Department of Mathematics and Systems Analysis

Knowledge creation in foresight

a practice- and systems-oriented view

Mikko Dufva

Aalto University

DOCTORAL DISSERTATIONS

Aalto University publication series
DOCTORAL DISSERTATIONS 222/2015
VTT SCIENCE 121

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A doctoral dissertation completed for the degree of Doctor of Science (Technology) to be defended, with the permission of the Aalto University School of Science, at a public examination held at the lecture hall H304 at Aalto University School of Science (Otakaari 1, 02150 Espoo, Finland) on 22 January 2016 at 12 noon.

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Aalto University publication series
DOCTORAL DISSERTATIONS 222/2015

VTT SCIENCE 121

ISBN 978-952-60-6607-3 (printed)
ISBN 978-952-60-6608-0 (pdf)
ISSN-L 1799-4934
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)
http://urn.fi/URN:ISBN:978-952-60-6608-0

ISBN 978-951-38-8383-6 (printed)
ISBN 978-951-38-8382-9 (pdf)
ISSN-L 2242-119X
ISSN 2242-119X (printed)
ISSN 2242-1203 (pdf)
http://urn.fi/URN:ISBN:978-951-38-8382-9

Unigrafia Oy
Helsinki 2015

Finland

441 697
Printed matter

Aalto University

Abstract

Aalto University, P.O. Box 11000, FI-00076 Aalto www.aalto.fi

Author
Mikko Dufva

Name of the doctoral dissertation
Knowledge creation in foresight – a practice- and systems-oriented view

Publisher School of Science

Unit Department of Mathematics and Systems Analysis

Series Aalto University publication series DOCTORAL DISSERTATIONS 222/2015

Field of research Systems and Operations Research

Manuscript submitted 5 October 2015 **Date of the defence** 22 January 2016

Permission to publish granted (date) 24 November 2015 **Language** English

☐ **Monograph** ☒ **Article dissertation (summary + original articles)**

Abstract

This dissertation studies the creation of futures knowledge in the practice of foresight. By futures knowledge I mean the perceptions about futures expressed by various stakeholders. Foresight is commonly used for anticipating future developments, scoping alternative futures and creating present actions based on futures knowledge. It is usually depicted as a process, where a group of experts and other stakeholders gather and produce knowledge about the future. This process view is problematic, because it does not usually consider the influence of the events and processes taking place outside a separate foresight process. The foresight process is often viewed as a strategic exercise disconnected from the everyday operations of organisations. Despite the wide use of foresight, the creation of futures knowledge has not received much attention in research on foresight. Instead, the focus has been on the production of outcomes, such as scenarios, roadmaps and visions.

In this dissertation, I present a systems view of foresight and study futures knowledge creation from a systems perspective. The theories and approaches on innovation systems, complex adaptive systems and foresight form the theoretical basis. My research methods are based on grounded theory and the research material consists of five foresight projects. The main results include futures knowledge typology, elements of a foresight system, futures knowledge as a network of concepts and a multi-layered foresight framework. Based on these results, I present two complementary views of futures knowledge creation. First, I argue that futures knowledge is created through the conversions between different types of knowledge. Second, futures knowledge is created gradually through the interaction between humans, dependent on the nature of the interaction, and can be seen as the shaping of the network of concepts.

The main theoretical contribution of this dissertation is the further elaboration of the systems view of foresight. This includes the elements of a foresight system, the futures knowledge typology and the multi-layered foresight. These can be applied in the study of foresight processes to identify and analyse different ways by which the processes create futures knowledge and support the formation of strategy. The main practical implication of the systems view to foresight is the shift from seeing foresight projects as separate to perceiving them as part of an interconnected whole. In order to enhance the creation of futures knowledge, these processes need to be flexible and enable intensive and broad participation among participants. In addition, futures knowledge should be seen more as a network of perceptions about alternative futures than separate outcomes of foresight projects.

Keywords Foresight, knowledge creation, futures research, systems thinking

ISBN (printed) 978-952-60-6607-3 **ISBN (pdf)** 978-952-60-6608-0

ISSN-L 1799-4934 **ISSN (printed)** 1799-4934 **ISSN (pdf)** 1799-4942

Location of publisher Helsinki **Location of printing** Helsinki **Year** 2015

Pages 157 **urn** http://urn.fi/URN:ISBN:978-952-60-6608-0

Aalto-yliopisto

Tiivistelmä

Aalto-yliopisto, PL 11000, 00076 Aalto www.aalto.fi

Tekijä
Mikko Dufva

Väitöskirjan nimi
Tulevaisuustietämyksen muodostuminen ennakoinnissa - käytännön ja systeeminäkökulma

Julkaisija Perustieteiden korkeakoulu

Yksikkö Matematiikan ja systeemianalyysin laitos

Sarja Aalto University publication series DOCTORAL DISSERTATIONS 222/2015

Tutkimusala Systeemi- ja operaatiotutkimus

Käsikirjoituksen pvm 05.10.2015 **Väitöspäivä** 22.01.2016

Julkaisuluvan myöntämispäivä 24.11.2015 **Kieli** Englanti

☐ **Monografia** ☒ **Yhdistelmäväitöskirja (yhteenveto-osa + erillisartikkelit)**

Tiivistelmä

Väitöskirjassani tutkin tulevaisuustietämyksen eli tulevaisuutta koskevien näkemysten muodostumista käytännön ennakointihankkeissa. Ennakointia käytetään yleisesti vaihtoehtoisten tulevaisuuksien hahmottamiseen ja nykyhetken toimenpiteiden muodostamiseen tulevaisuustietämyksen pohjalta. Ennakointi kuvataan yleensä prosessina, jossa joukko asiantuntijoita ja sidosryhmiä kokoontuu yhteen ja tuottaa tulevaisuutta koskevaa tietoa. Ennakointiprosessit ymmärretään usein organisaatioiden arkisen toiminnan näkökulmasta erillisinä strategiaharjoitteina. Tämä prosessinäkökulma on ongelmallinen, koska se jättää helposti yksittäisen ennakointiprosessin ulkopuoliset tapahtumat huomioimatta. Huolimatta ennakoinnin yleistyneestä käytöstä tulevaisuustietämyksen muodostumista ei ole paljoakaan tutkittu, vaan on keskitytty lähinnä ennakoinnin tulosten tuottamiseen, kuten skenaarioihin, tiekarttoihin ja visioihin.

Esitän väitöskirjassani näkemyksen ennakoinnista systeeminä ja tulkitsen tulevaisuustietämyksen muodostumista systeeminäkökulman kautta. Tutkimukseni pohjan luovat innovaatiojärjestelmien, monimutkaisten adaptiivisten järjestelmien ja ennakoinnin teoriat. Tutkimusmenetelmäni perustuu ankkuroituun teoriaan (grounded theory) ja aineistona käytän viittä ennakointihanketta. Tuloksina esitän tulevaisuustietämyksen typologian, ennakoinnin monitasomallin, ennakointijärjestelmän elementtien kuvauksen ja tulevaisuustietämyksen luonnehdinnan näkemysten verkostona. Näihin tuloksiin nojautuen tarjoan kaksi toisiaan tukevaa kuvausta tulevaisuustietämyksen muodostumisesta. Ensimmäisessä kuvauksessa tulevaisuustietämys kasvaa typologiassa esitettyjen tietomuotojen muutosten kautta. Toisessa kuvauksessa tulevaisuustietämys muovautuu hiljalleen ihmisten välisessä vuorovaikutuksessa ja ilmenee näkemysten verkoston muutoksina.

Väitöskirjani keskeinen teoreettinen anti on ennakoinnin systeeminäkökulman tarkentaminen ja edelleen kehittäminen. Ennakointijärjestelmän elementtien, tulevaisuustietämyksen typologian ja ennakoinnin monitasomallin avulla voidaan tunnistaa erilaisia tapoja, joilla ennakointiprosessit tuottavat tulevaisuustietämystä ja tukevat strategisen näkemyksen rakentumista. Käytännön tasolla systeeminen näkökulma tarkoittaa sitä, että näkemyksestä ennakoinnista yksittäisinä, erillisinä projekteina siirrytään ennakoinnin hahmottamiseen useina toisiinsa ja ympäristöönsä kytköksissä olevina prosesseina. Jotta tulevaisuustietämystä saadaan parhaiten muovattua, tulee näiden prosessien olla joustavia, moniäänisiä ja intensiivisen vuorovaikutuksen mahdollistavia. Lisäksi tulevaisuustietämys tulisi nähdä pikemminkin näkemysten verkostona kuin yksittäisinä ennakoinnin tuloksina.

Avainsanat Ennakointi, tiedon tuottaminen, tulevaisuudentutkimus, systeemiajattelu

ISBN (painettu) 978-952-60-6607-3 **ISBN (pdf)** 978-952-60-6608-0

ISSN-L 1799-4934 **ISSN (painettu)** 1799-4934 **ISSN (pdf)** 1799-4942

Julkaisupaikka Helsinki **Painopaikka** Helsinki **Vuosi** 2015

Sivumäärä 157 **urn** http://urn.fi/URN:ISBN:978-952-60-6608-0

Preface

The journey towards this dissertation started in January 2012 with a wavy line describing the convergence and divergence of knowledge in a foresight process. I would like to express my deepest gratitude to the drawer of that wavy line, my supervisor Toni Ahlqvist for excellent guidance, inspiring discussions and support in my development as a researcher. I am also most indebted to Professor Ahti Salo for his insightful comments, calls for clear definitions and help in clarifying the key points.

