Technological Forecasting & Social Change xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Wiring up multiple layers of innovation ecosystems: Contemplations from Personal Health Systems Foresight

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ARTICLE INFO

Article history:
Received 15 October 2015
Received in revised form 25 March 2016
Accepted 12 April 2016
Available online xxxx

Keywords:
Coordination
Governance
Innovation ecosystem
Multi-layered foresight
Personal health system

ABSTRACT

Many foresight exercises have been undertaken with the aim of improving the performance of innovation ecosystems. These ecosystems extend across different layers including the organisational, sectoral, regional, national and international dimensions. The interconnectedness of these layers has not have received much attention in foresight literature and practise. However, both the development and diffusion of innovations are subject to framework conditions not only within, but also across, multiple layers of innovation ecosystems.

The design and management of foresight exercises are thus liable to addressing and serving these different layers — especially when the goal is to improve the performance and impact of such "interconnected and interdependent systems". This paper develops further the concept of 'multi-layered foresight' by addressing multiple layers of innovation ecosystems in foresight design and management. We explore the implications of applying this type of foresight on improving systemic understanding, enhancing stakeholder networking and developing innovation capacities across the layers of ecosystems. The theoretical underpinnings are tested through a case study of the 'Personal Health Systems (PHS) Foresight' project. This project explored international future developments in the health sector, which is characterised by multiple disciplines, communities of practise, technologies, and geographical contexts. In the case of PHS the emerging innovation ecosystems are often conditioned by fragmented development communities, major barriers to market development, and duplication of efforts. The project combined analytical, social networking, online envisioning and scenario building methods to address complexity and create impact in multiple layers. Possible futures for personal health systems were explored through intense dialogues with stakeholders and a desirable future state was sketched through the success scenario methodology. The implications and strategic issues for different groups of stakeholders were outlined, enabling these stakeholders to articulate their efforts as part of a broader agenda at the multiple layers of innovation ecosystems.

1. Introduction

Foresight has been long recognised as an instrument that can be applied to "wiring up" innovation systems (Martin and Johnston, 1999). Activities have been undertaken with the aim of addressing the weak points in innovation systems (or ecosystems[1]) — such as poor connections between those concerned with scientific research and with the commercial exploitation of knowledge (Smits and Kuhlmann, 2004). Foresight processes can help to diagnose weaknesses in innovation ecosystems by bridging some of the gaps in innovation networks through interaction between stakeholders in participative and inclusive processes. While a number of large-scale foresight activities are concerned with national innovation systems (Georghiou et al., 2008; Könnölä et al., 2009; Havas et al., 2010), many others have been conducted at regional and city levels (Dufva et al., 2015; Gavigan et al., 2001; Keller et al., 2015) as well as corporate level (Rohrbeck and Gemünden, 2011; von der Gracht et al., 2010). There are also a number of international studies with an innovation focus (Cagnin and Könnölä, 2014; Brummer et al., 2008). This is understandable, given that innovation ecosystems can be considered as combining different layers — including organisational, sectoral, regional, national and international dimensions. However, the interconnectedness of these layers has not

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[1] While the authors recognise that there are certain differences between the concepts of innovation systems and ecosystems, for the sake of simplicity, we refer interchangeably to these two concepts. While the concept of innovation systems is widely used in the innovation policy literature pinpointing the interdependences among innovation stakeholders (e.g. Carlsson et al., 2002), the concept of innovation and entrepreneurial ecosystems have its roots in management literature (Moore, 1993) and is increasingly used also in innovation policy laying emphasis on the dynamic co-evolutionary nature of the system of innovation actors. The elaboration of the crossroads of these two concepts we leave for another paper.

http://dx.doi.org/10.1016/j.techfore.2016.04.018
0040-1625/

received sufficient attention in foresight literature and practise (Dufva et al., 2015). This may be problematic, given that innovation processes (including both the development and successful diffusion and adoption of innovations) are subject to framework conditions within and across multiple layers of innovation ecosystems.

Some of these linkages were highlighted by Miles and Keenan (2002), who looked at some of the rationales of linking regional foresight activities to those undertaken or underway at the national level:

1. To conform to national requirements to undertake an exercise, or to disseminate the results of a national foresight exercise into the regions
2. To utilise information from national foresight activities
3. To access the networks established in national foresight exercises
4. To become part of an ongoing national exercise
5. To stimulate regional foresight activities, or to reinforce those that are underway
6. To participate actively in the design of foresight programming and implementation.

Similar rationales apply when international, national, regional and organisational foresight exercises are linked — and not only from a broader geographical area but also to a more narrow one. Since much innovation occurs at relatively local levels, understanding the processes here can be vital for activity at broader levels. Interconnection between foresight exercises — at the same level or across layers — can increase their dissemination, ownership and chances for the implementation of recommendations (Saritas, 2006).

Herein, this paper is empirically-based theory building rooted in the observations the authors made during the FP7 (7th Framework Programme of the European Union) "Personal Health Systems Foresight"' project (PHS Foresight). This project explored future developments of a field characterised by multiple disciplines, communities of practise, technologies, and geographical dispersal. The emerging innovation ecosystems here are often confronted by fragmented development communities, major market barriers and severe duplication of efforts. Within such a challenging context, the authors realised the need for the foresight community to pay further attention to the multiple layers of innovation ecosystems in foresight activities.

The paper is structured as follows. In Section 2, we construct the conceptual framework for the multi-layered foresight design and management for wiring up multiple layers of innovation ecosystems.

In Section 3, we demonstrate the value of this framework by applying it in the analysis of the PHS Foresight project. While the project was not designed at the outset as a multi-layered foresight, the application of the framework in the project illustrates its analytical value and helps identify further implications on the design and management of multi-layered foresight.

In Section 4 we discuss the lessons learned from the analysis. For instance, we consider the measures enhancing the take-up of results in multiple layers, and the importance of recognising both the expected and unexpected outcomes when maximising the impact of foresight. Section 5 concludes the paper.

2. Multi-layered foresight design and management

Foresight contributes to the governance of innovation ecosystems through its emphasis on the exploration of long-term developments (which often transcend immediate differences in point of view), and in the formulation of common visions, which indicate joint actions across multiple layers of innovation ecosystems. These 'boundary objects' provide common ground for different stakeholders to exchange understandings and suggestions for action, learning both about the topics of foresight and the likely strategies of other agents.

In line with the Theory of Change (Connell and Kubisch, 1998), we position a foresight process as an intervention across multiple layers of innovation ecosystems with specific objectives and inputs to address challenges and to improve coordination. It produces both tangible and intangible outputs, with short and medium term outcomes that should impact upon the different layers of innovation ecosystems.

2.1. Multiple layers of innovation ecosystems

Foresight activities are themselves conducted with different scopes, and at different layers of innovation ecosystems. Dufva et al. (2015) introduce the concept of multi-layered foresight, identifying four layers in innovation systems: individuals, organisations, innovation systems and landscape. An innovation ecosystem is embedded in the societal developments of the landscape layer, and consists of different organisations, which in turn consist of individuals. The layers thus form a hierarchical system (Saritas, 2013).

We elaborate on Dufva et al. (2015) and open up the layer of innovation system entailing multiple layers of systems. This clarification may have considerable implications on the positioning of the foresight project as a systemic instrument for wiring up not only one system but the multiple innovation ecosystems. Indeed, discussing the challenges of managing innovation ecosystems in Europe, Schoen et al. (2011) argue that the conduct, funding and strategic orientation of research and innovation involve multi-level and multi-actor arrangements consisting of local, regional and (inter-) national levels. Innovation activities need to be understood to take place at different levels and between different actors.

In practise, though, the clear cut categorisations of different layers of systems are rarely possible. Not only systems in one layer overlap or interact in multiple ways with other layers, but there are systems that are per se multi-layered; often with particular scope of technology, industry or organisation (Hekkert et al., 2007; Carlsson, 2006). Furthermore, the layers of multiple systems are context specific, hence we do not advocate the use of specific set of layers but refrain to typify for the purposes of the paper some archetypal layers of local, regional, national and international ecosystems (Table 1) widely addressed by foresight and innovation (eco)systems literature.

