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Foresight tackling societal challenges: Impacts and implications on policy-making☆

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ABSTRACT

Foresight activities are often conducted to anticipate major societal future challenges and provide support to current decision-making. Whereas the paper reports some findings on the future of challenges especially related to sustainability, security and information society, it mainly provides evidence on how foresight impacts on policy-making and societal developments. The paper elaborates a framework with key design dimensions related to foresight process and outcomes in order to characterise different kinds of foresight projects. The framework is applied for the empirically based ex post analysis of selected foresight projects around the world in order to clarify (i) different roles for foresight in the innovation system and society and (ii) its respective impacts and implications on policy.

1. Introduction

In the realm of future-oriented technology analysis (FTA) [1] that encompasses foresight, forecasting and technology assessment approaches foresight is perhaps the most comprehensive one suitable for providing policy support to address major societal challenges. Foresight can be seen as a crucial function to prepare for the future; not only to identify the promising technological pathways, but also to engage relevant stakeholders and create common visions into action [2,3]. Furthermore, foresight processes can also become a pertinent design phase for the creation of new value networks that are based on the novel combinations of technologies, organisational partnerships and institutional arrangements. Interestingly, these dimensions match largely with approaches addressed when the major societal challenges are dealt with.

The locus of foresight activities has tended to shift from positivist and rationalist technology-focused approaches towards the recognition of broader concerns that encompass the entire innovation system, including its societal perspectives, for instance, sustainability, security and information society. While foresight is commonly used in connection with the public-

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sector agenda setting, it is also ever more common practice in business, non-governmental and international organisations. Furthermore, the focus on long-term developments and emphasis on the system level analysis, for instance, mean that it has not been easy to evaluate the impacts of the foresight project (for instance, [4–6]).

We elaborate further a foresight framework developed by Könnölä et al. [7] to characterise different foresight projects and apply it to ex post analysis of some national and international foresight projects around the world in order to clarify (i) different roles of foresight in the innovation system and (ii) its respective impacts and implications on policy and societal developments.

Section 2 elaborates the conceptual framework for the characterisation of different foresight projects. In Section 3, some national and international projects are examined and characterised within the framework, of which results are discussed in view of impacts on policy-making. Section 4 provides some conclusions and discussion on the possible advantages of the proposed framework for the characterisation of foresight projects as contribution to the policy-making process.

2. Characteristics of foresight projects

To understand the impacts of foresight in the system, it is beneficial to identify different types of foresight activities. The design of foresight activities addressing societal challenges can benefit from the structured approaches that help to identify the expectations concerning the management of the foresight process and final outcomes [8]. The systemic understanding of innovation processes has challenged conventional technology driven forecasting practices and called for new participatory foresight approaches that address also the consideration of diverse perspectives, formation of shared knowledge and examination of alternative futures. Foresight activities are also increasingly seen as crucial functions in order to prepare for the future – not only to identify the promising technological pathways but also to engage relevant stakeholders and create common visions and action plans [2,9]. Furthermore, foresight processes can often be seen as a pertinent design phase for the creation of new value networks that are based on novel combinations of technologies, organisational partnerships and institutional arrangements.

Along these lines Könnölä et al. [7] have developed a framework for the purposes of strategic management of a foresight portfolio in a contract research organisation. In this paper this framework is applied and elaborated for the purposes to characterise foresight projects conducted around the world in relation with major societal challenges. The framework consists of four key design dimensions. The first dimension addresses the type of main outcomes of the foresight project referring to its different kinds of impacts on the policy and society at large. The second dimension is about chosen future perspectives in the design of the project. The third dimension focuses on the way the project is managed and coordinated. And finally, the fourth dimension deals with different ways of engaging stakeholders in the project. In each of the four dimensions archetypal dichotomies are conceptualised for the further characterisation of a foresight project. Furthermore, for classification purposes, the framework considers outcomes and future perspectives both referring to the outcome-related aspects of the project, for instance responding to a question on what and what kind of outcomes are achieved. The management approach and stakeholder engagement refer, instead, to the process-related aspects of the project, for instance responding to a question on how the outcomes were achieved and by whom.

2.1. Type of outcomes prioritized: informative vs. instrumental outcomes

Foresight outcomes consist of outputs, results and impacts of the project. Outputs refer to the products and services, tangibles and intangibles. Results in turn refer to advantage (or disadvantage) that the beneficiaries obtain soon after the end of their participation; and impacts refer to consequences affecting beneficiaries during and after the project. For the purposes of the paper we consider instrumental and informative outcomes that are defined as follows:

- *Informative outcomes* refer to the use of foresight process and dedicated methods to improve the awareness and understanding of present and future challenges of the innovation system and its parts. Thus, the informative outcomes do not refer to the expectations that a foresight activity would necessarily lead to specific actions.
- *Instrumental outcomes* refer not only to informative outcomes but also to the use of foresight to support the specific foreseen decision-making situation, for example related to resource allocation or the formation of strategic partnerships or joint actions.

In view of societal challenges, there is a need to provide outcomes to support targeted decision making situations. As well it is necessary to collect and codify information that allow a better understanding of the future drivers and challenges, develop visions, defining the setting of priorities and have more accurate forecasts on the time-horizons of S&T developments.

2.2. Chosen future perspectives: consensual vs. diverse

Future perspectives can be addressed to define the approach of how and with what methods the project develops understanding of the future. Foresight activities often focus on the production of consensual future perspectives that refer to the creation of common understanding on priorities, relevant collaborative networks and future actions. These outcomes can be addressed in view of consensual or diverse future perspectives [9]:

- *Consensual future perspectives* refer to the creation of common understanding on priorities, relevant collaborative networks and future actions.
- *Diverse future perspectives* refer to developing and understanding diverse ideas, opinions and perspectives in priority-setting, identifying and fostering alternative and competing coalitions and value networks as well as exploring alternative futures and generating rivalling visions.