I would like to thank the VTT Graduate School for providing me with both an opportunity to work on inspiring projects and time and funding to concentrate on my dissertation. I thank the Ministry for Foreign Affairs of Finland for funding the "Innovation capacity in Antofagasta" project and the State Government of South Australia, Commonwealth Govt DIICCSRTE, the Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE), Regional Development Australia Limestone Coast Inc, and PIRSA for their assistance and contributions in The South Australian Cellulosic Value Chain Technology Roadmap project. This dissertation has also benefited from the "Platform Value Now" project funded by the Academy of Finland.

I had the opportunity to spend the summer 2014 at IIASA, which turned out to be a key event in the development of this dissertation. For this, I would especially like to thank Leena Ilmola-Sheppard for her stimulating guidance, as well as the always helpful IIASA staff and researchers, the Advanced Systems Analysis program, and all my YSSP colleagues. I am grateful to the Academy of Finland for the funding for this research exchange.

I have had the privilege to work with enthusiastic and brilliant researchers at VTT. I thank my team and colleagues for an atmosphere of curiosity and good cheer, and my team leader Johanna Kohl for her support and guidance in the turbulent organisational environment. A special thank you to my co-authors Raija Koivisto and Totti Könnölä for their valuable contributions. I would also like to thank the Systems Analysis Laboratory at Aalto University and the Doctoral Education Network in Systems Analysis, Decision Making and Risk Management.

A huge thank you to my parents for always supporting, encouraging and believing in me. Thanks to my extended family and friends for their support and motivation. Cheers to my daughter Eevi for being a ray of sunshine and reminding me of

what is important. Finally, a few words of enormous gratitude to my wife Emma: thank you for listening to the endless talk about my work, for challenging me to go forward, for giving me strength, and for loving me throughout this journey.

Tampere, December 2, 2015

Mikko Dufva

List of publications

This thesis is based on the following original publications which are referred to in the text as I–IV.

I Dufva, M. & Ahlqvist, T. 2015. Knowledge creation dynamics in foresight: A knowledge typology and exploratory method to analyse foresight workshops. *Technological Forecasting and Social Change*, 94, 251-268.

II Dufva, M. & Ahlqvist, T. 2015. Elements in the construction of future-orientation: A systems view of foresight. *Futures*, 73, 112-125.

III Dufva, M., Könnölä, T. & Koivisto, R. 2015. Multi-layered foresight: Lessons from regional foresight in Chile. *Futures*, 73, 100-111.

IV Dufva, M., Ilmola, L. & Ahlqvist, T. 2015. Emergence of shared perceptions of futures in a foresight system. Submitted manuscript, 32 pages.

Author's contributions

Paper I: Dufva is the lead author. The research topic was proposed by Ahlqvist and jointly developed by Dufva and Ahlqvist. Dufva developed the knowledge typology. Ahlqvist proposed the exploratory method and suggested the case study. Dufva carried out the analysis and wrote the initial version of the paper. Ahlqvist provided some key arguments and helped to finalise the paper.

Paper II: Dufva is the lead author. The research topic was developed jointly with Ahlqvist. Dufva developed the conceptual model, carried out the analysis of the case studies and wrote the paper. Ahlqvist and Dufva both participated in conducting and writing the case studies. Ahlqvist provided some justifying arguments and general comments on the paper.

Paper III: Dufva is the lead author. The research topic and study design were developed jointly by Dufva and Könnölä and the case study was conducted by Dufva, Könnölä and Koivisto. Dufva conducted the analysis and wrote the paper. Könnölä and Koivisto provided comments on the paper.

Paper IV: Dufva is the lead author. The research topic and the study design were developed by Dufva and Ilmola. Dufva conducted the analysis and wrote the paper. Ahlqvist and Ilmola provided comments on the paper.

Contents

1. Introduction

Knowing about the future has fascinated humans since the dawn of civilization (Bell, 2003). In pre-modern times, knowledge about the future – futures knowledge – was connected to strategic decisions such as when to hunt, sow or go to war, and to some extent also to the consequences of those decisions, and was divined by mystics such as oracles and mediums (Barrett, 1996). In modern times, the task of knowing about the future has become demystified and secular, and futures researchers and foresight practitioners aim to be transparent, systematic and explicit in their methods and assumptions (Bell, 2003). The resulting futures knowledge is not seen as deterministic forecasts of what will happen, but rather as knowledge about contingencies (Wright, 2009; Malaska, 2000), as fact-based probabilistic descriptions about the future (Piirainen & Gonzalez, 2015; Ketonen, 2009), as perceptions and preferences regarding the future (Fuller & Loogma, 2009; Slaughter, 2001) or more broadly as knowledge about possible, probable and preferable futures (Amara, 1981; Tapio & Hietanen, 2002; Bell, 2003; Niiniluoto, 2009). Futures knowledge has been approached from a philosophical viewpoint (De Jouvenel, 1967; Bell, 2003; Kuusi, 1999; Malaska & Masini, 2009; Gabriel, 2013; Sardar, 2010) and through the outcomes of foresight processes (Eerola & Miles, 2011; Andreescu et al., 2013; Miles, 2012). In this dissertation, I use a working definition of futures knowledge as the perceptions about futures, expressed in documents or discussions or through actions. This definition is elaborated throughout the thesis.

Futures knowledge is an important part of Western culture; Polak (1973) has even claimed that renewing the Western culture's image of the future is the key to its survival. This is ever more topical today, as the current situation does not look promising, with images of doom and gloom hanging over Europe (Saltelli & Dragomirescu-Gaina, 2014). Futures knowledge has been called for in order to respond to "Grand Challenges"[1], such as global warming, diminishing supplies of energy, and ageing societies (Boden et al., 2010; Haegeman et al., 2012; Ahlqvist & Rhisiart, 2015). Knowing alternative futures and the consequences of present actions is necessary for opening up a dialogue on what are desired futures (Nordmann, 2014; Andreescu et al., 2013) and avoiding disowned or used futures

[1] See the Lund Declaration 2009

(Inayatullah, 2008). On a global level, the recent sustainable development goals (UN, 2014) and its preceding document "The future we want" (UN, 2012) are examples of defining preferable futures in a policy-making context. There are even calls for more futures knowledge in order to identify and prepare for existential risks that have extremely severe consequences and are pan-generational in scope and thus threaten the existence or substantially reduce the well-being of humanity (Bostrom, 2013). Examples of such risks include nuclear holocaust, misuse of nanotechnology, asteroid impact and runaway global warming (Bostrom, 2002).

As the examples above indicate, the context of futures knowledge is often perceived of as turbulent and rapidly changing (Day & Schoemaker, 2004; Vecchiato, 2014). For example, in the introduction to his book "The future shock" Toffler described

> *"… the roaring current of change, a current so powerful today that it overturns institutions, shifts our values and shrivels our roots. Change is the process by which the future invades our lives…"* (Toffler 1970, p. 1).

More recently Rushkoff has claimed that we are living in "present shock" where

> *"… prophecy no longer feels like a description of the future but, rather, a guide to the present."* (Rushkoff 2013, p. 2)

In other words, one may ask whether the world is changing so rapidly that we are foreigners in our own present, and therefore try to escape it via fantasies of mass destruction, conspiracy theories and digital presence at the expense of physical presence (Rushkoff, 2013). It should be noted, however, that, while change is perceived to be rapid, it does not imply that it is necessarily rapid. For example, the operational environment of companies is claimed to be changing rapidly, full of disruptions and hypercompetitive, but there is little evidence to back this claim (McNamara et al., 2003; Landry, 2015).

Perceptions about futures knowledge influence attempts to create such knowledge. I illustrate this with a short story.

> *Once upon a time there were three friends, Herman, Wendell and Russell. They were all CEOs in large manufacturing companies. One day, while having lunch together, they started discussing possible disruptions that might affect their industry. Herman wanted to know what technologies will be the most significant. Wendell emphasised exploring alternative futures caused by the disruptions. Russell pointed out that labelling some things as disruptions told us more about current beliefs and wanting to stick to the old ways than about what will actually happen. After a heated discussion, they decided to look into the disruptions as part of the strategy making of their companies.*
>
> *Herman hired a top consultancy firm to figure out what technologies he should invest in. He wanted facts about the future, predictions based on solid evidence and was willing to pay big money for it. The consultants worked their magic, extrapolating trends and running fancy simulation models. After a while, they offered Herman a styl-*

ised slide set recommending him to invest in additive manufacturing, as that was clearly an emerging technology. Herman was glad of such a clear recommendation, but a little unsure what it would mean for his company. The consultancy firm offered to find that out too – for a modest fee.

Meanwhile, Wendell had launched a foresight project aimed at exploring the impact of different disruptions on the manufacturing sector. The project was well laid out, with top experts scanning the horizon for weak signals, answering Delphi questionnaires, brainstorming key factors of change and constructing alternative scenarios. The results were distilled into four beautifully illustrated and rich scenarios with catchy and imaginative names. All the experts who had been involved in the process were rather pleased with the outcome, which gave a comprehensive look into the futures of manufacturing. Those who had not been involved liked the striking names of the scenarios and the illustrations, but found the scenarios themselves as somewhat distant from their everyday reality. Soon everything returned to business as usual and the scenarios were archived on a bookshelf.