2.2. Issues: societal challenges and coordination

When addressing innovation ecosystems, foresight processes may point to opportunities involving novel combinations of technologies, organisational partnerships and institutional arrangements. These dimensions are similar to those addressed when future-oriented analysis is directed at grand societal challenges (Weber et al., 2012), where major systemic changes are bound to cut across established disciplinary and professional, institutional and organisational boundaries. Addressing grand societal challenges, which in some cases can be paralleled to initiating substantial technological change, requires particular attention to the multiple dimensions of the coordination of joint efforts. Könnölä and Haegeman (2012) elaborate four coordination dimensions in the context of transnational research, innovation programming and foresight management, including (i) horizontal, (ii) vertical (iii) temporal and (iv) intersystemic coordination). Taking account of the coordination of multi-layered innovation ecosystems, these dimensions can be recapitulated as follows:

- *Horizontal coordination between innovation and other policy and professional areas*. Könnölä et al. (2011), and, earlier LLA, PREST and ANRT (2002), note that successful research and innovation processes can be facilitated by (and often require) horizontal coordination with other policy areas (such as competition, regional, financial, employment and education policies). In more general terms, the OECD (2003) has called for horizontal coherence as a general governance objective—ensuring that individual objectives and policies developed by various entities are mutually reinforcing. Efforts at horizontal coordination must seek opportunities for collaborative policy formation while recognising the relevance of multiple perspectives in relation

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Table 1
The archetypal layers in local, regional, national and international ecosystems, examples and some related literature.

Ecosystem layers	Example	Related foresight literature, examples	Related innovation ecosystems literature, examples
International ecosystems	Innovation ecosystem of a multinational entreprise	Heger and Boman (2014), Rohrbeck and Gemünden (2011), Cagnin and Könnölä (2014)	Rong et al. (2014), Kim et al. (2016), Kuhlmann and Edler (2003), Zeschky et al. (2014), Pattberg (2005)
National ecosystems	Research and innovation ecosystem of Finland	Könnölä et al. (2009), Georghiou et al. (2008), Martin and Johnston (1999)	Carlsson (2006), Wieczorek et al. (2014), Ács et al. (2014)
Regional ecosystems	Silicon Valley	Miles and Keenan (2002), Dufva et al. (2015), Gavigan et al., 2001, Keller et al. (2015)	Wintjes and Hollanders (2011), Carayannis and Rakhmatullin (2014), Foray et al. (2012)
Local ecosystems	Entrepreneurial and innovation ecosystem within a University Campus	Fikirkoca and Saritas (2012), Wessels et al. (2015), Forces (2008)	Almirall et al. (2014), Maassen and Stensaker (2011), Collins (2015)

to the objectives of different policies. Methodologically, these efforts call for systematic multi-stakeholder processes with a long-term forward-looking perspective. This enables policy responsible to gain insights in contexts of others and therefore differentiated perspectives on a common topic. As a soft governance mechanism this facilitates interconnectivity and alignment of policies and promotes a 'joined-up' or 'whole-of-government' perspective. At the same time, by laying emphasis on the long-term forward-looking perspective for instance through alternative scenarios, foresight may avoid that discussions are being taken over by short-term policy agendas and debates.

- *Vertical coordination of multi-layered ecosystems*. The OECD (2003) also identified vertical coherence as a general long-term policy objective—ensuring that the practises of agencies, authorities and autonomous bodies, as well as the behaviour of sub-national levels of government, are mutually reinforcing and coherent with overall policy commitments. In Europe — as in other regions — vertical coordination needs to extend beyond national decision-making structures, for instance to include the regional cross-country coordination and the decision-making structures of the European Union. Könnölä et al. (2011) consider experiences from vertical coordination between local, regional and (inter-)national levels for managing multi-layered research and innovation systems. For instance, the articulation of thematic priorities for transnational research and innovation co-operation, e.g. from the EU level, raises issues related to their coherence with the priorities and needs of lower levels of governance, particularly in terms of consultation with national, regional and local authorities. Given the diversity and multiplicity of actors, achieving a thorough overall multi-level policy consistency will always remain a receding target; Reid et al. (2007) argue, policy coordination is most liable to assume soft forms, referring to facilitating knowledge exchange rather than joint funding mechanisms.
- *Temporal coordination of policies and innovation ecosystems*. The OECD (2003) defines temporal coherence as a general policy objective that ensures that policies continue to be effective over time and those short-term decisions do not contradict longer-term commitments. Temporal coordination focuses on how policies work out as they interact over time with other policies or other forces in society, including whether future costs are taken into account in today's policy-making. This is crucial for ensuring synergies between the programmes, given the role of time lags in transnational policy-making contexts. The alignment of differing (local/national/regional) innovation ecosystems, and vertical and horizontal coordination around particular efforts, are all subject to coordination challenges that have a strong temporal dimension. Sustaining policy efforts over time, when ecosystems require vertical and horizontal alignments, is not a small task, given changing political regimes and turbulent economic and technological circumstances.
- *Inter-systemic coordination*. Nations or regions aiming to collaborate in innovation activities often have innovation ecosystems that are established in quite different ways, reflecting factors such as size of the country, history of economic specialisation, R&D strengths, and so on (Anderson, 2011).There are structural differences in national programme, their funding and implementation orientation; in the distribution of research and innovation activities across innovation performers and in the extent of cross-sector collaboration (e.g. university–industry collaboration) and of government ability to influence innovation agendas. Indeed, countries vary in terms of the levels of interest they have at national level for collaborating beyond borders, and the openness of their programmes to other nations. This diversity of national activities and their implementation is liable to limit the effectiveness of transnational co-operation.

2.3. Multi-layered foresight

Within multi-layered systems, foresight outcomes affect different layers in different ways and with varying intensities. Much of the discussion on the benefits of foresight (e.g. Georghiou and Cassingena Harper, 2011; Martin, 2010), functions of foresight (Da Costa et al., 2008; Smits and Kuhlmann, 2004) and objectives of foresight (Salo et al., 2004; Georghiou et al., 2008) has been driven by empirical observations. However, it can be argued that they relate to the notion of foresight creating new knowledge (see, e.g. Eerola and Miles, 2011; Miles, 2010; Loikkanen et al., 2006). Evolutionary and institutional economics considers knowledge as a consequence of interaction between individuals, organisations and their environment, and sees knowledge as embedded in habits, routines (Hodgson and Knudsen, 2004; Hodgson and Knudsen, 2010) and skills (Nelson and Winter, 1977). This highlights the importance of engagement of people in learning and participatory processes in foresight.

Salo et al. (2004) coined three interdependent foresight objectives: i) improved systems understanding, ii) enhanced networking and iii) strengthened innovation activities. From these objectives and the premises of knowledge creation, Dufva et al. (2015) derived three general dimensions of foresight contributions named "facets of foresight": i) knowledge ii) relations and iii) capabilities (see also Table 2).

The archetypal logic chart of the design of multi-layered foresight is illustrated in Fig. 1. The layers of innovation ecosystems are described as hierarchical spheres. These ecosystems are subject to different issues (1.) that in this paper are typified to societal challenges and those specific to vertical, horizontal, temporal and intersystemic coordination of innovation activities. Multi-Layered Foresight is designed to address the identified issues. The three facets of foresight can be used to characterise the objectives (2.) to observe the contribution of foresight across different layers.

The inputs and implementation (3.) of the multi-layered foresight can draw resources from different layers of ecosystems. Herein, the implementation can benefit from flexible and modular design that enables the execution of parallel process thus contributing to the scalability of activities (Könnölä and Haegeman, 2012).

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Scalability, the ability to be expanded or upgraded, is needed to process contributions vertically from stakeholders considering local, regional, national or international priorities. The notion of scalability has at least three sub-dimensions (Könnölä et al., 2011; Könnölä and Haegeman, 2012):

- Input scalability, which makes it possible to involve varying amounts of contributions from a changing number of stakeholders.
- Geographical scalability, which makes it possible to involve stakeholders regardless of the geographical distance between them.
- Administrative scalability, which permits the decomposition of the foresight process into manageable sub-processes (see below modularity) and enables transitions between different levels of abstraction by way of problem structuring and synthesis.