Addressing both consensual and diverse future perspectives are crucial dimensions when dealing with sustainability, and security. In both fields, in particular the development of alternative scenarios help addressing uncertainties and diverse interconnections between many drivers. On the other hand, it is crucial to be able to develop also consensual visions and recommendations into action for policy and in more general decision-making processes.

2.3. Chosen management approach: fixed vs. autonomous

The foresight process can be taken up with different kinds of management approaches, which are often driven by the diverse expectations laid on the project. The creation of new, especially shared, knowledge is challenging, in particular, when the people participating in the foresight process typically have heterogeneous backgrounds, which occurs when various interest groups (industry, academia, government, NGOs, etc.) and different geographical areas (countries, regions, etc.) are engaging in the foresight process. This means that special attention must be paid to the organisation of the process and to the appropriate use of formal tools and procedures. Furthermore, those in charge of the foresight process are likely to benefit from the sharp definition of their role and approach in the management of the process. This makes it easier to design the process in a coherent way and to communicate the responsibilities of different stakeholders. Here, two extreme approaches can be identified in view of the classification purposes [10]:

- *Fixed management* can be characterised as centralised approach in which co-ordinators fix the scope and methods of the project at the outset and control the process, which is often the case for example in Delphi projects [11].
- *Autonomous management*, in turn, refers to the process intermediated by the co-ordinators, who facilitate autonomous and evolving participant-led continuum of meetings and other activities, which maybe the case for example in expert panel work.

Addressing major societal challenges such as security, sustainability and information society issues requires typically many types of participants as well as different kinds of methods to adapt to the interests and expectations of the participants but can also ensure the relevant outcomes useful for further application in decision-making. Thus, both dimensions may play important role in the design and management of a foresight process.

2.4. Chosen emphasis in stakeholder engagement: extensive vs. exclusive

One way to conceptualise stakeholder engagement is to define extensive and exclusive stakeholder engagement [12] and the continuum of different possible combined approaches between them, namely from confined exclusive engagement to extensive but exclusive engagement towards to extensive and open engagement of stakeholders.

- *Extensive stakeholder engagement* refers to the approach in which the actual number of participants is high, the stakeholder participation is encouraged and open for all the interested stakeholders and many kinds of stakeholders are invited to participate in the process.
- *Exclusive stakeholder engagement* means that stakeholder participation is not extensive and thus not open for all the stakeholders interested.

Extensive stakeholder engagement in a foresight process in which experts are also involved, allows stakeholders to become better aware of signals of change and threats and consequently to put in place preparedness mechanisms to act on time. Anticipation of intelligence (or knowledge) is a contribution to improve the knowledge base for the designing of policies. In the security, sustainability and information society fields, stakeholders have the possibility to develop scenarios on which basis diverse policy options could be outlined. Other benefits that could be achieved through the Foresight process include creation of linkages among participants, development of a shared understanding on the various issues at stake, and on future challenges. The opportunity for exclusive participation in foresight may also be highly important, since this mode allows confidentiality and trust among the participants. Hence, it is likely that in the foresight designs both exclusive and extensive elements are present.

3. Empirical findings on foresight projects addressing societal challenges

3.1. Introduction

Major societal challenges have been addressed by the foresight community for already several decades. In this paper we focus our analysis on three areas that have been increasingly addressed by the foresight community:

Table 1
Selected foresight projects addressing societal challenges.

Project	Outcomes	Future perspectives	Management	Stakeholder engagement
Nordic ICT Foresight[a] [17]	*Informative* Evaluations of key ICT applications, Nordic scenario set in context of ICT development, scenario-based visionary roadmaps. Building views of the Nordic potentials in ICT development among key actors. Action proposals and policy recommendations.	*Diverse* Alternative scenarios. Also identification of ICT applications with development potentials in Nordic region; future-oriented elaboration of factors affecting the Nordic business and development environment in ICT.	*Fixed* Structured discussion and the generation of new ideas in the workshops *Autonomous* Creative brainstorming and ideation in the different scenario and roadmapping workshops.	*Exclusive* Intensive stakeholder engagement in core group *Extensive* Co-operative idea and concept creation among stakeholders from different Nordic organisations and firms; networking.
VTT Water Research Roadmap 2006[b]	*Informative* Create common understanding on future challenges and VTT expertise. *Instrumental* Support the formation of different streams of R&D actions within VTT.	*Diverse* Inclusion of alternative views on priority-setting. The identification of key action areas for VTT water research and their priority-setting.	*Fixed* Structured questionnaire; defined agenda for workshops and structured priority-setting. *Autonomous* Flexible use of methods in working groups.	*Exclusive* VTT expert engagement in steering group and workshops to enable intensive communication. *Extensive* Networking among VTT experts on water related R&D through questionnaires, co-writing.
Nordic H2 Energy Foresight[c] [18]	*Informative* Awareness raising and deepening the overall understanding of the entire value chain (hydrogen production, storage, distribution, stationary hydrogen uses and hydrogen uses in transport). An action plan for the Nordic key actors – without a direct link to any decision process.	*Consensual* Shared understandings were searched for in order to be able to give action recommendations for the Nordic key actors. Still, a variety of views and opinions were considered and debated during the process.	*Fixed* The overall design of the process was determined already when planning the project. The model and modelling techniques in use guided the data gathering of the system analysis part. *Autonomous* There was still a significant degree of freedom to adapt to the perceived needs during the process and the development of roadmaps and scenarios.	*Extensive* The participation was open for research institutes, industry, associations and public organisations of the five Nordic countries.
EU: IRRIIS scenario work[d] [19]	*Informative* Identification of emerging safety and security issues in an EU project to ensure the safety of critical infrastructures.	*Consensual* A project level consensus on the future developments. Still, different scenarios were considered.	*Fixed* A fixed procedure and methods selected in the beginning of the project. *Autonomous* Autonomous scenario work among the stakeholders. The experience of stakeholders "overwrote" the methodological rigidity in some points.	*Exclusive* The work was carried out among the project partners. *Extensive* The results were tested against available expertise outside the project consortium.