Russell had also started a foresight project in his company. In fact, he encouraged members of the organisation to start foresight projects and integrate future-orientation into their everyday work in whatever way they deemed to be most suitable. Instead of a big all-encompassing foresight project, Russell decided to catalyse the discussion on futures of manufacturing within the existing processes in the company. From the outside, it all looked like a mess – a tangle of gatherings, workshops and coffee table discussions at all levels of the company. Members of the company were asked to describe probable and preferable futures of manufacturing and to articulate the reasoning behind their answers. This reasoning as well as worldviews behind certain technologies, such as additive manufacturing, were debated, reframed and reshaped. Russell also invited representatives of different stakeholder groups to participate in the discussion, to challenge the assumptions and to provide their own views. The members of the company were asked to reflect on their position and relationship in a larger system – how they were connected to the stakeholders and what was important for them and others. Russell did not try to create scenarios or predictions; he wanted to change the way the future is perceived and create action based on a new perception. As a result, the dominant discourse on futures of manufacturing in the company changed from reacting to disruptions to proactively shaping the future.

When the three friends met together for lunch again, Herman boasted about the predictions he had received and Wendell presented the glossy pictures of the scenarios the experts had made. Russell did not have anything to show. He did, however, understand the rather narrow context in which Herman's predictions made sense and the reasoning behind Russell's scenarios – as well as what they left out. He was prepared to make sense of the future as it emerges.

The short story illustrates three ways of approaching knowing about alternative futures as well as three depictions of futures knowledge. Herman's approach is an example of forecasting, of trying to predict the future. In this case, futures knowledge is described as a prediction, a description of what will happen. While still widely used, forecasting has been criticized since the Second World War for determinism, false objectivity and narrow scope (Kuosa, 2011a; Miles, 2008; Bell, 2003).

Wendell's approach is a typical example of foresight, where alternative futures are explored, resulting in knowledge about futures in the plural, often captured in the form of scenarios, trends and roadmaps. Foresight has gained popularity since the 1960s and is an established practice in policy-making and corporate strategy (Bell, 2003; Kuosa, 2011a; Miles et al., 2008; Rohrbeck, 2011). It offers a systematic approach and a broad set of methods in order to help structure and cope with the complexity and uncertainty inherent in futures. There are many definitions of foresight, but one that is commonly used is foresight as a "systematic, participatory, future-intelligence-gathering and medium-to-long-term vision-building process aimed at enabling present-day decisions and mobilizing joint actions" (see Miles et al. 2008, p. 11). While its roots are in technology assessment and policy (Miles, 2010), the domains of foresight nowadays range from "Grand Challenges" (De Smedt et al., 2013; Haegeman et al., 2012) and national policies (Gavigan & Scapolo, 1999; Georghiou & Keenan, 2006; Martin & Johnston, 1999) to corporate strategies (Rohrbeck, 2011; Becker, 2002) and organisational capabilities (Hines & Gold, 2014; Fuller & Warren, 2006).

In this dissertation, I approach the creation of futures knowledge from the third angle described in Russell's approach, which illustrates a "systems view" of foresight. By systems view I mean seeing the world as consisting of interacting elements and understanding phenomena as emerging from this interaction. In this systems view, foresight is seen as dependent on and influenced by other processes taking place simultaneously (Mendonça & Sapio, 2009). It is opposed to a "process view", where foresight is perceived as a separate, often linear process (Horton, 1999; Becker, 2002), and not fully integrated into the innovation system[2] or organisational practices as a continuous activity (Keller et al., 2015; Treyer, 2009; Köhler et al., 2015; Dreyer & Stang, 2013). Of course, in the "process view", foresight can have systematic and systemic characteristics. Therefore, I make a distinction between three uses of the concept of system in foresight:

1. Foresight as a *systematic* practice for exploring futures: foresight is a process where a set of methods is used in a planned and rigorous manner (systematically) in order to create futures knowledge (Habegger, 2010; Kuosa, 2011b; Miles et al., 2008; Miles, 2010; Yuan, 2010).

[2] An innovation system is a societal system consisting of actors and institutions that contribute, directly or indirectly, to the emergence or production of innovation (Hekkert et al., 2007, p. 414)

2. Foresight *about systems*: the topic of foresight is perceived to be a system[3], and foresight itself is a process where the system and the interdependencies between its parts are scrutinized in order to understand and shape the system (Coates, 2010; Miles, 2010; Rohrbeck & Schwarz, 2013; Yuan, 2010).

3. Foresight *as a system:* the practice of foresight is seen as part of the system it is analysing and trying to shape, and as dependent on and influenced by other processes taking place simultaneously (Mendonça & Sapio, 2009; Amanatidou & Guy, 2008; Andersen & Andersen, 2014; Barre, 2014; Saritas, 2013).

I build on the third view of foresight as a system. Foresight has been claimed to be shifting towards more systems-oriented approaches (Daheim & Uerz, 2008; Rask, 2008). While the systems view is still emerging, foresight has been defined as a system by a few authors (Amanatidou & Guy, 2008; Andersen & Andersen, 2014; Barre, 2014; Saritas, 2013; Uotila et al., 2012; Weber et al., 2012). I build on these contributions and further develop and define foresight as a system, and in particular study the implications of the systems view on the creation of futures knowledge.

1.1 Objectives and scope

My main research question is: How is futures knowledge created in the practice of foresight? This can be divided into 3 subquestions:

1. What is futures knowledge, and how is it manifested in foresight?
2. What is the process through which it is created in the practice of foresight?
3. How is it used and interpreted?

I focus on studying foresight in practice as opposed to ideal depictions of foresight processes that can be found in the foresight literature (See e.g. Horton 1999; Voros 2003; Heger & Rohrbeck 2012; Smith & Saritas 2011; Popper 2008). Because of this, I use a practical definition of futures knowledge as shared perceptions about alternative futures, or "justifiable contingent plausibilities" to rephrase the definition of knowledge associated with Plato (Fine & Carpenter, 2003). I thus follow a constructivist view to futures knowledge (see Fuller & Loogma 2009). This approach to knowledge can also be described as contextual and relational. This means that several viewpoints could simultaneously fulfil the criteria of "truth" in a particular systemic context. From this perspective, the system can contain multiple, even contradictory, views that can simultaneously be "true" in a particular context. Thus, rather than trying to understand knowledge in a classical objectivist

[3] A system is a functionally indivisible set of interconnected, interdependent agents, which together generate emergent, aggregate behaviour not attributable to any single agent (Ackoff, 1974)

sense, as a “truth claim”, the focus in this dissertation is on understanding the knowledge production in a more relational sense. The key question is: how the foresight exercise produces knowledge that is viewed as plausible or accessible by the participants? This can mean plausible images of alternative futures or new mindsets for thinking about the future. As foresight is mainly connected to advising present action, futures knowledge is used to guide present action.

I build on the existing literature on innovation systems, systems thinking, foresight, knowledge creation and strategic management. There are four main aspects of my research that characterise my contributions to previous research on foresight and knowledge creation:

1. **Systems view:** As a general framework for understanding the processes and dynamics of knowledge creation in foresight, I use systems thinking (e.g. Jackson 2000; Ackoff 1974; Kaufmann 1995). I view the practice of foresight as a system, which consists of agents[4] who interact and together create the behaviour of the system.

2. **Emergence and co-creation instead of control:** In my view, foresight as a system, and thus futures knowledge creation in it, cannot be controlled by a single agent in the system. Rather, futures knowledge emerges from the interaction between the agents or is co-created by them. Thus, my focus is not on seeking ways to control knowledge creation, but rather on analysing how it is created through the interactions in the system.

3. **Focus on practice:** As stated above, I focus on real-life foresight processes and projects and try to understand futures knowledge creation by analysing these processes. As a consequence, I focus mainly on the processes and interaction in the projects, not on the outcomes.

4. **Multiple levels of analysis:** While most research on knowledge creation has focused on a specific level, often that of an innovation system, I study multiple levels from the interactions between individuals through the organisational level to the level of an innovation system.

1.2 Postulates

There are three main postulates in my dissertation that together form a new understanding of what futures knowledge creation is: a system of agents shaping the concepts with which futures are perceived and discussed. By concept I mean the cognitive meaning of a word, term or phrase. Futures knowledge creation in foresight is thus more about shaping present perceptions and increasing the capacity to influence the system in order to move towards preferred futures than it is about knowing about a pre-existing future.

[4] An agent is an individual, a group, an organisation or other entity that acts, in other words, that has an agency (Anderson, 1999; Lane & Maxfield, 2005).

1. Foresight is a system that operates through processes

While there are many definitions of foresight, the majority of them view foresight as a process (see e.g. Horton 1999; Heger & Rohrbeck 2012; Popper 2008b; Smith & Saritas 2011; Voros 2003). Instead, I frame foresight as a system. By foresight system, I mean a set of agents interacting together and aiming to explore and anticipate alternative futures in order to guide present action. The foresight system operates through foresight processes, which are temporary and dynamic crystallizations of contemplation and activities in the foresight system. While system evokes images of control and objectivity, I approach it from a different viewpoint. A foresight system is not controlled by any single agent, and it cannot be described objectively in its entirety. This is because the system is dynamic: the system is constantly changing in time. Every agent has an influence on the system and the overall system behaviour emerges from the interaction between the agents. However, the agents cannot be certain how their actions will influence the system. Thus, it is more meaningful to talk about co-evolution than about control. Furthermore, the agents have different perceptions as to what the system is in terms of its structure. Thus, there is no single overall picture of the system, and there can only be partial perspectives on the system.