Modularity refers to process design where analogous sub-processes—or modules—can be enacted relatively independently from the other sub-processes (Könnölä et al., 2011). This concept is key to attaining scalability: for instance, input scalability can be achieved by carrying out modules of analogous foresight processes in different countries, after which further sub-processes can be conducted to interpret these processes, say, from the viewpoint of internationally agreed priorities. Modularity also makes it easier to compare the results of sub-processes and to achieve economies of scale.

The use of a structured approach and exploitation of the internet can support the monitoring, evaluation and overall legitimacy of the activity by way of allowing traceability of jointly proposed themes or visions on the future. But accommodating different interests, capabilities and culture across innovation ecosystems also calls for flexibility in the design and management of the foresight process. Foresight can be structured in a way that allows flexibility in design to respond to the changing expectations of stakeholders, for instance including open access and the exit of participating organisations may be taken into account.

Outputs (4.) of the multi-layered foresight are also considered across the layers. Whereas outcomes (5.) may be reflected in terms of achieving the foresight objectives across the layers, impacts (6.) may be best related to the societal challenges and improving the coordination across the systems. In the following sections, we apply this framework to reflect the case study on the Personal Health Systems Foresight project.

3. Case study: Personal Health Systems Foresight

In this section we apply the logic chart of multi-layered foresight in the reflection on the design and management of the European FP7 'Personal Health Systems (PHS) Foresight' Project (Pombo-Juárez et al., 2014). It explored future developments of a field characterised by multiple disciplines, communities of practise, technologies and geographical dispersal; and one where, as noted, innovation ecosystems that are emerging here often confront fragmented development communities and major market barriers. There is much duplication of efforts, some of which may result in incompatible solutions and problematic lock-ins. Hence, we find the project suitable for illustrating the value of multi-layered foresight approach. The section follows the structure of the logic chart (Fig. 1) starting with the PHS challenges in the multiple layers of innovation ecosystems.

Table 2
Three facets of foresight. Adapted from Dufva et al. (2015).

Facet	Definition
Creation and diffusion of knowledge	The production of new knowledge and insights about possible future developments and the consequences of present actions that help stakeholders to (re-)position themselves across the layers of ecosystems.
Enhancing relations and networking	The creation of new connections between different stakeholders and across sectors, and the restructuring and enhancing of existing networks across layers of ecosystems.
Development of capabilities	The learning of new capabilities that contribute to the future-orientation of individuals and organisations across the layers of ecosystems.

3.1. PHS challenges in multiple layers of innovation ecosystems

Health care systems around the world face well-known challenges, such as rising costs, ageing population, increasing demand and shortage of health care professionals. PHS is seen as part of the solution by many people. PHS can assist in the provision of continuous, quality controlled and personalised health services to empowered individuals. As technologies involved in services supply, PHS provides a horizontal development area across a variety of patient groups, clinical specialties, technology fields and health services. Hence, the development of PHS requires — and can provoke — the emergence of novel cross-disciplinary and sectoral innovation partnerships (Schartinger et al., 2015).

Building on the earlier definitions (e.g. Codagnone, 2009) we consider PHS for the purposes of this work to consist of:

- Ambient, wearable and/or in-body devices, which acquire, monitor and communicate physiological and other health-related data
- Intelligent processing of the acquired information (data analytics), and coupling it with expert biomedical knowledge and in some cases, knowledge of social circumstances and living conditions
- Action based on the processing of acquired information, either applied to the individuals being monitored, or to health practise more generally, concerning information provision and/or more active engagement in anything from disease and disability prevention (for example through diet and lifestyle management) to diagnosis, treatment and rehabilitation.

While there has been much experimentation with specific PHS in specific contexts, knowledge and experience about how to implement research results into concrete policy and strategy development in health are still in its infancy. Often systemic changes are necessary conditions for PHS to generate benefits within health systems. This is particularly the case with regard to the research and innovation actions that have been undertaken at the European level. The patterns of innovation in PHS need to be examined in sectoral, national, and other contexts.

For the illustrative purposes, the archetypal layers of innovation ecosystems can be applied to structure the PHS challenges (see Table 3).

Furthermore, in line with Könnölä and Haegeman (2012) and as discussed in Section 2 several kinds of coordination issues can be identified, as detailed in Table 4.

Within the context of the PHS challenges across the layers of the innovation ecosystems and multiple coordination challenges, the project consortium defined the overall objectives for the foresight project. These can be structured within the framework of foresight facets introduced in Section 2 (see, Table 5).

3.2. Inputs and PHS stakeholder incentives

The project objectives and implementation plan were considered within the limits of the available resources. As a European Commission Coordination and Support Action, the project received approx. 500,000 euros contribution from the Commission.

A major effort was made to engage different stakeholders across all layers of innovation ecosystems. They contributed to the project on a voluntary basis. Such voluntary engagement was largely driven by the opportunities provided for the participants to engage in mutual learning

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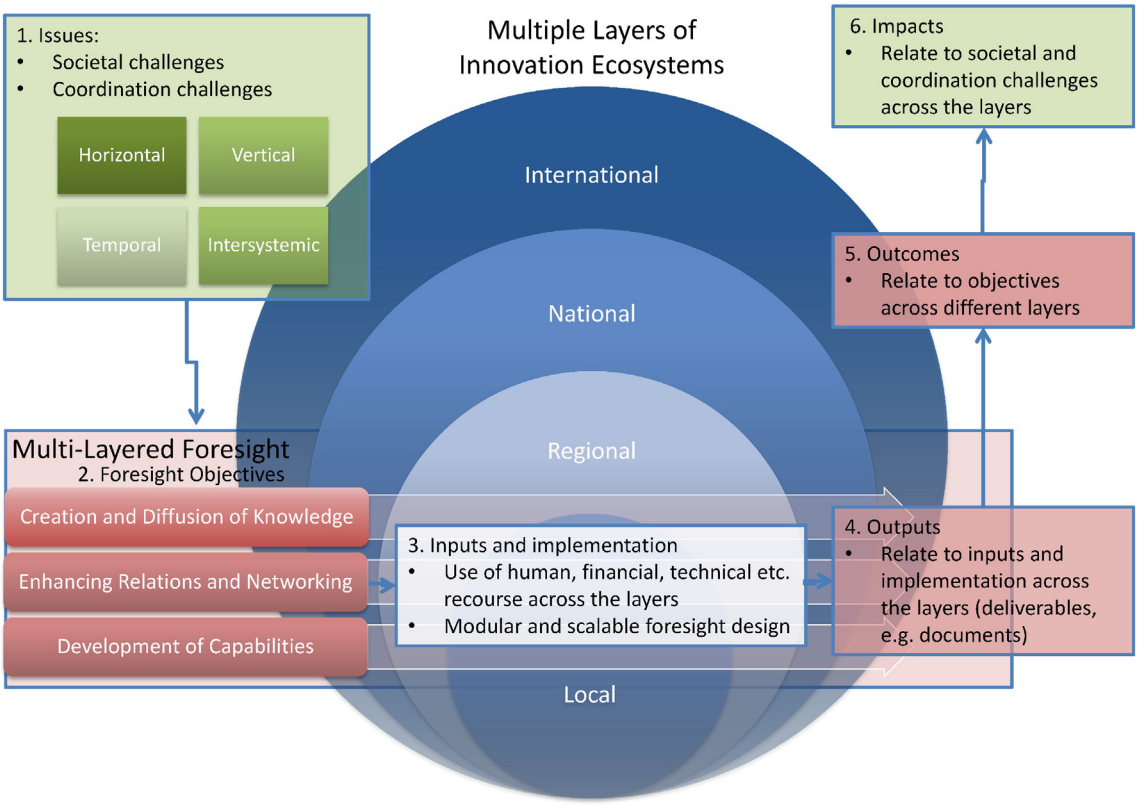

Fig. 1. Logic chart of a foresight project within the multiple layers of innovation ecosystems (modified from (Könnölä, 2016)).