Table 1 (*Continued*)

Project	Outcomes	Future perspectives	Management	Stakeholder engagement
UK DCDC Global Strategic Trends Programme	*Informative* Identification of cross-dimensional analysis of the future context of defence in the next 30 years. *Instrumental* The document is a source for the development of the UK Defence policy.	*Consensual* This process aims to provide new evidence and thinking on strategic trends on specific risks highlighting significant defence and security implications. The findings consist in probability based outcomes.	*Fixed* The procedure was fixed at the beginning of the process. It applies trend analysis with a time-horizon of 30 years. *Autonomous* Expert group work.	*Exclusive* Process was mainly small expert group work. *Extensive* Ideas were exposed in conferences and a survey was launched to opinion-formers leaders in business, government, media, NGOs and academia. The outcomes were reviewed by external experts. The findings were tested against the views of an international and largely non-Western peer group.
Foresight Canada[e]	*Informative* Identification of emerging and frontier technology domains addressing subjects such as future fuels, bio-health innovation, geo-strategic systems, animal health and infectious disease. *Instrumental* The outputs were used to contribute to a joint security technology initiative of Canada as well as strategic S&T investments in the Defence R&D Canada Centre for Security Science.	*Consensual* The outputs drove discussions of national security challenges to provide input into capabilities needed to meet these challenges.	*Fixed* Strategic environmental scan based on experts' view was used assess probability and impacts of projected threats. *Autonomous* The overall process was based on workshops. Creative workshop discussions.	*Extensive* The process involved a network of security stakeholders. These were coming from different government departments, private companies, and research organisations. *Exclusive* Only invited participants.
Generation of innovation ideas in Finnish Foresight Forum[f] [20]	*Informative* Identification of future developments in nutrigenomics, (ii) health care and social services and (iii) services for the provision of personal experiences. *Instrumental* Identification of innovation ideas and promoting stakeholder networking.	*Diverse* Analysis of diverging views on innovation ideas among stakeholders.	*Fixed* Robust portfolio modelling, online surveys. *Autonomous* Stakeholder workshops.	*Extensive* Wide stakeholder participation in online surveys. *Exclusive* Limited but open stakeholder participation in the workshops.

Table 1 (*Continued*)

Project	Outcomes	Future perspectives	Management	Stakeholder engagement
FISTERA: Foresight on Information Society Technologies in the European Research Area[g] [21]	*Informative* Identification and SWOT analysis of socio-techno-economic trends, drivers and challenges; key characteristics of ICT research in Europe including human resources aspects; futures challenges, applications and priorities for developing the information society in the EU. *Instrumental* Outputs contributed to prepare the FP7 (Framework Programme) ICT programme.	*Consensual* FISTERA identified priority application areas where investments in ICT research should be intensified in the future, motivated both by S&T developments and by socio-economic needs.	*Fixed* Scenario workshops, on-line Delphi study, on-line forum, national seminars (“FISTERA road show”), supported by desk research). *Flexibility* Results of each phase of the project were widely disseminated and feedback on these results was used in the next phases, also to adapt the methodological approach.	*Extensive* There was an extensive engagement of stakeholders. More than 500 experts including policy makers, business actors and researchers from all EU Member States responded to the on-line Delphi study. In addition, more than 600 stakeholders in a various EU Member States were addressed in a series of national seminars. A number of scenario workshops were held, each involving in average 25 participants.
Future Impact of ICTs on Environmental Sustainability[h] [22]	*Informative* Explore how ICTs will influence future environmental sustainability (time horizon: 2020) and develop policy recommendations. Results were discussed with both DG Information Society and DG Transport and Energy of the European Commission.	*Diverse* Description of a large degree of uncertainty of impact of ICTs on the environment. The scenarios developed during the project accommodated a diverse range of views and suggested a number of possibilities.	*Fixed* The methodology was fixed at the beginning of the project. It consisted of data gathering and combination of qualitative scenarios and quantitative modelling.	*Exclusive* The project was mainly conducted by the research partners. The scenario building step involved around fifteen external experts and stakeholders. At various steps of the projects, experts were consulted to validate the results and methodological aspects. Policy recommendations were validated thought interviews of about twenty experts in ICT or environmental policy
The 8th Japanese technology foresight program	*Informative* Understanding future S&T challenges. *Instrumental* The 8th Japanese technology foresight program aims to provide necessary information for making the 3rd S&T basic plan of Japan.	*Consensual* The 8th Japanese technology foresight program consists of consensual Delphi survey, scenario, bibliometrics and needs analyses.	*Fixed* The methodology for the 8th Japanese technology foresight program is fixed at the beginning of the project, including: Delphi, Scenario, bibliometrics, and social and economic needs analysis. *Autonomous* There was still a significant degree of freedom to adapt to the perceived needs during the process and the development of scenarios and social and economic needs.	*Extensive* There was an extensive engagement of diversified stakeholders. About 2239 experts participated in Delphi survey. Also, many experts of social sciences participated in scenarios analysis and needs analysis.
Innovation 25 in Japan	*Informative* The final report of “innovation 25” has set out 5 scenarios for future Japan, and find out the prior S&T topics to achieve the social goals. Instrumental “Innovation 25”aims to make long-term strategy for Japan.	*Consensual* “Innovation 25”has set 5 scenarios of Japan society in 2025,and it includes “Long Health Society”, “Safe and Secure Society”, “Society with Multiple Career Path”, “Japan contributing to Global Issues” and “Japan Opening to the World”.	*Fixed* The methodology was fixed at the beginning. The Cabinet Office established the Innovation 25 Strategy Council and the Innovation 25 Special Mission, and six fields were discussed by workshops independently. *Autonomous* There is freedom in discussion for social scenarios in each field, and the priority setting of science and technology based on technology foresight.	*Extensive* There was an extensive engagement of diversified stakeholders from government, academia and industry.