2. Futures knowledge is a network of concepts reflecting the perceptions about futures

The systems concept is useful for understanding what futures knowledge is. It is an emergent property of the foresight system, a network of concepts reflecting the perceptions that the agents have. Different perceptions about futures appear as clusters of connected concepts. Different agents will emphasise different clusters and ignore others. Thus, there are multiple views on the network of concepts, and multiple views to futures. The network of concepts represents a way of talking about the future: what is seen to be relevant, what issues are seen as connected and how different things are framed. In other words, futures knowledge is dependent on the context and on the agents. It is constituted by the actions of the agents acting in a particular context.

3. Knowledge creation in foresight means changing the network by changing the emphasis or reframing concepts, and to a lesser extent by introducing new concepts to the discussion about futures

Taking a systems view of foresight and framing futures knowledge as a network of concepts opens a new view of futures knowledge creation. The network of concepts is not static, but varies depending on the behaviour of agents in time. The network changes as new connections are formed between the concepts and old ones are ignored as a consequence of agent interactions. From time to time a new concept might emerge, but mostly futures are discussed using existing concepts.

This means that knowledge creation in foresight is not mainly about creating new knowledge through sudden flashes of insight or visionary statements. Rather, futures knowledge creation is a gradual process of shaping the network of concepts by changing the emphasis and reframing. Introducing new concepts is a minor, but important part. Futures knowledge is created and shaped by adding and removing links between concepts, changing the emphasis of concepts and by introducing new concepts.

1.3 Research approach

The research approach is based on grounded theory (Glaser & Strauss, 1967; Glaser, 2011). Grounded theory is a research methodology for constructing theory based on analysis of mostly qualitative data. Instead of starting from a theory and collecting data to validate it, the approach in grounded theory starts with a general question, and key elements of theory are identified based on the collection, review and analysis of data. The results presented in this dissertation are an outcome of an iterative process of case study research and theory building. As research data, I utilised five foresight projects as case studies. I started by reviewing the literature on foresight and knowledge creation and developed initial conceptual models based on current theories and approaches in foresight and knowledge management. I took part in foresight projects and observed how the conceptual models fitted the actual practice of foresight and how they could be used to explain futures knowledge creation. I analysed the case studies based on field notes, project documentation and discussions with project participants. The focus in the analysis was on futures knowledge and its creation, but I also considered which events took place in the process, between whom, how and why. Based on the analysis and experiences from the projects, I modified the conceptual models to better fit the data. In practice, the research process was much more iterative than is described here, maintaining a constant dialogue between the assumptions behind the conceptual models and the practice of foresight manifested in the case studies.

All case studies are based on ex-post analysis of real-life projects. The projects varied in their geographical and organisational scope. Also, my personal relation to these projects varied (see Table 1). Four of the case studies were foresight projects realised by the VTT Technical Research Centre of Finland in different geographical and organisational settings. The fifth case study was a national foresight exercise realised by the Finnish Prime Minister's Office (Valtioneuvoston kanslia). There were altogether five case studies based on five projects:

- studying the workshop discussions in the "Building services roadmap" project,
- structuring the process and outcomes of the foresight exercise in the "Innovation capacity in Antofagasta" project,
- analysing the foresight system of the "Foresight network" project,

- analysing the foresight system of the "Cellulosic value chain roadmap" project and
- analysing the emergence of shared perceptions in the making of the Finnish government's "Report on the Future".

Four case studies were based on projects carried out at the VTT Technical Research Centre of Finland. The fifth one, on the Finnish government's report on the future, was analysed as part of a research exchange with the International Institute for Applied Systems Analysis (IIASA) during summer of 2014.

Table 1. Description of the case studies

Case study	Research focus in case	Aim of the project	Participants in the project	My role in the project	Research conducted
Building services roadmap	Knowledge creation in foresight workshops	Industry level coordination	Substance area experts	External analysis based on transcriptions	Project: 2006 – 2007 Analysis: 2013
Innovation capacity in Antofagasta	Structuring foresight contributions	Regional capacity building	Regional stakeholders	Part of the team conducting the project	Project: 2012 – 2013 Analysis: 2013
Foresight network	The elements of foresight system	Organisational capacity building	Experts in the organisation	Part of the team conducting the project	Project: 2012 – 2013 Analysis: 2014
Cellulosic fibre value chain	The elements of foresight system	Regional capacity building	Regional stakeholders	Part of the team conducting the project	Project: 2013 Analysis: 2015
Report on the future	Emergence of shared perceptions	National policy intelligence	National stakeholders	External analysis based on documentation	Project: 2011 – 2014 Analysis: 2014

The building services roadmap project was carried out by VTT in 2006. Its goal was to produce a roadmap for building services, focused on technological and market opportunities (Paiho et al., 2007; Paiho et al., 2008). The project included the gathering of background information, three workshops and documenting the results to a roadmap report. The case study focused on the first workshop, which had the aim of exploring different drivers and developments and producing new insights into the emerging technologies of building services. In addition to the

presentations and documentation of the results, the workshop discussions were recorded and transcribed. Thus, it was possible to analyse the workshop several years after it had been held. I did not take part in the project, but did the analysis of the discussion long after the project had ended. I codified the discussion using a typology of futures knowledge derived initially from the literature on knowledge management, but modified based on the data. The aim of the analysis was to find out how futures knowledge is manifested in the foresight workshops and how it is created.

The Innovation capacity in Antofagasta project started in January 2012 and ended in December 2013 (VTT & CICITEM, 2015). It was conducted jointly by VTT and the Mining Technological and Scientific Research Centre CICITEM in Chile. The overall objective was to enhance the innovation-driven sustainable economic development of the Antofagasta region, and the project consisted of a foresight and innovation management part. The case study is based on a foresight exercise carried out in the project, entitled “Water in Antofagasta 2040”. The aim was to create a shared vision of research and innovation activities around water research in the region and to build a capacity to conduct foresight exercises. I took part in conducting the foresight exercise as well as other foresight activities in the project. I analysed the foresight exercise using four different layers of analysis in order to better structure the contributions of a regional foresight.

The foresight network was a VTT internal project and conducted from 2012 to 2013 (Myllyoja, 2014; see also Ahlqvist, 2012; Dufva et al., 2013). The aim was to increase the foresight capacity of VTT, to share the foresight expertise and experiences inside the organisation, enhance networking both inside and outside the organisation and to develop the foresight offering of VTT. The project included annual foresight conferences, a foresight training programme, project specific foresight workshops and an online platform to enhance collaboration and information sharing. I took part in designing and facilitating the training, workshops and online platform. After the project had ended, I analysed the process and outcomes, framing the project as a foresight system inside the organisation.

The South Australian Cellulosic Value Chain Technology Roadmap project was contract research carried out by VTT in 2013 (Ahlqvist, Vanderhoek, et al., 2013; Ahlqvist, Kettle, et al., 2013). The aim was to create a roadmap for the renewal of the forest industry in the Green Triangle region in South Australia. I took part in the interviews and workshops conducted in the project and in designing the methodology used in the project. After the project had ended, I analysed the process and outcomes based on research notes and material produced during the project in order to frame the project as part of a regional foresight system.

The Finnish Government’s report on the future (VNK, 2013) was prepared through a participatory process from 2011 to 2014. The report on the future is prepared by the Government for the Parliament once during each parliamentary term. This time the focus was on “Well-being through sustainable growth” in Finland in 2030. The report on the future is an important part of Finnish policy making, as it is used as one of the inputs when drafting the next Government Programme. I did not take part in the making of the report, but I had access to the

written material produced by the key actors during the process, including the classified minutes of the government meetings. I thus had an external view of the process and analysed the changes in the concepts used when the project participants engaged in a discussion on the future.

While these five projects differ in their aims, research questions, geographical focus and substance area, they all resemble each other in that they have an explicit focus on the future. Thus, in my research frame I can consider them as examples of futures knowledge creation by the participants in the projects. The variability in the cases allows me to focus on different aspects of futures knowledge and its creation: in the case of the building services roadmap, I focus on distilling how futures knowledge is manifested and created in workshops, in the Chilean case, I identify the many context-dependent forms of futures knowledge, in the foresight network and cellulosic fibre value chain cases, I describe the system elements and their dynamics in knowledge creation, and in the case on the report on the future, I frame futures knowledge as a network of concepts and its creation as a changing of the concept network. Thus, taken together these cases offer complementary views of futures knowledge creation, embracing the complexity of it and going beyond a linear process depiction of "people and resource in, futures knowledge out".

This dissertation is structured as follows: after this introductory section, I review the key literature that has influenced the research and on which I build in section 2. I describe the current understanding of foresight, futures knowledge and knowledge creation, and the systems theories that are relevant for this dissertation, namely complex adaptive systems and innovation systems. Following the theoretical underpinnings, I introduce the main research findings in section 3. Rather than summarising the original publications, I focus on the key concepts that are also reflected in the theses introduced in this section: the typology of futures knowledge, the systems view, multiple nested system layers, futures knowledge as a network, and the process of futures knowledge creation, which ties the first four concepts together. I then discuss the main implications of these findings in sections 4 and 5. I first draw out the implications for strategy and policy making and the use of foresight in informing decisions in section 4 and then describe the theoretical implications with a focus on foresight research and research methodology. Section 6 provides a summary of the key results.

2. Theoretical foundation

The theoretical framework of this dissertation draws from the literatures on innovation systems, systems thinking, foresight, knowledge management and strategy. Because I study foresight and futures knowledge creation in the context of innovation systems, I will first review the relevant literature on innovation and innovation systems. I will then deepen and further define the concept of system and the systems view based on the literature on systems thinking and systems approaches. Next, I will provide an overview on the development and definitions of foresight, and then focus especially on knowledge and knowledge creation and management. Finally, I will consider how futures knowledge is used in strategic management.