Table 3
Multi-layered European innovation system of PHS: points of departure and challenges.

Layer	Challenges
International innovation ecosystems	Fragmentation of PHS initiatives Duplication of efforts Lack of standards and interoperability Room for further coordination
National innovation ecosystems	National health systems reluctant to explore new product-service systems Barriers to market access Rigidities in reimbursement models Lack of interoperability, fragmentation of health data Duplication of efforts Promising private sector initiatives
Regional innovation ecosystems	Promising pilots that often suffer from lack of sufficient scale Difficulties in streamlining PHS efforts with the national health system
Local innovation ecosystems	Promising public sector pilots Promising private sector initiatives Difficulties in engaging all relevant stakeholders including, e.g., patients/citizens

and networking (for numbers and types of stakeholders engaged, refer to Table 6).

3.3. Implementation of PHS Foresight[2]

The project design reflected the context of multiple-layers of innovation ecosystems in its governance structures and methodology. The project's governance structure included not just the consortium of researchers, but also its steering group, advisory board and stakeholder panel representing all layers of innovation ecosystems. Overall, the governance structure, together with the multiple forms of stakeholder engagement across the ecosystems, was intended to ensure that sufficient responsiveness would be provided across a multitude of stakeholders, to empower them and to create mutual learning opportunities.

The methodology and process designed for the foresight process combined analytical approaches, social networking, online envisioning, scenario building, and road mapping methods, in order to address the complexity of the focal object (European PHS) and to create impact in multiple layers of the emerging innovation ecosystems. Possible futures for PHS were explored through intense dialogues with stakeholders, and a desirable future state was elaborated through the success scenario methodology. The implications of the analyses as well as strategic issues were outlined and discussed with different groups of stakeholders across the layers of innovation ecosystems.

Table 4
Dimensions of coordination within multi-layered PHS innovation systems.

Dimension	Coordination issues
Horizontal	Coordination of the interdisciplinary and multi-sectoral PHS field across a variety of patient groups, clinical specialties, technology fields and health services.
Vertical	Coordination of local, regional, national and European efforts. PHS innovation ecosystems are conditioned and/or embedded in regional, national and transnational healthcare systems that require active coordination and streamlining of efforts across the layers.
Temporal	Vertical and inter-systemic coordination of timing of initiatives and programmes are needed to enable pooling of resources and coordination of efforts. In the field of PHS the fragmentation of initiatives prevents coordinated timing.
Inter-systemic	Identification of common interests and joining forces to pool resources, gain power and have impact across regions and countries that may allow sufficient economies of scale. However, institutional and legal differences and interoperability issues create major barriers.

[2] See the PHS Foresight Reports in the end of this paper for the details of the project.

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Table 5
Three facets of foresight and the objectives of PHS Foresight.

Facet	Objectives
Knowledge	To achieve a deeper understanding of mismatches between the potential of PHS and current policy and innovation initiatives, and associated framework conditions across the layers of ecosystems
	To tackle future opportunities and alternative trajectories, aligning actor perspectives for the development of a joint strategic action plan, including recommendations for a possible new European Innovation Partnership (EIP)
	To enhance understanding of the state-of-the-art, barriers and drivers of PHS and related key initiatives across the layers of ecosystems
Relations	To support more mobilised and networked innovation communities which promote PHS around jointly formulated issues that support the pooling of resources and streamlining of diverse innovation initiatives across the layers of ecosystems
	To achieve a transparent, open and inclusive engagement of stakeholders, and targeted dissemination of results across the layers of ecosystems
Capabilities	To offer learning opportunities for stakeholders to conduct foresight activities across the layers of ecosystems
	To familiarise stakeholders with concepts such as service-system, system innovation, transition management to encourage comprehensive development of PHS across the layers of ecosystems

3.3.1. Understanding drivers and barriers[3]

A number of methods were applied in parallel to map existing activities and understand barriers and drivers confronted by PHS across innovation ecosystems. Relevant literature was reviewed and key stakeholders in multiple layers of the innovation systems were interviewed within the scope of the project. At the international level, European social network analysis was applied to data on European R&D projects, and bibliometric and patent analyses were conducted.

Based on the literature review and interviews the keywords in the realm of PHS were defined for the bibliometric and patent analysis that provided further understanding on present state and future trends of research and development on the PHS topic in Europe and beyond. Patents are among the best known indicators of technological invention and outputs of research and development processes, thus the project analysed patents in the field of PHS, with patent information obtained from the "Derwent Innovation Index" (ThomsonReuters, 2013a) and "Patent Citation Index" (ThomsonReuters, 2013b).

Our first approach was to get a comprehensive overview of the various kinds of PHS projects through web-based research. Apart from the purely technical research projects, PHS projects exist on different levels of aggregation and analysis: i) meta level international projects defining and demarcating the PHS area, ii) meso level projects combining an analytical approach with a strong focus towards local applications around Europe and iii) micro level projects driven by local actors and focused on application.

PHS projects are on the one hand part of research and development processes; on the other hand they also mark diffusion processes of best practises and flows of information among the components of a social network. Knowledge about PHS diffuses through flows of information throughout all phases of the innovation process — R&D, distribution/diffusion and application/implementation phases. Herein, tools and concepts of social network analysis (SNA) were used in this study to visualize project-based R&D collaboration networks and to identify central actors in the area of PHS on the European level. This SNA perspective focused not on the individual social actors, but on the broader interaction contexts within which the actors are embedded; thus providing understanding of the multiple-layers of the system.

Particular attention was paid to the innovation ecosystem level, with case studies of selected R&D projects around Europe: this was intended to achieve in-depth understanding of the implementation challenges. PHS case studies were identified, by mapping EU projects and through a structured web search with defined keywords, resulting in a set of 39 cases.

3.3.2. Development of visions[4]

To initiate a more future-oriented exploration of the PHS field and increase awareness of our project among stakeholders in multiple layers of innovation systems around Europe and beyond, the project launched a Web 2.0 online platform for soliciting, commenting and multi-criteria assessment of visions of PHS futures. After testing the platform and engaging the members of the project consortium and external advisors, members of the advisory board and the stakeholder panel were invited to register and invite their colleagues and networks to engage. Further outreach activities were established through social networks, printed leaflets and targeted promotion. The result was that a total of 42 visions were submitted, commented, refined and assessed with multiple criteria. The registered participants submitted through the online form their visions on a personal health system that could be in operation in Europe by the year 2030. The participants could comment and assess each other's visions. The multi-criteria assessment of visions supported the identification of most feasible, relevant and novel visions, and provided improved understanding of the PHS community preferences and future directions.

3.3.3. Scenario workshops[5]

The project involved two workshops for exploring alternative future PHS scenarios for the year 2030 across Europe. A multiple scenario approach was taken in the first scenario workshop: small groups of relevant experts from around Europe elaborated scenarios based on those established in an earlier study of PHS (Personal Health Systems), and originally published in the PHS2020 Scenarios report (Codagnone, 2009) in order to provide a continuity with the previous work. This earlier study reviewed a wide range of drivers of change in the PHS context, before elaborating scenarios. Additional scenarios were developed in the workshop, not as predictions of what would happen, but to clarify the range of plausible developments that might characterise the PHS field and provide insight into the circumstances under which different developments might unfold, and into the relations between the different issues addressed in the scenarios. Three European scenarios were eventually elaborated — these retained some features of the original PHS2020 starter scenarios, but were less distinctive from one another, and could quite reasonably be seen as minor variations of an overall scenario of fairly steady, but still rather incremental, change in multiple layers of the ecosystems. Substantial modification of health systems and their financing was anticipated through the application of PHS — but there was less of a disruption with current systems than many proponents of PHS might anticipate.

The first workshop was followed by another one that developed a success scenario. The aim was to examine what might be a desirable, yet feasible, future for PHS in Europe in the period round 2030. The conditions and actions necessary to realise the scenario were examined, and participants were encouraged to suggest indicators to measure the progress towards the vision, along with roadmapping strategic actions to be taken forward by different stakeholders in multiple layers of the innovation ecosystems.