Table 1 (*Continued*)

Project	Outcomes	Future perspectives	Management	Stakeholder engagement
National Technology Roadmap in Korea	*Informative* Learning about the technology pathways and needs. National Technology Roadmap in Korea aims to make long term strategy plan.	*Consensual* National Technology Roadmap (NTRM) in Korea has set up five complementary visions, two of which are related to sustainability and security directly, including "Advancing the E2 (Environment and Energy) Frontier" and the "Improving National Safety and Prestige".	*Fixed* The major activities in establishing NTRM have been guided by the NTRM Head Council. The Executive Committee was also set up with 5 sub-committees that are the core body in developing NTRM. In addition, TRM teams (in total 74 teams) were set up to draw TRMs for key technologies in the second stage. *Autonomous* Each TRM team consists of around 10 technology experts from industries, academic circles and research circles.	*Extensive* A total of 751 committee members have participated in drawing NTRM.
The Revision 3rd Korean technology foresight	*Informative* S&T developments *Instrumental* The "Revision of 3rd Korean TF" aims to strength the linkage between the foresight and policy-making, namely to provide necessary information for making the 2nd Korea S&T Framework plan.	*Consensual* The "Revision of 3rd Korean TF" has analysed the impacts of 19 megatrends & issues, and identified 182 future strategic technologies.	*Fixed* The methodology was fixed at the beginning.	*Extensive* There are broad engagement of diversified stakeholders from government, academia and industry.
National Technology Foresight in China	*Informative* Understanding future S&T developments and needs. NTFC aims to provide also necessary information for making five-year plan of science & technology development.	*Consensual* NTFC has identified lots of key technologies in 9 research fields based on the Delphi survey.	*Fixed* The methodology was fixed at the beginning.	*Extensive* Very diversified stakeholders from government, academia and industry have participated in NTFC.
Technology Foresight towards 2020 in China	*Informative* TF2020 aims to provide necessary information for making long term strategy for science and technology development in China, and for influencing the allocation of S&T resources in CAS.	*Consensual* TF2020 has set up 6 pictures of China development in 2020, and identified 734 key technologies in 8 research fields based on the Delphi survey.	*Fixed* The methodology was fixed at the beginning.	*Extensive* Diversified stakeholders from government, academia and industry are very active in the process of TF2020.

[a] Commissioned by the Nordic council.
[b] Commissioned and conducted by VTT Technical Research Centre.
[c] Commissioned by the Nordic council.
[d] The EU Integrated Project IRRIIS – Integrated Risk Reduction of Information-based Infrastructure Systems.
[e] Commissioned by the Office of the National Science Advisor (ONSA).
[f] Commissioned by the Finnish Government.
[g] A FP5 IST Thematic Network (2002–2005) coordinated by JRC-IPTS and managed in collaboration with DG Information Society.
[h] Commissioned by JRC-IPTS.

- *Sustainability:* since the Brundlandt Commission [13], many alternative definitions of sustainability have been proposed and diverse interpretations of the concept made. Many of these are based upon the 'three-pillar' or 'triple bottom line' concept, which separates development issues into social and economic factors, emphasising that material gains are not sufficient measures or preservers of human well-being [14]. For instance, some major sustainability challenges address climate change, global equity and competiveness.
- *Security:* the term refers to the condition of being protected against danger or loss that originate from outside such as war, disaster, civil unrest, vandalism, or sabotage. Herein, security means that something not only is secure or safe but that it has been secured. Security is typically related to critical infrastructure, a term used by governments to describe material assets that are essential for the functioning of a society and economy (such as electricity generation and distribution, telecommunication, transportation systems, public health, financial services, and security services (both police and military).
- *Information society:* a term put forward by Castells [15] to describe a society built on technologies of information storage, retrieval, and transmission, time-space compression, post-Fordism, flexible accumulation, and the advance of finance capital, which is characterized by networking, globalization, and the flexibility, individuality, and instability of work. Information society calls, for instance, for a new legislative framework to recognize and protect the users of cyberspace. The European Commission has been an active promoter of the information society.[4]

While the authors consider diverse approaches valuable in the realm of foresight to address societal challenges, for the purposes of this paper, the empirical part focuses on foresight and its respective implications on policy. A quick scan was performed on foresight projects that address security, sustainability and/or information society issues. The suitability of the identified projects was discussed and the list of projects for further analysis was agreed. The attempt was not to make a global scan of the conducted foresight projects in these fields, but rather to analyse projects that the authors knew well and considered relevant and/or distinctive to provide some empirical findings for further analysis and for attesting the developed framework and its usability. The projects are described shortly in Table 1.

