plausibility of scenarios. In addition, the "expected realisation rate" indicator reflects potential development, and measures based on scenario analysis (Brandes 2009).

Table 4.3 outlines major indicators associated with methodologies applicable in the respective phases of a Foresight study.

Table 4.3 Indicators for Foresight methodologies

Phase Foresight process	Methodology	Objective	Indicators	Data requirements	Strengths	Limitations
Pre-Foresight/ scoping	Workshop	Identification of main research directions	Broad lists of technology and science fields	Objectivity required	Broad coverage of multiple topics/ subjects	Potential threat that Lobby groups might influence the agenda
	Key technologies	Revelation of the most significant technology directions in the subject field	Keyword counts	Broad keyword for technologies needed	Broad analysis	Vague analysis
Desk research	Literature review	Collection of initial information for the description of prospective markets, products, technologies, scientific and technological resolutions	Keyword counts	Quantitative data	Broad overview of topics/technologies	Difficulties determining the appropriate keyword
				Objective data solidly researched		Secondary data – collection procedure of primary data often remains unclear
	Bibliometrics	Reveal of recent trends of advanced products, demands and technologies in the subject field	Publication counts			
		Elaboration of preliminary list of experts (domestic and foreign) for expert group’s creation	Citation counts			
	Patent analysis	Reveal of recent trends of advanced products,	IPC class dynamic			

		demands and technologies in the subject field				
		Elaboration of preliminary list of experts (domestic and foreign) for expert group's creation				
	Benchmarking	Elaboration of a list of perspective products, technologies and R&D				
	Scanning	Estimation of external environment for subject field				
Expert procedures	Interviews	Adjustment in of a list of the most prospective products, technologies and R&D	Qualitative assessments Ratings Rankings			
	Expert panels	Creation of chains R&D–technology–products–markets, Discussion and assessment of future market dynamics, factors influencing market development in a long term prospects				
	Delphi	Identification of major trends, possible applications etc.	Quantitative	Micro data of the respondent and the organisation	Detect insights of specific needs for future regulation	High cost and time-consuming

(continued)

Table 4.3 (continued)

Phase Foresight process	Methodology	Objective	Indicators	Data requirements	Strengths	Limitations
			Qualitative	Assessment of future relevance of regulation, but also actual relevance of existing regulation	Findings from the surveyed sample can be generalized to the universe	Processing and analysis of data requires large human resources Identification of adequate samples Some types of information are difficult to obtain (answers to counterfactual questions or earlier situations) Long time series generally not available
	Surveys		Qualitative	Qualitative and semiquantitative data from Delphi surveys	Consensus-building to reduce uncertainty about regulatory priorities and impacts	Impossibility to detect major technological breakthroughs and their regulatory requirements
			Semiquantitative			In case of conflicting interests, missing-consensus about priorities Identification of experts Uncertainty increases with complexity of the context (technology, markets) and future time horizon

Creative analysis	Wild cards and weak signals (WiWe)	Determination of potential application fields	Weak signals	Structured data set	Open for new unexpected developments and trends	Indicative data but not scientifically founded
		Identification of new substantial market and market segments	Qualitative assessments without direct reference to special technologies	Semantic analysis of trends		
	Backcasting	Creation of an idea about expected state of a subject field				
	SWOT-analysis	Determination of strong and weak sides, assessment of opportunities and threats			Structured analysis of risk and benefits	Mainly qualitative indicators with reasonable room for interpretation
	Cross-impact analysis (CIA)	Analysis of innovation chains: R&D–technology–products assessment of interactions between products and technologies characteristics and also preferable consumer features in different segments of the market				
	Brainstorming	Determination of links between different elements of roadmap				

(continued)

Table 4.3 (continued)