[3] For futher details on the methods and results related to analysing barriers and drivers see: PHS Foresight deliverable D1.1, available at http://phsforesight.eu/reports.

[4] For further details on the visioning process and the 42 visions assessed see PHS Foresight deliverable D2.1, available at: http://www.phsforesight.eu/reports.

[5] For further details on the scenario work see PHS Foresight deliverables i) 'Personal Health Systems A Success Scenario Report' and ii) D3.2, available at: http://www.phsforesight.eu/reports.

Please cite this article as: Pombo-Juárez, L., et al., Wiring up multiple layers of innovation ecosystems: Contemplations from Personal Health Systems Foresight, Technol. Forecast. Soc. Change (2016), http://dx.doi.org/10.1016/j.techfore.2016.04.018

Table 6
Multi-layered implementation of tasks and stakeholder engagement.

Task	Flexible, modular and scalable design and management	Addressing multiple layers of innovation ecosystems	Stakeholder engagement
Analysing barriers and drivers	Parallel application of different methodologies across the layers of innovation ecosystems	Literature-review and interviews in multiple layers of the innovation systems. At the international layer, social network analysis on European R&D projects and bibliometric and patent analyses. Attention to the local layers of innovation ecosystems in case studies of selected R&D projects around Europe.	Stakeholders of 39 case studies contacted to exchange information on local innovation ecosystems. Also national and international stakeholders contacted to exchange information on PHS initiatives and studies. Over 20 other European research projects were contacted.
Development of visions	Use of online platform for extensive engagement of stakeholder across the layers of innovation ecosystems Flexible and modular process allowing simultaneous generation, commenting and assessment of visions.	Web 2.0 online platform for solicitation, commenting and multi-criteria assessment of visions on PHS futures. Participants identified and invited through email lists, co-nomination, co-promotion and social media across the layers of innovation ecosystems.	The development of visions engaged in total of 580 users across the layers of innovation ecosystems entailing: • 23 private users (patients, relatives, etc.) • 187 professional users (medical professionals, etc.) • 209 suppliers (solution providers, system integrators, etc.) • 161 supporters (researchers, policy-makers, advocates)
Scenario workshops	Building on earlier macro level scenarios to develop more specific new scenarios. In the workshops parallel scenario working groups allowed addressing different types of PHS and future scenarios. Success scenarios defined actions for stakeholders across the layers of the ecosystems.	Three European scenarios elaborated on specific PHS topics based on earlier macro level scenarios in the first workshop. The second workshop developed a success scenario with detailed indicators to measure the progress towards the vision and with strategic actions to be taken forward by different stakeholders in multiple layers of the innovation ecosystems.	The two workshops engaged in total of 55 (28 + 27) users across the layers of innovation ecosystems entailing: • 8 + 6 professional users (medical professionals, etc.) • 6 + 5 suppliers (solution providers, system integrators, etc.) • 14 + 16 supporters (researchers, policy-makers, advocates) • Private user (patients, relatives, etc.) perspectives were represented by all participants.
Strategic plan	Use of online questionnaire facilitated further engagement of workshop participants Online collaboration among the project team supported the flexible development of the plan.	The strategic plan was developed in dialogue with stakeholders from multiple layers of the innovation system to identify a plausible and desirable course of development and the strategic actions required for achievement.	The participants of the second workshop were invited to answer the questionnaire. The advisory board and the stakeholder panel representing all layers and user groups were invited to comment the plan.
Community building and dissemination	Execution of multiple measures in parallel. Co-organisation of and participation in partner events Social media presence supporting co-nomination and wider dissemination Expert interviews for strategic guidance and further dissemination.	Different dissemination measures were used to enhance the take-up of results in multiple layers. The project engaged with and contributed to a number of other initiatives, with an aim to serve the multiple layers of innovation ecosystems.	Beyond the stakeholder engagements in other tasks, the project was presented in over 15 partner events representing all user groups and layers of ecosystems. The online platform engaged up to 900 registered members and over 8000 visits. 18 expert interviews were conducts among the Advisory Board Members and Stakeholder Panellists covering multiple layers of ecosystems.

3.3.4. Strategic plan[6]

Different phases of the project provided insights for a strategic plan for further European wide coordination and collaboration in the area of PHS. The strategic plan was developed in dialogue with stakeholders from multiple layers of the innovation system, to identify a plausible and desirable course of development towards a successful future for European PHS, along with the strategic actions required for its achievement.

This required a process of discussing research results, debating and agreeing upon goals and indicators, and identifying feasible actions. This process was valuable for creating mutual understanding and for sharing knowledge. The action points that were developed and the priorities that may be established, alongside other outcomes, should be able to help mobilise future activity (e.g. formation and reinforcement of networks). Having been derived from a participative process, this framework should possess fairly wide appeal and legitimacy.

3.3.5. Community building and dissemination[7]

The project generated reports, podcasts and newsletters to disseminate its progress and results. In order to cater different types of stakeholders from different layers of the system, the project paid particular attention to the engagement of stakeholders and dissemination of the results. As noted, the project established an Advisory Board and a Stakeholder Panel for PHS Futures from different layers of innovation systems. The members provided their insights and guidance for the use of the project and enhancement of the take-up of results. The project partners disseminated the findings in social media and in conferences, hopefully reaching all layers of the innovation system(s). Furthermore, the project consortium engaged with and contributed to a number of other initiatives with the aim of serving multiple layers of innovation systems. They engaged with local ecosystems especially through the 39 case studies around Europe and identified synergies with 48 other FP7 projects and over 30 other international initiatives from different research and advocate groups to standardisation organisations. Interaction took place across multiple layers in the stakeholder workshops and

[6] For further details on strategic plan see PHS Foresight deliverables D4.1 and D4.2, available at: http://www.phsforesight.eu/reports.

[7] For further details on communication see PHS Foresight deliverable D5.2, available at: http://www.phsforesight.eu/reports.

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online engagements. Further dissemination measures were used to enhance the take-up of results in multiple layers when maximising the impact of foresight.

Table 6 summarises the implementation of different tasks briefly explained above addressing the multiple layers of innovation systems. It also reflects flexible, modular and scalable design and management and stakeholder engagement.

3.4. Outputs, outcomes and impacts

The project team's self-assessment on the project reveals the challenge of making difference with a single foresight exercise across multiple layers of innovation ecosystems. We reflect the contribution of the project in terms of three facets of foresight; knowledge, relations and capabilities.

3.4.1. Knowledge

The published reports containing the various analyses of PHS, and related visions, scenarios and actions plans are tangible outputs (Da Costa et al., 2008) of the foresight process in focus. They are publicly available and have been downloaded by stakeholders in various domains of the innovation eco-systems. In principle, they are able to provide contributions to the improved understanding of the PHS and help different stakeholders across the layers of innovation ecosystems to better position their efforts with regard to future developments.

Discussions in the course of the project confirmed that industrial firms and many other innovators operating vertically across different layers of ecosystems see PHS as featuring vast technological opportunities. While the project aimed at wiring up the systems and moving beyond scattered experiments to more systematic introduction of cost-effective and beneficial PHS systems, numerous coordination challenges remain that could only be made explicit during the foresight process but not be solved. There were two common elements here. First, the demand for PHS from public healthcare systems as a whole is poorly articulated, as well as from the great majority of individual patients and other potential users. This is not to say that we may not see take-off of specific PHS-type applications, for example via “apps” and accessories for mobile phones, or via more sophisticated emergency alarms for older people. Such patchy and uneven development is a likely scenario in the event of lack of action from public services. Second, the institutional arrangements (e.g. legislation, regulations, and financing) present in multiple layers of the ecosystems are largely in favour of incumbent technologies.

While the exploration of the PHS field provides valuable insights, the implementation of recommendations suggested by different stakeholders across the systems is a subject of further coordination efforts beyond the influence of the project.