The conceptual dichotomies of the foresight dimensions defined in Section 2 provide a structure for the analysis assuming, of course, that foresight project consists of identifiable elements for the classification. In practice, foresight activities often consist of some elements of the both sides of these dichotomies, and altogether they form the combination of a case specific process design. The positioning of individual projects in the framework clarifies the methodological decisions and the rationales of stakeholder engagement. Once the projects are positioned in the framework they provide an overview of the whole portfolio of foresight projects analysed that supports building the more holistic view of the selected activities.

The foresight projects listed in Table 1 can be classified according to the foresight design and management dimensions discussed in Section 2. When the dimensions of outcomes (informative vs. instrumental) and future perspectives (consensual vs. diverse) correspond the horizontal and vertical lines, the selected foresight projects (described in Table 1) can be positioned in four different quadrants (consensual and informative; consensual and instrumental; diverse and informative and diverse and instrumental) (Fig. 1).

In parallel, the projects can also be positioned in view of process oriented dimensions. When the process management (autonomous and fixed) and stakeholder engagement (extensive and exclusive) dimensions are considered to correspond to the horizontal and vertical axes, they produce together a coordinate system (see Fig. 2). Here, the horizontal axis represents the qualitative continuum from fixed to autonomous management, and the vertical axis the continuum from extensive to exclusive stakeholder engagement.

Further on, if the coordinate system of Fig. 2 is positioned to each quadrant of Fig. 1, the foresight projects can be positioned in the coordinates to provide detailed information on the nature of the outcomes and process of each project (Fig. 3). Hence, once the project is in one of the four quadrants (according to consensual vs. diverse and informative vs. instrumental) the position of the project can be defined in the coordinates (from fixed to autonomous and from exclusive to extensive).

Projects positioned in the quadrants and the coordinate systems provide bases for further analysis of their characteristics and methodological choices. Subsequently, we discuss the impacts of the selected projects on policy in the four quadrants, which we call *Visions*, *Priorities*, *Agora* and *Innovations* foresight.

3.2. Visions foresight (consensual perspectives and informative outcomes)

Visions foresight can be characterised as consensual, informative processes that create understanding on common priorities, relevant collaborative networks and/or future actions. They are expected to improve the understanding of present

[4] In 1997 the European Commission published a "Green Paper" pointing at the development of a new Information Society, characterised not only by convergence of technology and by exchange of information other many different networks, but also by development of new services and new ways of doing business and of interacting with citizens [16]. The main purpose of the green paper was to launch a debate on the regulatory framework to put in place in order to support the development of the Information Society in Europe. In parallel with addressing regulatory aspects, the European Union (EU) included in its Fifth Framework Programme for Research and Technological Development (FP5: 1998–2002) a specific programme for research on a "User-friendly information society". Today, with the i2010 policy framework, the EU aims to "promote the positive contribution that information and communication technologies (ICT) can make to the economy, society and personal quality of life," and the ICT priority has the largest budget share of the current European RTD Framework Programme (FP7: 2007–2013).

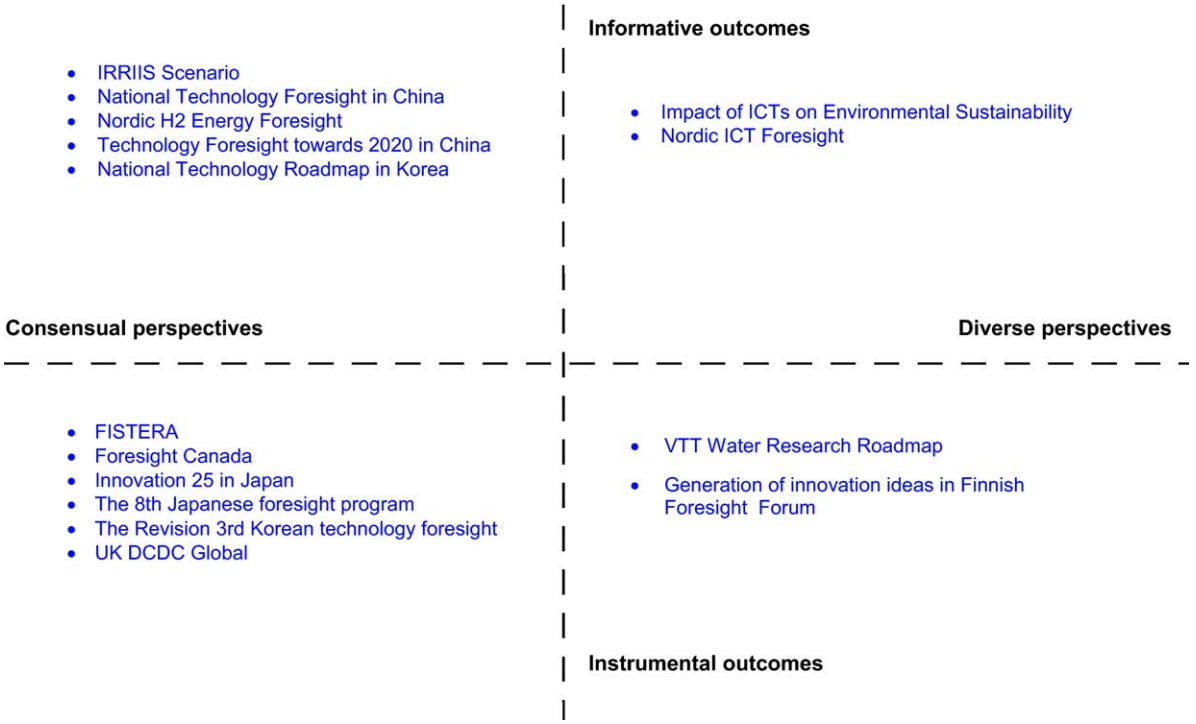

Fig. 1. Foresight projects positioned in view of the dimensions of outcomes (informative vs. instrumental) and future perspectives (consensual vs. diverse).