2.1 Innovation systems

An innovation system consists of agents that interact in order to produce and diffuse economically useful knowledge (Lundvall, 1992). Hekkert et al. (2007, p. 414) define it as

> *"a heuristic attempt, developed to analyse all societal subsystems, actors, and institutions contributing in one way or the other, directly or indirectly, intentionally or not, to the emergence or production of innovation."*

Innovation systems were first considered on the national level, but nowadays the approach also includes regional, sectoral and technological viewpoints (Andersen & Andersen, 2014). These viewpoints are partly overlapping (Hekkert et al., 2007; Carlsson et al., 2002). One of the challenges in managing innovation systems is that they are multi-level and multi-actor arrangements consisting of local, regional, national and international levels (Schoen et al., 2011). These different levels are also reflected in foresight activities, which include national, regional, sectoral and technology-specific foresight exercises (Andersen & Andersen, 2014).

The innovation system approach analyses the structure and dynamics of how innovation activities take place between different agents, such as companies, research organisations, government ministries or interest groups (Alkemade et al., 2007). It aims to understand the relations between science, technology and eco-

nomic performance and solve "system failures" (Smith, 2000; Carlsson & Jacobsson, 1997; Salmenkaita & Salo, 2002). The key question is how to create a system which fosters innovation and through that economic growth and, more recently, also sustainability (Jacobsson & Bergek, 2011). The goal is to provide a tool for identifying system weaknesses and

> *"to inform policy makers of the problems that an intervention needs to solve in order to promote the growth of a particular system or to influence its direction."* (Jacobsson & Bergek, 2011, p. 42)

Initially, the innovation systems focused on the structural features enabling innovation, but more recent approaches analyse the processes and dynamics of the innovation system (Hekkert et al., 2007; van den Bergh et al., 2011; Suurs, 2009). Lists of "functions" have been proposed, which describe the processes and structures that need to be in place in a well performing innovation system (Hekkert et al., 2007; Jacobsson and Bergek, 2004). For example, Hekkert et al. (2007), list 7 functions:

- Entrepreneurial activities: Activities of existing and new companies related to experimentation
- Knowledge development: Production of knowledge related to the emerging innovation system
- Knowledge diffusion: Transfer of knowledge within the system
- Guidance of the search: Processes directing the focus of experimentation
- Market formation: Activities to support the creation of new markets
- Resources mobilisation: Financing, labour and other resources available
- Creation of legitimacy: Processes related to the acceptance and attitude towards the innovation

Analysing the dynamics and structure of innovation systems helps to understand the context in which foresight is practiced. The rationales of foresight often relate to the improvement of the science and technology system (Martin, 1995; Martin & Johnston, 1999) or nowadays more broadly the innovation system (Andersen & Andersen, 2014). However, the idea of innovation as a systemic activity has not fully been integrated to foresight and foresight is argued to be

> *"in a catching-up process vis-à-vis innovation studies by gradually incorporating the implications of a systemic understanding of innovation"* (Andersen & Andersen, 2014, p. 284).

In this dissertation, I consider foresight activities as part of an innovation system and frame them as a foresight system. In addition to the theory of innovation systems, I use systems thinking as the theoretical basis for analysing foresight as a system.

2.2 Systems thinking

Generally speaking, systems thinking is an approach to understanding and coping with complex real-world situations (Jackson, 2000). It embraces holism instead of reductionism in order to emphasise the connections and interdependency in a system. The aims and approaches in systems thinking differ, but they all employ similar concepts, even though the meaning might be different. The key concept is that of a system. Jackson (2003, p. 3) gives a very general definition:

> *"system is a complex whole the functioning of which depends on its parts and the interactions between those parts."*

Ackoff (1974; 1971) defines a system as a functionally indivisible set of interconnected, interdependent parts, which together generate emergent, aggregate behaviour not attributable to any single element. A key distinction in thinking about systems is between perceiving systems as ontological entities or as conceptual constructs, the dominant view nowadays being in the latter, more constructive view (Reynolds & Holwell, 2010). This latter view of systems as ways of seeing the world is also followed in this dissertation.

Other useful concepts in systems thinking for describing and analysing a system include:

- Element or part of a system: A system consists of a set of interrelated parts or elements, which can range from abstract concepts to organisations and human social structures to physical objects and individuals (Ackoff, 1971).
- Actor or agent in a system: In social systems, that is systems concerning human beings, the elements can be called actors or agents, where the former usually means an individual and the latter can be an individual, group or other entity that can act (Lane & Maxfield, 2005; Anderson, 1999). In this dissertation, I mainly use the term "agent".
- Interaction and feedback: The agents or elements in the system interact, i.e. they influence each other. This interaction forms feedback loops, which can be negative, i.e. stabilising, or positive, i.e. self-enforcing (Kuhn, 1974).
- Boundary and the environment of a system: A system has a boundary that sets it apart from its environment (Jackson, 2000). The environment is thus external to the system, although it can affect the system (Ackoff, 1971). By redefining the boundary, the perception of what the system is and how it functions also changes (Checkland, 1981).
- Input and output of a system: Matter, energy and information can cross the boundary between the system and its environment. A flow into the system is called input, and a flow out of the system is called output (Kuhn, 1974).
- Emergence: A key idea in systems thinking is that the whole is more than the sum of its parts. Emergence reflects this idea and has been defined as "the arising of novel and coherent structures, patterns and properties dur-

ing the process of self-organisation in complex systems" (Goldstein, 1999, p. 49). Interaction between the agents can lead to emergent phenomena, also referred to as system behaviour (Jackson, 2003).

Systems thinking as a discipline has its roots in cybernetics (Wiener, 1948) and general systems theory (von Bertalanffy, 1950; Von Bertalanffy, 1968), but now includes a broad spectrum of approaches (Jackson, 2000; Jackson, 2003). Jackson categorises these approaches based on four paradigms in the social sciences: functionalist, interpretive, emancipatory and postmodern (Jackson, 2003; Jackson, 2000). In the functionalist paradigm, systems are seen as "objective aspects of a reality independent of us as observers" (Jackson, 2000, p. 107). The functionalist paradigm includes most of the systems thinking approaches, such as the general systems theory (Von Bertalanffy, 1968), system dynamics (Forrester, 1994), complexity theory (Stacey, 1996), the social systems theory (Luhmann, 2006) and the so-called "hard systems thinking" (Checkland, 1981), e.g. operational research (Churchman et al., 1957) and systems engineering (Jenkins, 1972). One notable and influential systems approach from the functionalist paradigm has been the report on Limits to Growth, forecasting the resource use and carrying capacity of the world based on system dynamics (Meadows et al. 1972).

In this dissertation, I mainly follow the view of systems thinking based on the interpretative paradigm. In the interpretive paradigm, the focus is on the perceptions, values, beliefs and interests of people in a system (Jackson, 2000). This approach is also referred to as "soft systems thinking" in contrast to "hard systems thinking" (Checkland, 1981). The view is subjective instead of objective: multiple perceptions of reality can co-exist and thus also multiple perceptions of what the system is: for example, what are its boundaries, parts and interactions (Churchman, 1979; Ackoff, 1974)?. Examples of systems approaches in the interpretive paradigm include the theory of purposeful systems (Ackoff & Emery, 1972), soft systems methodology (Checkland, 1981; Checkland & Poulter, 2010) and systems thinking as the "fifth discipline" (Senge, 1990).

The emancipatory systems approaches emphasise the power relations inherent in social systems (Jackson, 2000). The focus is on identifying the sources of inequality, oppression, domination and discrimination and radically transforming the system. One example of such an approach is the critical system heuristics (Ulrich, 1983; Ulrich & Reynolds, 2010). The aim in the emancipatory systems approaches is, as the name suggests, emancipation and liberation either of the individual or on the societal level, whereas the interpretive systems approaches seek to explain and describe systems, and the functional systems approaches try to model, manage and control systems. In stark contrast to all these approaches, the postmodern paradigm rejects the assumptions of rationality, purpose and direction (Jackson, 2003; Jackson, 2000). It critiques the grand narrative of progress, which has its roots in the Enlightenment. While the basic philosophy of postmodernism is to steer away from providing clear methods or structures, as the focus is on deconstruction of the current discourse, there are some system approaches that can be

categorised as postmodern (Jackson, 2000), such as the “Participatory Appraisal of Needs and the Development of Action” (PANDA) (White & Taket, 1997).

There is one specific systems approach that I employ in this dissertation: the theory of complex adaptive systems, which I use to characterise foresight as a system. A complex adaptive social system consists of agents with different perceptions acting in parallel (Anderson, 1999; Stacey, 1995; Kaufmann, 1995; Pascale et al., 1999). It is a self-organizing and dissipative structure, meaning that order and patterns emerge without central control if there is an energy flow (input) into the system. This energy can, for example, be new agents or information. A complex adaptive social system can exist in a state of “bounded instability” (Stacey, 1995), where the exact behaviour of agents cannot be predicted, but will be within limits. Of course, it can also be unstable and in a chaotic state. As the name suggests, a complex adaptive system evolves in response to changes in its environment and as a result of the actions of its agents. The agents, their perceptions, their interactions and the structure of the system change over time.

Systems thinking has been influential in foresight and futures research (Kuosa, 2011a; Leonard & Beer, 2004; Samet, 2010). Foresight has been defined as a systemic process of futures inquiry (Saritas, 2013; Miles et al., 2008) and many of the methods used embrace systems thinking (Aaltonen & Sanders, 2006). However, foresight itself is not usually seen as a system, but rather as a process. Also, the theory of complex adaptive systems has been used in foresight, for example for understanding systemic transitions (Vasileiadou & Safarzyńska, 2010; de Haan & Rotmans, 2011) or as a theoretical background for developing scenarios (Vervoort et al., 2010; Soste et al., 2015) and identifying weak signals (Ilmola & Kuusi, 2006). In general, it has been used as a theoretical framework for understanding the dynamics of the topic of foresight exercises.