3.4.2. Relations

The PHS field is one in which demand currently remains poorly articulated, despite substantial technological opportunities. There is the common problem of multiple, potentially competing, technological approaches and standardisation efforts to face, and the organisation of product-service systems which configure these technologies in applications and solutions is much less clear. Demand and development applications will need to be coordinated, and this is unlikely to happen rapidly and in socially equitable ways through market forces alone. Neither can a single foresight project with limited resources has sufficient impact for such change.

In the project major efforts were made to engage stakeholders across different layers of innovation ecosystems. Online participation and co-organisation and co-promotion of PHS related events turned out to be invaluable measures for networking and exchange of information. For instance, the online platform engaged up to 900 registered members and over 8000 visits. This wired up different layers of ecosystems and provided new structures for future collaboration. Herein, the limited resources hampered the possibilities to engage the stakeholders in direct interaction. While online tools provided some means towards this direction it was especially the interviews and workshops that enabled building mutual trust and learning and co-creation of visions and respective solutions.

3.4.3. Capabilities

The project engaged various stakeholders and enhanced their capabilities relevant for wiring up different layers especially trough the project design and offering opportunities for reflecting upon their own role in the various layers of the ecosystems. Furthermore, many stakeholders were not familiar with foresight methodologies and system models to coordinate and develop PHS across ecosystems. Foresight engagements created opportunities for learning new capabilities that stakeholders could apply in their organisations. During the project participants familiarised with the use of online platform, interviews, scenario workshops, surveys in the development of foresight knowledge. However, it was namely the workshop participation that enabled also in-depth methodological learning.

In Table 7 the project outputs, outcomes and impacts are reflected within three facets of foresight: knowledge, relations and capabilities on different layers of innovation ecosystems.

4. Discussion

The PHS Foresight project attempted to manage interfaces in engaging disconnected stakeholder communities via different channels. This approach can help pinpoint unbalanced developments, like locally established PHS application projects that miss opportunities to establish elsewhere. Yet, it remains unclear whether the number of stakeholders that might be needed to really coordinate multiple layers of innovation ecosystems and build momentum for more rapid change was nearly enough. Still the project constitutes a humble effort to establish better anticipatory capabilities to deal with potential disruptive developments. This is a common drawback which limited projects encounter in general.

The coordination of foresight and of actual policy measures concerning such an overarching domain, within multiple layers of innovation systems, is the sort of challenge that will be confronted whenever profound technological opportunities arise, or grand challenges are addressed. The design and management of multi-layered foresight can benefit from i) the structured stakeholder engagement across the layers, ii) the flexible, modular and scalable design of activities and iii) taking also into account the multiple layers in the implementation of chosen foresight methods.

In the following we critically assess the contributions of a specific foresight exercise to wire up the various layers of innovation ecosystems.

4.1. Structured stakeholder engagement

In the design of the exercise, multi-layered foresight pays particular attention to the representation and engagement of stakeholders across different layers of innovation ecosystems. PHS Foresight systematically addressed a variety of stakeholders to reflect the diversity within the innovation ecosystems. However, an issue worth investigating in the future is the degree to which certain groups of stakeholders are systematically underrepresented in foresight activities (Cagnin et al., 2014). Apart from large firms which often have departments dedicated to EU communication, firms especially, but also professional associations, are actors who are often interested but rarely take part in European workshops or other foresight activities.

In particular, foresight activities can benefit from further attention to the balanced representation of different layers of the innovation ecosystems to address such vertical coordination.

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Table 7
Reflections on outputs, outcomes and impacts vis-à-vis three facets of foresight on multiple layers of the innovation systems.

Layer	Knowledge	Relations	Capabilities
International innovation ecosystems	Strategic plan and topics suitable for European collaboration A common understanding on potential of PHS, problems and barriers Benchmarking regional efforts across countries	Networking and co-promotion across numerous international networks, alliances and projects.	Limited direct engagement of international constituencies, hence limited learning of new capabilities mainly through the dissemination of deliverables.
National innovation systems	Common themes were addressed to see where solutions were possible. It was not the project's aim to discuss the considerable diversity of national innovation (and health!) systems.	Nationally relevant stakeholders were engaged, but only few engaged in workshops and/or interviews while the majority engaged online.	The take up of new capabilities, namely foresight methods and ecosystem models, among nationally relevant experts was facilitated through workshops and online engagement.
Regional innovation systems	Case studies promoted knowledge exchange between regional projects on good practise	Relevant regional stakeholders were engaged, but only few engaged in workshops and/or interviews while the majority engaged online.	The take up of new capabilities, namely foresight methods and ecosystem models, among regional participants was facilitated through workshops and online engagement.
Innovation ecosystems	Case studies promoted knowledge exchange between regional projects on good practise. Elaboration of future visions and scenarios supported further reflection on new business models.	Different types of stakeholders provided good coverage of ecosystems. The scenario work helped identify new relevant stakeholders.	The take up of new capabilities, namely foresight methods and ecosystem models, among regional participants was facilitated through workshops and online engagement.

While the representativeness of different types of stakeholders (private and professional users, suppliers and supporters) within the ecosystem was reached, representation of different ecosystems across Europe remained low despite the efforts. Relevant national and regional stakeholders were engaged, but it proved difficult to comprehensively engage authorities on such a specific topic like PHS. On the local layer of innovation ecosystems, diverse stakeholders were engaged. However, the high number of ecosystems in Europe meant that only a fraction of the whole diversity of ecosystems could be engaged directly.

4.2. Flexible design

Definition of decision points between the series of modules are crucial in order to allow the (re)direction of the project based on stakeholder feedback. Thus the responsiveness to different layers of innovation ecosystems is ensured. PHS Foresight design allowed a number of decision points and in some occasions also new directions were taken. For instance, in case of designing the online engagements, the project team piloted the approach first with the focus on collecting innovation ideas that was later refined based on stakeholder feedback to focus on future visions on PHS.

4.3. Modular and scalable design

Multi-layered foresight design and management can benefit from the definition of parallel foresight modules of activities for better scalability, and thus ability to address different layers. The project design entailed a number of tasks (e.g. interviews, workshops and surveys) that could address in parallel the stakeholders in different ecosystems. Such a scalable design could have been integrated in the initial project design but with additional resource allocations for the coordination of efforts.

4.4. Multi-layered perspectives and foresight methods

At the outset of the PHS Foresight, the project team paid particular attention to demarcate the realm of PHS and to construct a thesaurus in support of bibliometric and patent analysis. These analyses could have also benefited from the application of multi-layered framework for exploring systematically the field of PHS in different layers of ecosystems and developed knowledge base for further coordination across the layers. The online visioning process engaged different target groups across the layers. Further efforts could have been done to address the layers with multiple language options in the online platform. Scenarios work relied heavily on workshops in which due to the resource limitations the number of participants had to be limited, hence creating difficulties to ensure sufficient representation of all layers.

5. Conclusions

In this paper of empirically-based theory building we focused on the context of multiple layers of innovation ecosystems in the design and management of foresight activities. The development and application of this framework in the analysis of PHS Foresight helped identify some implications on the design and management of multi-layered foresight.

This particular exercise can be but one contribution to the body of foresight exercises across Europe and beyond, examining PHS, health issues, and other science, technology and innovation topics. The European dimension and sponsorship of the study necessarily drew attention to the multi-layered nature of innovation systems.

The findings of the paper indicate that the systemic interconnections and interactions within and across different innovation systems should be reflected both at the design and implementation phase of a foresight exercise as well as in the recommendations. The impact of foresight exercises will increase if activities in multiple layers are examined and engaged, and strategies are designed, as far as possible, in a concerted way as the strategic implications of a foresight exercise range across different layers of innovation ecosystems. This paper is by no means a concluding statement on the implications of multiple layers of innovation systems on foresight design and management. On the contrary, this contribution is intended to stimulate further debate.

Acknowledgements

The paper is based on a foresight project co-funded by the European Commission, Project reference: 305801, funded under: FP7-HEALTH. All the authors worked on this project. A number of stakeholders contributed to the project on a voluntary basis. In particular, we would like to thank stakeholder panellists and the members of the advisory board, together with workshop participants, interviewees and numerous online contributors who invested in their time to the project. Contributions to this paper by Ian Miles and Ozcan Saritas were provided within the framework of the Basic Research Program at the National Research University HSE and was supported within the framework of the subsidy granted to the HSE by the Government of the Russian Federation for the implementation of the Global Competitiveness Program.