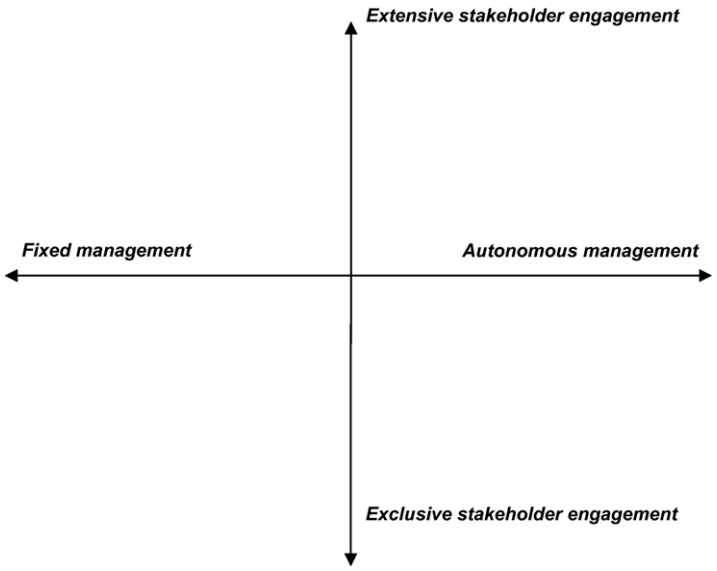

Fig. 2. Process management (from fixed to autonomous) and stakeholder engagement (from exclusive to extensive) dimensions in a coordinate system.

and future challenges of the innovation system and its parts. However, specific short-term actions are not necessarily expected after the projects. This setting relieves the participants partly from claiming value and from the pressures of policy-making and lobbying and hence may enable also otherwise adversary parties to learn together and search for common ground for long-term agendas.

Among the foresight projects examined, *IRRIIS Scenario* work was part of the European integrated project that provided improved understanding of the developments in the security field. It was expected that the project results would describe the future scenarios in detail, including diverse uncertainties in such scenarios. This challenge was dealt with in the brainstorming workshops, intensive e-mail communication, commenting and co-writing. The consensual scenario work was

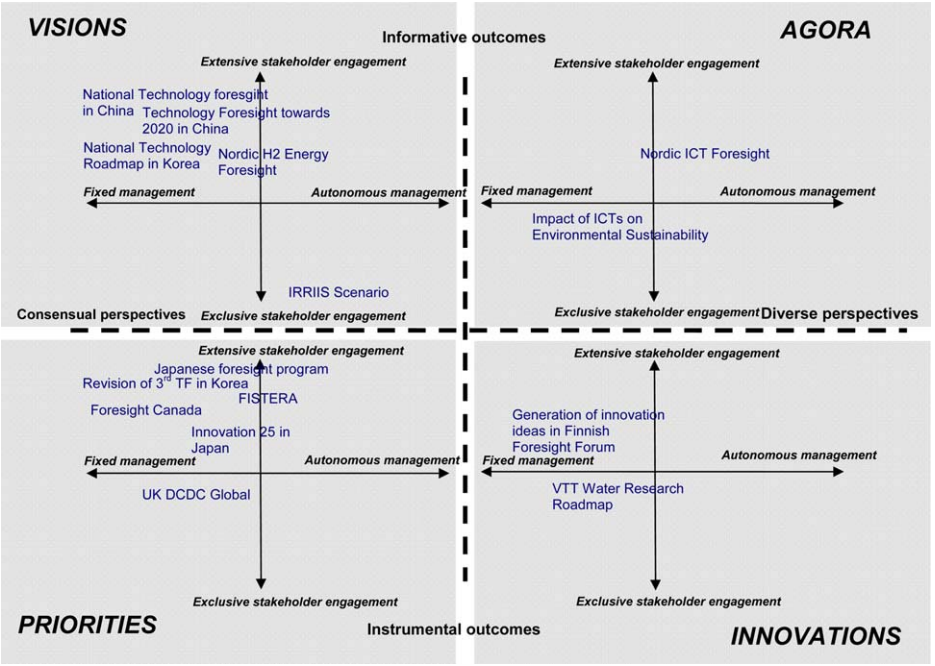

Fig. 3. Foresight projects positioned in view of the dimensions of outcomes (informative vs. instrumental), future perspectives (consensual vs. diverse) and in the coordinate system of stakeholder engagement (extensive and exclusive) and management (autonomous and fixed).

considered extremely challenging due to high uncertainties related to the issue. The results were communicated to the Commission, but direct impacts to policy-making have not been recorded.

In the *Nordic H2 Energy Foresight* the major challenge was to create shared understandings on future hydrogen-based energy systems between different stakeholder groups representing five different countries. For foresight activities on emerging issues that are not yet proven to be of high policy importance it may be difficult to engage policy-makers in the process. In the Nordic H2 Energy Foresight, specific efforts were made to engage policy-makers but with limited immediate success. This may be partly due to the initial positioning of the projects as informative rather than instrumental, thus not considered as policy-making processes [9]. At best, indirect and diffuse policy links during and after such projects may be influential in the long run, however.