2.3 Foresight

Foresight has its roots in multiple applications, such as military strategy, operational research, management science, and technology assessment, but has broadened its scope beyond these foundations towards anticipating developments in markets, industries and society in general (Miles et al., 2008; Kuosa, 2011a; Sardar, 2010). The recent development of foresight is argued to be towards a didactic view embracing paradoxes, conflicts and participation (Kuosa, 2011a; Daheim & Uerz, 2008) and both anticipating and shaping or influencing futures (Eriksson & Weber, 2008).

As the scope has broadened, different “flavours” or “schools” of foresight have emerged, emphasising different aspects, including slightly different orientations towards futures knowledge and its creation. In order to understand these orientations, it is necessary to understand the different approaches to foresight. While different categorisations of foresight and futures studies exist (see e.g. Miles et al. 2008; Samet 2010; Kuosa 2011a; Salmenkaita & Salo 2004; Barré 2001), I structure foresight approaches as three ideal types that differ in how futures knowledge

is perceived: policy-oriented foresight, capacity building foresight and transformative foresight. It should be noted that these are ideal types, and foresight exercises often include aspects of each of these three types.

Policy-oriented foresight is practiced under names such as fully-fledged foresight (Miles, 2010), forward looking activities (Commission, 2010), technology futures analysis (Technology Futures Analysis Methods Working Group, 2004) and future-oriented technology analysis (FTA) (Cagnin et al., 2008). In this ideal type, the focus is often on the process and methods and futures knowledge is perceived to be mainly the explicit outcomes (Eerola & Miles, 2011). Policy-oriented foresight aims at providing policy-makers with a description of possible futures, debate what is preferable and give recommendations for actions in order to reach a preferable future and avoid undesired futures (HLEG, 2002). It often aims to include a broad set of stakeholders, although the impact of stakeholder participation has been questioned (Kettunen, 2014; Van der Helm, 2007). Foresight projects are mainly initiated and facilitated by foresight practitioners and consultants appointed by the policy-makers, and the policy makers are the primary users of the results, while they themselves seldom take part in the actual foresight process.

Capacity building foresight is often focused on the organisational or regional level and practiced under names such as corporate foresight (Rohrbeck, 2011; Cuhls & Johnston, 2008; Becker, 2002) or regional foresight (Uotila et al., 2005). It emphasizes scanning the operational environment of a company or organisation, anticipating relevant future developments and building the capacity to respond to them in order to ensure the survival of the company or organisation. Futures knowledge is created by senior management, consultants or dedicated foresight units within the organisation. It encompasses both the explicit outcomes captured in e.g. company strategy or a technology roadmap, and the organisational capacity described as the future-orientation (Rohrbeck & Bade, 2012) or foresight or anticipatory culture (Nugroho & Saritas, 2009; Saritas, 2013; Ahlqvist et al., 2012).

Transformative foresight (Kahane, 2012) and integral foresight (Slaughter, 2008; Slaughter, 2001; Hideg, 2013) have their basis in critical futures studies (Bell, 2003; Inayatullah, 1998) and emphasize the shaping of the futures instead of describing alternative futures. They acknowledge that foresight is not value-free and that the main focus should be on facilitating change towards a future that the participants feel are worth striving for. The focus is on empowering the participants, which should include all stakeholders related to the issue at hand. Knowledge creation is thus not about creating descriptions of alternative futures that have a veil of objectivity or building organisational capacity, but rather about exploring different possibilities in order to uncover the values and assumptions of stakeholders: to know what is desirable and what is not, and the consequences of present actions.

What is common to all three ideal types is their emphasis on process. Foresight is described as an intervention or a separate project with people and resources as input and futures knowledge as output (Horton, 1999; Heger & Rohrbeck, 2012; Popper, 2008b; Smith & Saritas, 2011; Voros, 2003). This process orientation and

subsequent lack of systems understanding has provoked some criticism lately (Andersen & Andersen, 2014; Saritas, 2013; Amanatidou & Guy, 2008). A more systemic view can be found in the approaches of Innovation systems foresight (Andersen & Andersen, 2014; Andersen et al., 2014), systemic foresight methodology (Saritas, 2013), foresight system (Amanatidou & Guy, 2008) and FTA systems (Weber et al., 2012). An overview of how foresight is perceived in these approaches is given in Table 2. These approaches have a policy-orientation, but also emphasise the functioning of the innovation system and the capacities of the agents in the system. In these approaches, futures knowledge covers not only the outcomes, i.e. explicit knowledge, but also the tacit knowledge embodied and accumulated in the agents of the system. I build on and elaborate this understanding of foresight.

Table 2. Systems approaches to foresight

Approach	Description of foresight	Source
Innovation system foresight	Systemic and systematic process, embracing the systems view of innovation and aimed at improving innovation system performance	(Andersen & Andersen, 2014)
Systemic foresight methodology	Systemic inquiry, an iterative, dynamic and non-linear process, focused on learning about the underlying system	(Saritas, 2013)
Foresight system	System comprised of actors, objectives, processes, inputs and outputs and their interrelationships	(Amanatidou & Guy, 2008)
FTA systems	Configuration consisting of individual capacities and mindsets, institutional and organisational set-up and institutional context, aimed at supporting decision making	(Weber et al., 2012)

2.4 Knowledge and its creation

Futures knowledge has characteristics that make it distinct from knowledge about the present or past. Knowledge about the future is neither true nor false, but rather contingent on the actions of the past and present (Wright, 2009; Gabriel, 2013). Thus, there can be multiple, conflicting descriptions of the future, all as true or false as the other. However, de Jouvenel argues that we are subjectively certain of the future, that is we take many aspects of the future as known, but this certainty can collapse based on what actually happens (De Jouvenel, 1967). Thus, the things we know about futures are constructs (De Jouvenel, 1967; Fuller & Loogma, 2009).

Descriptions of futures knowledge are based on the discussion around knowledge in general. A common distinction is that between tacit and explicit

knowledge (Polanyi, 1966; Nonaka & Takeuchi, 1995). Explicit knowledge is captured in documents, reports and other tangible forms. Tacit knowledge or implicit knowledge is embodied in individuals. Related to the tacit-explicit split, knowledge has also been described as being connected to a thing or to a process (Boisot, 1998). While explicit knowledge is seen as rather objective information about ”what things are”, tacit knowledge covers skills and competences, in other words information about ”how to do things” (Polanyi, 1966; Nonaka et al., 2000). This division has been critiqued as being too simplistic, because explicit knowledge is always to some extent ”sticky” (Uotila et al., 2005) meaning that it is always connected to the context and needs to be interpreted. Therefore, the tacit-explicit divide should be seen more as a continuum than a discrete division (Nonaka, 1994).

The tacit-explicit categorisation has been broadened to cover the special characteristics of futures knowledge by adding a category of self-transcending knowledge (Scharmer, 2001; Uotila et al., 2005). This is described as implicit knowledge about the sources of information and the capability to presence potential (Scharmer, 2001). This brings to the fore the sources and boundaries of knowledge. While explicit and tacit knowledge focus on things or processes that are known (either explicitly or implicitly), self-transcending knowledge emphasises going beyond what is known and broadening the boundaries of knowledge. In other words, self-transcending knowledge focuses on things that are not known.

These three categories are present in futures knowledge. Futures knowledge has been described by focusing on the explicit outcomes (Eerola & Miles, 2011), the embodied implicit knowledge (Karlsen & Karlsen, 2007) and the self-transcending knowledge (Uotila et al., 2005). The foresight process often encapsulates futures knowledge in scenarios, roadmaps and trend descriptions (Eerola & Miles, 2011). Some people have emphasised the process of sharing the implicit knowledge embodied in individuals, often in experts (Uotila et al., 2005; Karlsen & Karlsen, 2007; Kettunen, 2014). Others argue that the real value of foresight is in producing novel insights and knowledge about alternative futures (Inayatullah, 1998; Bussey, 2014) and that simply sharing and encapsulating knowledge should be left for other activities (Staton, 2008).

While knowledge creation in foresight is relatively little studied, it has been theorized in other fields, most prominently in knowledge management. One widely used framework is the SECI model (Nonaka & Takeuchi, 1995; Nonaka et al., 2000). It describes knowledge creation in an organisation as a spiral of knowledge conversions between tacit and explicit knowledge going through four phases:

1. Socialisation, where people meet face-to-face and exchange tacit knowledge by observing each other.
2. Externalisation, where the tacit knowledge is articulated into explicit form
3. Combination, where pieces of explicit knowledge are integrated to form larger wholes

4. Internalisation, where the combined explicit knowledge is internalised through training and learning by doing

The SECI model has been used to categorise the activities in foresight (Eerola & Miles, 2011), and has also been broadened to include knowledge conversions specific to foresight (Uotila et al., 2005). The broadened version of the SECI model – named the "rye-bread model" – adds two more phases between internalising and socialising. The first is potentialisation, which means sensing future potentials, and the second is visualisation, meaning embodying the sensed potentials and coming up with new mental models and visions.