Contributions to this paper by Totti Könnölä was made possible by the financial support of Insight Foresight Institute based in Madrid, Spain.

References

Ács, Z.J., Autio, E., Szerb, L., 2014. National systems of entrepreneurship: measurement issues and policy implications. Res. Policy 43 (3), 476–494. http://dx.doi.org/10.1016/j.respol.2013.08.016.

Almirall, E., Lee, M., Majchrzak, A., 2014. Open innovation requires integrated competition-community ecosystems: lessons learned from civic open innovation. Bus. Horiz. 57 (3), 391–400 (Available at: http://www.sciencedirect.com/science/article/pii/S0007681313002176, Accessed January 7, 2015).

Anderson, M.S., 2011. International research collaborations: anticipating challenges instead of being surprised. The Europa World of Learning. Routledge, UK, p. 11.

Brummer, V., Könnölä, T., Salo, A., 2008. Foresight within ERA-NETs: experiences from the preparation of an international research program. Technol. Forecast. Soc. Chang. 75 (4), 483–495 (Available at: http://www.sciencedirect.com/science/article/pii/S0040162508000358, Accessed October 2, 2014).

Cagnin, C., Könnölä, T., 2014. Global foresight: lessons from a scenario and roadmapping exercise on manufacturing systems. Futures 59, 27–38 (Available at: http://www.sciencedirect.com/science/article/pii/S001632871400010X, Accessed October 7, 2014).

Cagnin, C., et al., 2014. Bridging the "policy" and "polity" with foresight to enable democratic participation in policy making Cristiano Cagnin, Denis Loveridge, Susanne Giesecke and Ozcan Saritas. Futures.

Carayannis, E.G., Rakhmatullin, R., 2014. The quadruple/quintuple innovation helixes and smart specialisation strategies for sustainable and inclusive growth in Europe and beyond. J. Knowl. Econ. 5, 212–239.

Carlsson, B., 2006. Internationalization of innovation systems: a survey of the literature. Res. Policy 35 (1), 56–67 (Available at: http://www.sciencedirect.com/science/article/pii/S0048733305001757, Accessed August 27, 2014).

Carlsson, B., et al., 2002. Innovation systems: analytical and methodological issues. Res. Policy 31 (2), 233–245 (Available at: http://www.sciencedirect.com/science/article/pii/S004873330100138X, Accessed October 24, 2014).

Codagnone, C., 2009. Reconstructing the whole : present and future of personal health systems. Available at: http://www.ehealthnews.eu/images/stories/pdf/phs2020-book-rev16082009.pdf.

Collins, P.K., 2015. Building a local design and entrepreneurship ecosystem. Procedia Technol. 20, 258–262. http://dx.doi.org/10.1016/j.protcy.2015.07.041.

Connell, J.P., Kubisch, A.C., 1998. Applying a theory of change approach to the evaluation of comprehensive community initiatives: progress, prospects, and problems. In: F.-A., K., Kubisch, A.C., Connell, J.P. (Eds.), Theory Measurement and Analysis. Vols. 2(15-44), pp. 15–44 (Available at: http://communities.usaidallnet.gov/fa/system/files/Applying+Theory+of+Change+Approach.pdf).

Da Costa, O., et al., 2008. The impact of foresight on policy-making: insights from the FORLEARN mutual learning process. Tech. Anal. Strat. Manag. 20 (3), 369–387.

Dufva, M., Könnölä, T., Koivisto, R., 2015. Multi-layered foresight: lessons from regional foresight in Chile. Futures 73, 100–111 (Available at: https://ec.europa.eu/jrc/en/event/site/fta2014).

Eerola, A., Miles, I., 2011. Methods and tools contributing to FTA: a knowledge-based perspective. Futures 43 (3), 265–278.

Fikirkoca, A., Saritas, O., 2012. Foresight for science parks: the case of Ankara University. Tech. Anal. Strat. Manag. 24 (10), 1071–1085.

Foray D.Guide to Research and Innovation Strategies for Smart Specialization (RIS3).

Forces, J., 2008. In a world of open innovation : guidelines. pp. 1–32 (Available at: http://www.eirma.asso.fr/f3/local_links.php?action=jump&id=796). October).

Gavigan, J.P., et al., 2001. A practical guide to regional foresight. Reproduction (Available at: foresight.jrc.ec.europa.eu/documents/eur20128en.pdf).

Georghiou, L., Cassingena Harper, J., 2011. From priority-setting to articulation of demand: foresight for research and innovation policy and strategy. Futures 43 (3), 243–251 (Available at: http://www.sciencedirect.com/science/article/pii/S0016328710002673, Accessed October 14, 2014).

Georghiou, L., et al., 2008. The Handbook of Technology Foresight : Concepts and Practice. Edward Elgar, Cheltenham, UK.

Havas, A., Schartinger, D., Weber, M., 2010. The impact of foresight on innovation policy-making: recent experiences and future perspectives. Res. Eval. 19 (2), 91–104.

Heger, T., Boman, M., 2014. Networked foresight—the case of EIT ICT labs. Technological Forecasting and Social Change (Available at: http://www.sciencedirect.com/science/article/pii/S004016251400050X, Accessed January 26, 2015).

Hekkert, M.P., et al., 2007. Functions of innovation systems: a new approach for analysing technological change. Technol. Forecast. Soc. Chang. 74 (4), 413–432 (Available at: http://www.sciencedirect.com/science/article/pii/S0040162506000564, Accessed July 9, 2014).

Hodgson, G.M., Knudsen, T., 2004. The complex evolution of a simple traffic convention: the functions and implications of habit. J. Econ. Behav. Organ. 54 (1), 19–47 (Available at: http://linkinghub.elsevier.com/retrieve/pii/S0167268103002002, Accessed October 8, 2014).

Hodgson, G.M., Knudsen, T., 2010. Generative replication and the evolution of complexity. J. Econ. Behav. Organ. 75 (1), 12–24 (Available at: http://linkinghub.elsevier.com/retrieve/pii/S0167268110000454, Accessed October 10, 2014).

Keller, J., Markmann, C., von der Gracht, H.A., 2015. Foresight support systems to facilitate regional innovations: a conceptualization case for a German logistics cluster. Technol. Forecast. Soc. Chang. 97, 15–28. http://dx.doi.org/10.1016/j.techfore.2013.12.031.

Kim, H.J., Kim, I., Lee, H., 2016. Third-party mobile app developers' continued participation in platform-centric ecosystems: an empirical investigation of two different mechanisms. Int. J. Inf. Manag. 36 (1), 44–59 (Available at: http://linkinghub.elsevier.com/retrieve/pii/S0268401215000894).

Könnölä, T., 2016. Multi-layered foresight: the concept and methodological implications. Available at: www.if-institute.org.

Könnölä, T., Haegeman, K., 2012. Embedding foresight in transnational research programming. Sci. Public Policy 39 (2), 191–207 (http://spp.oxfordjournals.org/cgi/doi/10.1093/scipol/scs020 Accessed November 30, 2014.).

Könnölä, T., Salo, A., Brummer, V., 2009. FinnSight 2015 — A National Joint Foresight Exercise. Foresight, p. 4 (Available at: http://www.foresight-platform.eu/brief/efp-brief-no-164-finnsight-2015-?-a-national-joint-foresight-exercise/).

Könnölä, T., Salo, A., Brummer, V., 2011. Foresight for European coordination: developing national priorities for the forest-based sector technology platform. Int. J. Technol. Manag. 54 (4), 438.

Kuhlmann, S., Edler, J., 2003. Scenarios of technology and innovation policies in Europe: investigating future governance. Technol. Forecast. Soc. Chang. 70 (7), 619–637 (Available at: http://www.sciencedirect.com/science/article/pii/S0040162503000271, Accessed January 26, 2015).

LLA, PREST & ANRT, 2002. Innovation tomorrow : innovation policy and the regulatory framework: making innovation an integral part of the broader structural agenda. Luxembourg.