Consensual and informative foresight processes in Asian countries such as Japan[5], China[6] and Korea, seem to have important role both in enhancing national systems as well as in the international communication. National Technology Foresight in China and Technology Foresight towards 2020 in China as well as National Technology Roadmap in Korea were all strongly informative processes that were initiated to capture experts' views on future S&T challenges. Hence, the processes served policy-making by providing relevant background information, but they were not as such meant to engage policy-makers in the process. In practice, the technology foresight in Korea and China has borrowed lots of experiences from technology foresight projects in Japan.

3.3. Priorities foresight (consensual perspectives and instrumental outcomes)

Priorities foresight can be characterised as consensual and instrumental processes that create common understanding on priorities, networks and/or future actions as well as support the specific foreseen decision-making situation. Among decision-makers this is likely to lead to interests in the results. However, policy interests may also enter in the foresight process and create rigidities and difficulties to provide new and fresh perspectives for change. This may be supported by ensuring extensive stakeholder participation through the diversity and high number of participants.

Among the foresight projects examined, *FISTERA: Foresight on Information Society Technologies in the European Research Area* (2002–2005) was an FP5 IST Thematic Network coordinated by JRC-IPTS and managed in collaboration with DG

[5] Japan is the pioneer of technology forecasting and foresight, and has completed 8 times technology foresight activities since 1970.

[6] FTA projects in China in broad sense can be traced to "The 12 Years Science Development Planning" made in 1956, when over one thousand top scientists participated in the work ranging from technology selection, priority setting, subject arrangement, resource distribution, by using a method similar to a Delphi survey.

Information Society. FISTERA highlighted priority application areas where R&D investments should be intensified in the future, motivated both by S&T developments and by socio-economic needs [23]. FISTERA did influence directions for R&D in ICTs in Europe. Its contribution was, however, difficult to trace in published official documents of the European Commission that often do not explicitly refer to sources of ideas. Its results fed and generated a number of debates on the future of information and communication technologies and the development of a knowledge society in Europe. In terms of indirect impact, the "Technology Trajectory" concept developed by FISTERA was used by industry and academia as a "thinking tool". The FISTERA methodology inspired several national foresight projects, notably in Austria and Hungary. A review of FISTERA by NISTEP underlined the relevance of FISTERA's approach to formulate national science and technology policies also in Japan [24].

The *Foresight project conducted in Canada* through a series of collaborative projects aimed at emerging and frontier technology domains that could be important to national policy development process for the next ten years. The outputs were used to drive the interdepartmental discussions of challenges to Public Safety and Emergency Preparedness Canada (PSEPC), the capabilities needed to meet the challenges, and how S&T foresight and strategic S&T investments in the new Centre for Security Science could help to acquire those capabilities. The process assisted the new Public Security Technical Programme (PSTP) of the Canadian office of the National Science Advisor (ONSA). ONSA had been asked to provide advice on a futures-oriented Public Security Science and Technology agenda that could be aligned with the US Department of Homeland Security as part of the Security and Prosperity Partnership of North America. The initiative provided focus to the capabilities and skill areas that a new Defence Research & Development Canada (DRDC) Centre for Security Science might need to meet the anticipated national security.

The outcomes of consensual and instrumental *technology foresight activities in Asian* countries such as Japan, Korea and China have played increasingly important role in the policy-making process for science & technology and innovation. For instance, the 8th technology foresight provided important support for making the 3rd basic plan for science and technology of Japan. China is planning to make the 12th five years plan for science and technology development by using the knowledge generated from roadmap activity.

In the UK, the Development, Concept and Doctrine Centre (DCDC) a Directorate General of the Ministry of Defence (MOD) conducted a foresight process that produced as a key output a report "the *DCDC Global Strategic Trends Programme* 2007–2036". The trend-analysis is supported by a wide external consultation of experts in order to make the information included in the report both comprehensive and independent. The work is the product of analysis by the DCDC therefore it could be labelled as exclusive in terms of stakeholder engagement. However, it has aspects of extensive engagement of stakeholders as outcomes are tested against the views of international panel of peer experts through exposure of results in conferences and by commissioning a survey that is consulting leaders in governments, business NGOs and the academic sector. It is updated on a regular basis as new evidence and thinking emerge. This initiative is designed to result in improved quality of defence policy. It is one of the source documents for the development of the UK Defence Policy. The outcomes of DCDC Strategic Trends are target to defence decision-makers but it could also have wider impacts in society and be used to stimulate a wider discussion among stakeholders.

3.4. Agora foresight (diverse perspectives and informative outcomes)

Agora foresight can be characterised as informative processes with diverse future perspectives that explore diverse ideas and opinions, identify and foster alternative and competing coalitions and value networks as well as identify alternative futures and rivalling visions. This relieves participants on the intensive search for consensus and direct support for decision-making, which provides opportunities for creative thinking and the inclusion of diverse and alternative view-points that can challenge incumbent and path-dependent approaches hindering – especially radical – changes in the innovation system. Such agora type of foresight activities provide a basis for a wide societal debate among different interest groups even with strongly diverging views on the desired future. Among the two projects examined in this quadrant, the European project "*Future Impact of ICTs on Environmental Sustainability*" aimed to explore (qualitatively) and to assess (quantitatively) the ways in which ICTs would influence future environmental sustainability (time horizon: 2020). The findings of the project showed that a large degree of uncertainty existed on impact of ICTs on the environment, and that "rebound effects" could lead to opposite impacts to that desired (e.g. if transportation becomes cheaper and faster thanks to ICTs, this could create more traffic and more energy consumption). Outputs were discussed with both DG Information Society and DG Transport and Energy of the European Commission. Findings were also used in subsequent JRC-IPTS projects [25].