Phase Foresight process	Methodology	Objective	Indicators	Data requirements	Strengths	Limitations
	Stakeholders analysis	Estimation of roadmap beneficiaries and ways of effective use of roadmap for them				
Interactive discussion	Scenario workshops	Development of alternative paths of subject area development	Quantitative data for market descriptions	Real time data with projected future developments	Different future scenarios developed	Uncertainty of future data
			Qualitative data for technology assessment	Primary data complemented with secondary historic data	Awareness raised for different combinations of possible futures	Societal and other weak data are hard to predict correctly
	Workshops	Public discussion of a roadmap. Bring the information about the main results to the notice of a broad spectrum of stakeholders				
		Indicators	Quantitative also providing qualitative information	Adequate science and technology indicators combined with qualitative data	Systematic approach	Only quantitative data is not sufficient to detect emerging fields of regulation
					Comparison across technologies, countries and over time	Little information about possible types of regulation
					Detailed analysis allows the identification of specific regulation-relevant content and even stakeholders	Influence of non-technology-related factors cannot be considered

Source: Adapted from Blind (2004)

4.4 Conclusions

Foresight is a powerful tool that is frequently applied in response to major challenges facing science, technology, and innovation policy. Such challenges include the failure of industry to exploit scientific discoveries, and the need to concentrate budgetary resources on research areas (Hanney et al. 2001). With the use of Foresight policy makers give a clear indication to the science, technology, and innovation community that policy making in a broader sense is considering a bottom-up approach rather than a purely top-down one.

Foresight in a broader sense goes beyond simple predictions by including competitive intelligence approaches at different levels; in this manner, it becomes anticipatory intelligence, based on a wide diversity of viewpoints, and knowledge sources (Malanowski and Zweck 2007). These sources in turn serve as a base for future-oriented decision making. Essentially, Foresight is "an instrument of strategic policy intelligence which seeks to generate an enhanced understanding of possible scientific and technological developments and their impact on economy and society" (Salo and Cuhls 2003). Foresight therefore considers the role and impact of technology in the framework of the economy, and society as a whole, thus linking science and technology to wealth creation, and improvements in living standards (Martin, Johnston 1999).

Foresight studies at the national level need to consider not only the future prospects of technology fields, and the competences already available in existing clusters within a country in order to leverage the economic, and social potential of these technology fields. It is also crucial to consider the existing infrastructure in order to achieve a successful and sustainable implementation of study results. Hence, "what really matters is the need to convince these firms that the new technology will not force them to give up the position they have in the local socio-economic system and to which they are used; what really matters is to convince these firms of the possibility of fully grasping the new technology, and therefore of shaping it, so being able to still play a relevant role in the continuous knowledge creation process, which underlies the future evolution of the technology" (Roveda and Vecchiato 2008). Thus, future technology and knowledge fields detected by Foresight studies need to be converted into understandable and usable language in order to be accepted and absorbed by local industrial clusters. Roveda and Vecciato correctly assert that for product creation, and generation within a regional cluster, it is not only organizational skills, and processes that are important, "but also its history, culture, social values: definitely, a combination of resources and circumstances that, altogether, are something of unique and completely different from the one of any other place. Therefore, if external scientific and technological experts want to give an effective contribution to local firms, they must be able to become themselves a part of the district, by speaking an understandable language and by adapting their approach to problem setting and solving to the usual way of thinking and doing of local entrepreneurs" (Roveda and Vecchiato 2008). The "knowledge creating company" proposed by Nonaka and Takeuchi as early as the mid-nineties stresses the importance of overlapping information, resources, and business activities within companies, and regional agglomerations of companies. In addition, the inclusion of companies alone is no guarantee that Foresight studies can, and will have a measurable and sustainable impact. Moreover, it is essential to involve company representatives from different hierarchical levels – senior management, middle management, and frontline employees – in the Foresight studies, since they all have different perceptions of the capabilities of the companies, the interfaces within, and between the companies, and of the external infrastructure of comapanies (Nonaka and Takeuchi 1995). Hence, within corporations there are different types of knowledge generated, and used in daily operations, which do not necessarily fit into long-term, focused Foresight studies. It turns out that the scope of Foresight studies is even broader encompassing different types of knowledge.

In addition, communication between different actors and hierarchical levels strongly influences the way information is perceived. Beyond the formal output of Foresight studies, follow-up activities are needed.

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 of any given Foresight study, and the selection of methodology within the Foresight framework. Given the 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 tailor-made for each Foresight study, which in turn are not necessarily fully comparable between different Foresight studies. However, these indicators might eventually be used as input for other Foresight studies.

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