Loikkanen, T., Kutinlahti, P., Eerola, A., 2006. Towards an integrated framework of impact assessment and foresight studies in innovation policy analysis. The Second International Seminar on Future-oriented Technology Analysis (FTA).

Maassen, P., Stensaker, B., 2011. The knowledge triangle, European higher education policy logics and policy implications. High. Educ. 61 (6), 757–769 (Available at: http://link.springer.com/10.1007/s10734-010-9360-4, Accessed August 25, 2014).

Martin, B.R., 2010. The origins of the concept of "foresight" in science and technology: an insider's perspective. Technol. Forecast. Soc. Chang. 77 (9), 1438–1447 (Available at: http://linkinghub.elsevier.com/retrieve/pii/S0040162510001307, Accessed August 9, 2014).

Martin, B.R., Johnston, R., 1999. Technology foresight for wiring up the national innovation system. Technol. Forecast. Soc. Chang. 60 (1), 37–54 (Available at: http://www.sciencedirect.com/science/article/pii/S0040162598000225, Accessed October 14, 2014).

Miles, I., 2010. The development of technology foresight: a review. Technol. Forecast. Soc. Chang. 77 (9), 1448–1456.

Miles, I., Keenan, M., 2002. Bringing it all back home: linking national and regional foresight. IPTS Report No. 61, pp. 29–35.

Moore, J.F., 1993. Predators and prey: a new ecology of competition. Harv. Bus. Rev. 71 (3), 75–86.

Nelson, R.R., Winter, S.G., 1977. In search of useful theory of innovation. Res. Policy 6 (1), 36–76.

OECD, 2003. Policy Coherence, Paris.

Pattberg, P., 2005. The institutionalization of private governance: how business and nonprofit organizations agree on transnational rules. Governance 18 (4), 589–610.

Reid, A., et al., 2007. Economic and scientific policy synergies between the EU 7th Research Framework Programme, the competitiveness and innovation framework programme and the structural funds, Brussels. Available at: http://www.europarl.europa.eu/RegData/etudes/etudes/join/2007/385645/IPOL-ITRE_ET(2007)385645_EN.pdf.

Rohrbeck, R., Gemünden, H.G., 2011. Corporate foresight: its three roles in enhancing the innovation capacity of a firm. Technol. Forecast. Soc. Chang. 78 (2), 231–243 (Available at: http://www.sciencedirect.com/science/article/pii/S004016251000140X, Accessed January 26, 2015).

Rong, K., et al., 2014. Understanding business ecosystem using a 6C framework in internet-of-things-based sectors. Int. J. Prod. Econ. 159, 41–55 (Available at: http://www.sciencedirect.com/science/article/pii/S0925527314002813).

Salo, A., Könnölä, T., Hjelt, M., 2004. Responsiveness in foresight management: reflections from the Finnish food and drink industry. Int. J. Foresight Innov. Policy 1 (1/2), 70.

Saritas, O., 2006. Systems Thinking for Foresight. University of Manchester, Manchester (PhD Thesis).

Saritas, O., 2013. Systemic foresight methodology. In: Meissner, D., Gokhberg, L., Sokolov, A. (Eds.), Science, Technology and Innovation Policy for the Future: Potentials and Limits of Foresight Studies. Springer, pp. 83–117 (Available at: http://link.springer.com/10.1007/978-3-642-31827-6).

Schartinger, D., et al., 2015. Personal health systems technologies : critical issues in service innovation and diffusion. Technology Innovation Management Review, pp. 46–57 (February).

Schoen, A., et al., 2011. Tailoring foresight to field specificities. Futures 43 (3), 232–242 (Available at: http://www.sciencedirect.com/science/article/pii/S0016328710002661, Accessed October 14, 2014).

Smits, R., Kuhlmann, S., 2004. The rise of systemic instruments in innovation policy. Int. J. Foresight Innov. Policy 1 (1/2), 4.

ThomsonReuters, 2013a. Derwent innovation index. Available at: http://thomsonreuters.com/en/products-services/scholarly-scientific-research/scholarly-search-and-discovery/derwent-innovations-index.html.

ThomsonReuters, 2013b. Patent citation index. Available at: http://thomsonreuters.com/en/products-services/intellectual-property/patent-research-and-analysis/derwent-world-patents-index.html.

von der Gracht, H.A., Vennemann, C.R., Darkow, I.-L., 2010. Corporate foresight and innovation management: a portfolio-approach in evaluating organizational development.

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Futures 42 (4), 380–393 (Available at: http://www.sciencedirect.com/science/article/pii/S0016328709001979, Accessed February 13, 2015).
Weber, K.M., et al., 2012. Coping with a fast-changing world: towards new systems of future-oriented technology analysis. Sci. Public Policy 39 (2), 153–165.
Wessels, J., Schumann, K., Vde-it, V.D.I., 2015. The City of the Future Project Case Study under the OECD Systems Innovation Project (January).
Wieczorek, A.J., et al., 2014. Broadening the national focus in technological innovation system analysis: the case of offshore wind. Environmental Innovation and Societal Transitions (Available at: http://www.sciencedirect.com/science/article/pii/S2210422414000665, Accessed October 14, 2014).
Wintjes, R., Hollanders, H., 2011. Innovation pathways and policy challenges at the regional level: smart specialization. Innovation 1–49.
Zeschky, M., et al., 2014. Coordination in global R&D organizations: an examination of the role of subsidiary mandate and modular product architectures in dispersed R&D organizations. Technovation 34 (10), 594–604 (Available at: http://www.sciencedirect.com/science/article/pii/S0166497214000832, Accessed January 26, 2015).

PHS foresight project reports

Amanatidou, E., Miles, I., Saritas, Ö., Schartinger, D., Schreier, G., Pombo-Juárez, L., Giesecke, S., Könnölä, T., 2014a. Personal health systems a success scenario report. http://www.phsforesight.eu/reports (eScholarID:245773).
Amanatidou, E., Miles, I., Saritas, Ö., Schartinger, D., Schreier, G., Pombo-Juárez, L., Giesecke, S., Könnölä, T., 2014b. Personal health systems scenario workshop report. http://www.phsforesight.eu/reports (eScholarID:245769).
Amanatidou, E., Miles, I., Saritas, Ö., Schartinger, D., Giesecke, S., Pombo-Juárez, L., 2014c. Personal health systems: a success scenario PHS project, D3.1 report on PHS scenarios and vision 2030. Available at: http://www.phsforesight.eu/reports.
Pombo-Juárez, L., Könnölä, T., Amanatidou, E., Schartinger, D., Giesecke, S., Schreier, G., Saritas, Ö., Miles, I., 2013a. Personal health systems: foresight community and synergies PHS project D5.2 report 'online community and synergies with initiatives'. Available at: http://www.phsforesight.eu/reports.
Pombo-Juárez, L., Könnölä, T., Amanatidou, E., Schartinger, D., Giesecke, S., Schreier, G., Saritas, Ö., Miles, I., 2013b. PHS: opportunities for innovation partnerships PHS project, D2.1, report 'PHS communities and innovation partnerships'. Available at: http://www.phsforesight.eu/reports.
Pombo-Juárez, L., Guisecke, S., Miles, I., Schartinger, D., Amanatidou, E., Schreier, G., Saritas, Ö., 2014. Personal health systems: foresight synthesis PHS project, D 4.1 synthesis report (final report). Available at: http://www.phsforesight.eu/reports.
Schartinger, D., Giesecke, S., Heller-Schuh, B., Amanatidou, E., Schreir, G., Miles, I., Pombo-Juárez, L., Saritas, Ö., Kastner, P., Könnölä, T., 2013. Personal Health Systems State of the Art. D 1.1 Report on State-of-the-Art and Policy Recommendations. eScholarID: 213713.

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Please cite this article as: Pombo-Juárez, L., et al., Wiring up multiple layers of innovation ecosystems: Contemplations from Personal Health Systems Foresight, Technol. Forecast. Soc. Change (2016), http://dx.doi.org/10.1016/j.techfore.2016.04.018