The Nordic ICT Foresight was designed to provide a relevant platform to discuss in a structured way the future of ICT in Nordic countries. Hence, it was not planned to have direct impacts to decision-making. However, the participants from different sectors of the society benefited from the project. It helped them position in the system, network with other stakeholders and in general enhanced their innovation capabilities.

The foresight projects identified in Asia seemed to be all consensual; hence this would suggest that foresight projects with open-ended diverse visions of the future are not common in these countries. However, the diversity of viewpoints in Asian countries may come from the richness of activities. Foresight activities in Asian countries are conducted in different levels, such as national level, regional level, sector level and firm's level.

3.5. Innovations foresight (diverse perspectives and instrumental outcomes)

Innovations foresight can be characterised as instrumental processes with diverse future perspectives that generate many ideas, opinions and perspectives, which support the specific foreseen decision-making situation or for the formation of strategic partnerships/joint actions. The driving for diversity of perspectives together with instrumental results are likely to lead to concrete innovation ideas and partnerships that are not watered down by the search for wide consensus within the innovation system.

Among the projects analysed, only two projects were positioned in this quadrant. The first one was an internal foresight project in VTT Technical Research Centre of Finland. The key foci of the *VTT Water Research Roadmap* were the creative combination of wide-ranging water related issues at VTT as well as the generation of new R&D initiatives. The instrumental approach and still integration of diverse perspectives was largely possible, because the project was organised internally, which meant that also competitive and delicate issue could be addressed already during the process. The second project identified was a foresight process attached to *Finnish Foresight Forum*, which engaged different stakeholder groups, encouraged them to submit ideas on prospective innovations, and explicated multiple perspectives in the evaluation and analysis of these ideas.

Drawing upon these lines of thinking, consensual foresight objectives and diversity considerations are complementary perspectives which are both needed in attempts to enhance the performance of innovation systems: for example, the implementation of S&T policies may call for a sufficient degree of consensus about appropriate policy instruments (e.g., RTD programs), while preparedness for the future can be promoted through the diversity of activities within such instruments (e.g., projects based on rivalling coalitions and different technological arrangements).

4. Conclusions

In the past years, increasing attention has been paid to the relevance of foresight for policy-making by coming up with different characterisation and typology of different foresight projects (for instance, [7,12,26,27]). This paper contributes to this work by further elaborating the framework of Könnölä et al. [7]. While the framework is suitable for both the ex-ante and ex post analysis of foresight projects, we elaborate and attest its validity in the context of ex post analysis of a number of foresight projects focusing on sustainability, security and information society and their contribution to policy-making.

Our analysis supports the thesis that different classes of foresight projects have respective different types of impacts on policy and society. It is likely that the design and management of foresight projects have to look for cautious balance between different design dimensions in order to accommodate different stakeholder expectations.

Most of the projects we analysed have important informative functions in sense that they aim to provide new knowledge for better understanding of issues and of their future implications and challenges. This is almost a natural function or characteristic of any foresight project that stems from the process itself, but this does not necessarily lead to immediate actions or identification of policy options. Foresight with instrumental outcomes is likely to be designed in order to support the decision-making process and lead to development of actions and therefore also its usefulness and effectiveness for supporting policy-making is more evident. The positioning of the projects in the framework (as depicted in Fig. 3 of this paper) helped characterise the projects and the related expectations on them. Here, we make the following remarks:

- Tracing the impacts of foresight is often very difficult. In many cases, policy-makers do not refer to the sources used when decisions are made.
- Almost all the analysed projects have outcomes that can be characterised as consensual. This is not surprising as one of the important foresight objectives are the priority-setting and common vision-building. However, the lack of projects with outcomes emphasising diverse future perspectives may lead to limited exploration of alternative future pathways which are often addressed as strengths of many foresight methods and approaches.
- It may often be appropriate to design a foresight process as informative when it addresses a new or emerging (technological) field or when the issues are characterised by high uncertainties. This allows addressing diverse perspectives and scenarios as well as common vision-building. However, positioning a project as informative and communicating this characteristic to stakeholders may create difficulties in attracting those stakeholders who wish to be closer to decision-making. The exploration of alternative forms of participation for decision-makers and other participants with serious time constrains can thus be of utmost importance.
- Projects with the focus on instrumental outcomes have often important informative impacts, including indirect or unexpected impacts. Foresight influences all participants in the process as well as their networks. Furthermore, the outputs are often "re-used" by actors not considered in the design phase. This systemic nature of foresight may have several ramifications, for instance, rationales for co-financing projects.

The results of our ex post analysis of foresight projects confirm the wide set of expectations laid on foresight activities. We expect that the developed framework can facilitate the discussion about the expectations and the management of foresight projects and about its impact on policy-making and society at large.

There is a clear need for further research on evaluation of foresight impacts not only with the purpose of doing the evaluation of a project but mainly to draw conclusions on how foresight can be improved as an instrument contributing to knowledge creation for policy and decision-making in more general. The conceptual and empirical work on the evaluation of

foresight is ever more important to position foresight as one of the key supporting tools for policy-making to anticipate how major societal challenges ahead can be addressed such as those tackled in this paper, e.g. security, sustainability and information society challenges. The correct positioning and management of foresight is crucial to link it better with policy-making formulation, which is increasingly based on evidence base at all policy levels and for all policy domains. Furthermore, in order to better address major societal challenges with foresight and other FTA activities, we consider that another relevant future avenue might be to enhance the international foresight collaboration in terms of exchange of experiences and the implementation of common foresight projects.

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