While the SECI model is widely used (Gourlay, 2006) and has attracted praise since it was first proposed (Hauptman & Neuringer, 1997), it has also received severe criticism. It is argued to be too simplistic and ambiguous, not founded on empirical evidence, describing knowledge creation as too mechanistic or deterministic and emphasizing the role of managers and ignoring other actors (Gourlay, 2006; Poell & Van der Krogt, 2003; Zhu, 2006; McAdam & McCreedy, 1999; Engeström, 1999). Furthermore, it considers the tacit and explicit knowledge as rather distinct forms of knowledge and assumes that all tacit knowledge can be externalised (Li & Gao, 2003; Yolles, 2000; Kimble, 2002). I take this criticism into account when using the SECI model as a basis for describing the typology of futures knowledge and knowledge creation dynamics in foresight.

2.5 Strategic management

Futures knowledge is an essential part of strategic decision making. Theories on strategy generally describe strategy making as a future-oriented process and assume that those who are producing the strategy, quite often the top-level managers, have an idea of what the future will be like (Costanzo & MacKay, 2009; Ahuja et al., 2005). Foresight is argued to be a key process in converting disparate "blocks of knowledge" into perceptions of futures (Durant, 2009). How futures knowledge is used in strategic management varies depending on how strategy and strategy building is perceived. An excellent overview of the schools of strategy is given by Mintzberg et al. (1998), who describe 10 schools of strategy divided into three broad groups: a prescriptive or descriptive approach, or a combination of them.

In the prescriptive approach, strategy is seen as a process of design (Selznick, 1957), planning (Ansoff, 1965) or positioning (Porter, 1980; Porter, 1985). The aim is to guide strategy makers – usually managers – in developing the most successful strategy. The future developments in the operational environment are anticipated through a formal forecasting or horizon scanning process (Mintzberg et al., 1998). In contrast, in the descriptive approach the emphasis is on describing different aspects of strategy, such as culture, power, environment and learning. The perceptions of futures knowledge vary based on which aspect is emphasised. For example, in what Mintzberg et al. (1998) call the entrepreneurial school, futures knowledge is seen as the radical vision expressed by a lone visionary, while the

cognitive school focuses more on the interpretations of alternative futures embodied in the mental models – schemas – of individuals. A combination of both prescriptive and descriptive approaches to strategy is represented in the configuration school, which focuses on the states of the organisation – configurations – and on the process of transformation between these states.

These three approaches: prescriptive, descriptive and a combination of them relate loosely to the three approaches to foresight described in section 2.3. The view of strategy as planning and positioning is common in policy-oriented foresight (see e.g. Ruff 2014; Moehrle et al. 2013), while in particular the aspects of learning and culture are emphasised in capacity building foresight (see e.g. Rohrbeck & Schwarz 2013; Godet 2000). The view of strategy as configurations and strategy making as a process of transformation is relevant for transformative foresight, which can also gain from considerations of power relations and cognitive processes in the descriptive approach. From the systems view of foresight, the concepts of dynamic capabilities[5] (Teece et al., 1997) and the learning organisation[6] (e.g. Senge 1990) described in the learning school are useful.

[5] Dynamic capabilities refer to the organisation's ability to "integrate, build and reconfigure internal and external competences to address rapidly changing environments" (Teece et al., 1997, p.516)

[6] A learning organisation is decentralised, collaborative, flexible and effective and capable of cumulative learning and constant self-renewal (Senge, 1990).

3. Research contribution

There are five main theoretical contributions of my dissertation. The first is elaborating how futures knowledge manifests itself in the practice of foresight and developing a typology of futures knowledge. The second is framing foresight as a system instead of a process, and making a distinction between a foresight system and a foresight process. Third, I develop a multi-layer framework to position the focal point of different foresight processes in relation to one another and connecting them through the systems view. The fourth contribution is framing futures knowledge as a network of concepts instead of separate nuggets of information. The final and main contribution is providing two descriptions of futures knowledge creation in foresight practice based on the systems view, typology of futures knowledge and the perception of futures knowledge as a network. These two descriptions also answer the main research question: How is futures knowledge created in the practice of foresight? In this section, I will describe these research contributions in more detail based on the four research articles.

3.1 Typology of futures knowledge

Article I (Knowledge creation dynamics in foresight: a knowledge typology and exploratory method to analyse foresight workshops) provides a brief review of the philosophical and theoretical basis of futures knowledge. Based on this review, it is suggested in the article that futures knowledge could be defined as "justified contingent plausibilities" as opposed to "justified true belief" (see Fine & Carpenter 2003). Futures knowledge is contingent upon present actions (Wright, 2009) and describes alternative images of the futures, and the rationalities behind these images under certain plausibility assumptions (Fuller & Loogma, 2009; Gabriel, 2013). Furthermore, in article I futures knowledge is structured into four categories: codified, articulated, embodied and out-of-radar, depending on how it is manifested in a foresight process. I define these as:

- Codified knowledge: knowledge that is explicit and encapsulated in tangible artefacts, such as documents or databases. Codified knowledge is not overly dependent on the context in which it is created and thus easily transferable to other processes. Other similar concepts include explicit

knowledge or information (van den Berg, 2013), “knowledge that” (Gourlay, 2006) and codifiable implicit knowledge (Karlsen & Karlsen, 2007).

- Articulated knowledge: knowledge that is expressed in the process using the codes and language dependent on the process. Articulated knowledge is tied to the context in which it is uttered and is thus not easily transferable to other processes without a loss in original intent.
- Embodied knowledge: knowledge embodied by agents in the system, including skills, know-how and expertise. It is “knowledge-how” (Gourlay, 2006) about “things we do” as opposed to explicit knowledge about “things” (Scharmer, 2001).
- Out-of-radar knowledge: future-oriented knowledge that seems irrelevant in the context, is ignored or outside the scope of the process, but can open up new directions for the discussion. It “moves the knowledge frontier” (Karlsen & Karlsen, 2007) and has been described as a “monstrosity”, because it threatens what is considered normal (Staton, 2008).

Out-of-radar knowledge is thus the main source of novel insights on the futures, and it appears as a process rather than as separate utterances. It is produced through reframing, challenging assumptions, or perhaps most often by cumulatively building on other agents’ ideas. In order to understand these processes, it is necessary to define what a foresight system is.

3.2 Systems view of foresight

A key distinction I make compared to much of the previous literature on foresight is that between a foresight system and the foresight process, and this distinction is elaborated in articles II (Elements in the construction of future-orientation: a systems view of foresight) and IV (Emergence of shared perceptions of futures in a foresight system). A foresight system is a changing ensemble of agents, who collaboratively aim to produce future-oriented insights, decisions and actions in a given context. It is a complex adaptive system (Stacey, 1995; Kaufmann, 1995), consisting of agents sharing, discussing, debating and shaping perceptions of futures. A foresight system operates through foresight processes and connects them. A foresight process is a temporary crystallization of contemplation and activities in the foresight system. The processes are temporary, transient, but the system with its agents is more permanent, although its structure is constantly changing. Futures knowledge emerges in the interaction between the agents in the system, which takes place mainly in the foresight processes.

In article II the foresight system is defined more thoroughly by describing six elements that are useful for understanding it: agents, cognitive schemes, strategic objects, mediating events, memory objects and metaphors (see figure 1). Agents are the individuals or groups who participate in foresight. These are often called stakeholders, participants and experts in foresight, depending on what is empha-

sised. “Stakeholder” puts the emphasis on the issue and the interests of different agents (cf. Soste et al. 2015), “participant” emphasises the process, especially the face-to-face meetings, and “expert” the knowledge embodied by the agents. I use the term agent to emphasise “agency”: the ability to act in a system.

Agents have different cognitive schemes, which are defined as a set of mental constructs about who the other agents are, how the agents interact with each other, and what is the aim and context of a foresight process (Lane & Maxfield, 2005; Ericson, 2001). They convene around strategic objects, a term defined by Ahlqvist (2012) based on the concept of a boundary object (Star & Griesemer, 1989). Boundary objects are

> *“objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites“* (Star & Griesemer, 1989, p. 393).

Strategic object are deliberately constructed boundary objects forming a base and loci for an epistemic community, which is defined as “a coalition of actors that aim at building common practices through deploying different theories, codes and tools, and by applying different knowledge processes” (Ahlqvist, 2012, p. 3). The agents in a foresight process form an epistemic community and convene around a strategic object, a focal point for the process.

The agent interaction is mediated by scaffolding structures, for example conferences, thematic groups, websites and mailing lists (Lane & Maxfield, 2005). In order to make the difference between system structure and scaffolding structures clearer, they are renamed as mediating events in the article. Compared to a scaffolding structure, a mediating event emphasises the temporal dimension. This also sets it apart from another similar concept, that of a mediating instrument, which is both a way of intervening to a decision making situation and representing or framing the context of the situation (Miller & O’Leary 2007; see also Ahlqvist 2014).

Another distinction between a scaffolding structure and a mediating event is the inclusion of agency. Lane and Maxfield (2005) include industry associations in their definition of a scaffolding structure, and state that some scaffolding structures can have agency in the sense that action is carried out ”in the name” of the structure. While mediating events can also be argued to have agency, for example when a scenario is produced “by a workshop”, I attribute the agency to the agents involved. I define the mediating event as a temporary virtual or physical gathering or information exchange between agents. In line with the mediating instrument, it is both a way of intervention and representation.

Knowledge is produced in the interaction between agents and captured in either memory objects, which are packaged artefacts of codified information (see Cacciatori 2008), or in metaphors, which are mappings from one domain to another in order to highlight some aspect of the original topic (Thibodeau & Boroditsky, 2011). In terms of the typology, memory objects relate to codified knowledge: the tangible outcomes of the foresight process that are expressed either in written or

visual form. Metaphors relate to articulated knowledge: the context-dependent utterances in a foresight process.

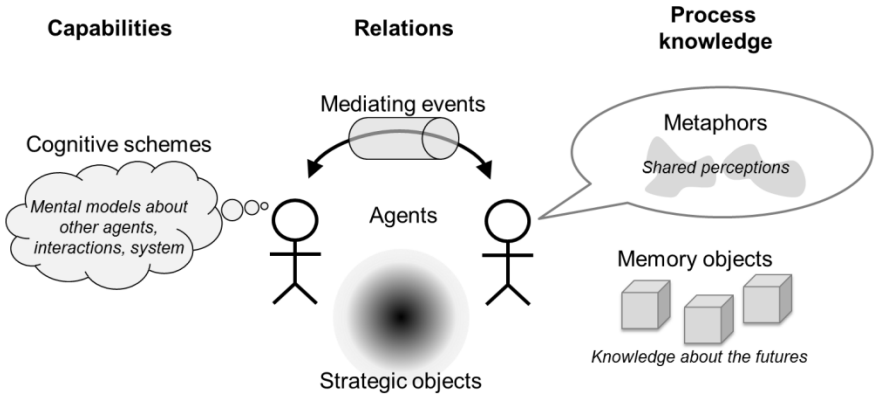

Figure 1. Elements of a foresight system.

The six elements are grouped under three facets of foresight: knowledge, capabilities and relations (Figure 1). Memory objects and metaphors can be used to represent the knowledge that is produced in the foresight processes. In order to distinguish it from futures knowledge in general, I call it process knowledge. This process knowledge then influences the cognitive schemes of the agents and their capabilities, or, in the terms of the futures knowledge typology, is embodied by the agents. I call the ability to use futures knowledge "futures capability" so as to delineate it from capabilities in general. It includes the ability to be aware of the context of futures knowledge and consider multiple perceptions. Futures capability is a form of dynamic capability (Teece et al., 1997) in that it entails renewing existing mental models based on anticipation of the changes in the environment and the ability to adapt and reconfigure current actions. It is similar to "futures literacy", defined as "the capacity to explore the potential of the present to give rise to the future" (Miller, 2007, p. 347). Futures literacy is a cumulative capacity and developing it provides "a more advanced grasp of the epistemology and ontology of the future" (Rhisiart et al., 2014, p.7). In the context of corporate foresight, Rohrbeck has also discussed the capabilities to use futures knowledge (Rohrbeck, 2011) or the building up of "organisational future orientation", defined as "the ability to identify and interpret changes in the environment and trigger adequate responses to ensure long-term survival and success." (Rohrbeck & Bade, 2012, p.2)

The capabilities of the agents affect the interaction and thus the relations between the agents by influencing how agents perceive the strategic objects. By relations I mean the interdependence between agents and how they influence each other. I employ relations as an "analytical lens" of tracking connections between agents and understanding the dynamics of the system (Ahlqvist, 2013).

This view emphasises the connections and interaction between agents in the system rather than system as a “vessel” or a collection of agents. These connection and interactions – and thus also the relations - are also influenced by mediating events. The mediating events influence the way agents interact, e.g. virtually through surveys or face-to-face in workshops, and how the context is presented, e.g. as an open topic for ideation, or as an objective image of the future to be commented. To close the loop, relations between agents influence the interaction between agents, which produces new knowledge in the process (figure 2). In terms of the typology, this new knowledge is out-of-radar knowledge, while the other three knowledge categories are about sharing existing knowledge.

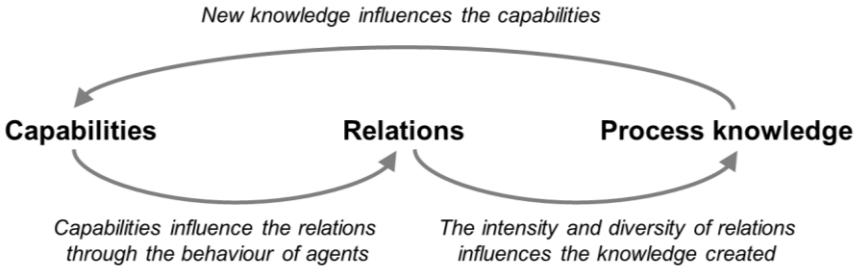

Figure 2. The interaction between capabilities, relations and process knowledge.

The three facets of foresight are further elaborated and based on existing literature in article III (Multi-layered foresight: lessons from regional foresight in Chile). Capabilities range from skills to conduct foresight to new mindsets and ways of thinking, and from an individual’s know-how to organisational future-orientation to system or even societal level capabilities to anticipate and prepare for alternative futures. Likewise, relations can be temporary weak ties (Granovetter, 1973) made in workshops or the setting up of a regional or national network of actors aiming to enhance innovation activities. Knowledge represents the improved understanding of future developments articulated as forecasts, scenarios, roadmaps, weak signals, wild cards, emerging issues and recommendations.

The elements of the system and facets of foresight highlight different aspects of the dynamics of the system. By themselves they do not provide a comprehensive understanding of the system, but together they help analyse system behaviour. It is thus worth emphasizing that I am not advocating a reductionist viewpoint, but rather a holistic and systemic viewpoint. The systems view I describe highlights the interaction and connections between agents as a key factor in the creation of futures knowledge in foresight.

3.3 Multiple, nested layers

The interaction and connections differ depending on the scope and aim of the foresight process. Therefore, it is necessary to position the foresight processes based on their main emphasis. In order to do this, the concept of Multi-Layered Foresight is developed in article III (Multi-layered foresight: lessons from regional foresight in Chile). Four layers are described in which foresight operates: landscape, innovation systems, organisations and individuals. The landscape layer focuses on the external developments and environment of the foresight exercise, and thus foresight on this layer produces mainly descriptive knowledge on possible futures developments, such as the State of the Future reports (e.g. Glenn et al. 2014). On the innovation systems layer, the emphasis is on the structure and dynamics of different intertwined innovation sub-systems (regional, technological, sectoral, see Hekkert et al. 2007) and on enhancing or "wiring up" the innovation system (Martin & Johnston, 1999). The organisations layer brings the focus inside an organisation and includes considerations of company strategy, the anticipatory capacities and future-oriented culture (Rohrbeck & Gemünden, 2011), and the allocation of resources, for example the balance between exploration and exploitation (March, 1991). The individual layer emphasises individual capacities and capabilities and changing the cognitive schemes of individuals. Since it often receives less attention than the other layers, I will discuss it in more detail here.

Individuals have different roles in a foresight process. They may be "experts", whose specific knowledge and views are wanted in the process, representatives of their organisation(s) or interest group(s), or generally "stakeholders", that is people who have an interest or stake in the issue (Soste et al., 2015). An individual may have several roles in a foresight process, although often only one formal role. In terms of the elements of a foresight system, these roles can be described as different cognitive schemes. The strategic object and the mediating event influences which of the cognitive schemes the individual – or agent – uses to make sense of the issue and enact the environment accordingly (see Weick 1995). On the other hand, the knowledge produced in the process influences the cognitive schemes and may result in the formation of new cognitive schemes. This type of reframing of the agent role can be achieved through embodying out-of-radar knowledge or articulated knowledge, which differs substantially from current cognitive schemes.

A multi-layer construct is not, of course, a novel concept in foresight. Perhaps the best known example is the Causal Layered Analysis (CLA) (Inayatullah, 1998), which describes four layers of analysis in a foresight process: litany, system, worldview and myth. These layers are relevant on the landscape, system, organisation and individual layers. Whereas the layers in CLA describe the depth of analysis and what is challenged, the concept of multi-layered foresight describes where the CLA could be applied and what its contribution would be. Understanding the litany, system structure, worldviews and myths is as important on the landscape layer as it is on the individual layer.

Another relevant and complementary construct to the concept of Multi-Layered Foresight is that of the Multi-Level Perspective (Geels, 2002; Geels, 2011), which

deals with the knowledge creation and exploitation and seeks to explain societal transitions through the interplay between three levels: the landscape, the regime and the niche. A transition in a socio-technical regime may occur if there is enough pressure from the landscape, which is the environment of the regime, as well as new solutions from the niche, that is from protected spaces dedicated to creating new innovations. Compared to the layers presented here, the landscape layers are similar in that focus on the external changes taking place over a long time span. The regime and niche and their dynamic interactions can be positioned at the innovation system layer.

The layers help position the foresight exercises in relation to one another. They also help us understand what might be ignored in the foresight exercise. For example, while the focus might be on enhancing the innovation system, the foresight exercise will most likely also contribute to knowledge, relations and capabilities on the organisational and individual layers. The articles in this dissertation focus on different layers. Article I focuses on the individuals and to some extent the organisational layers, article II on the organisational and innovation system layers and article IV in the innovation system layer. While the main focus of the case study in article III is on the innovation systems layer, the contributions to different layers are explicated.

3.4 Futures knowledge as a network

A key contribution of this dissertation is explicating a view of futures knowledge as a network. This view is presented in article IV (Emergence of shared perceptions of futures in a foresight system), where, instead of separate outcomes, the focus is on what concepts were used when talking about the future and how they were connected in different phases of the process. Futures knowledge is thus presented as a network of concepts used when talking about the future (see Figure 3). The agents differ in how they view the network. For example, a technology expert might focus on concepts revolving around a certain technology, while a policy-maker might highlight concepts currently on the political agenda. Thus, the network view captures both the content of futures knowledge and helping us understand its different interpretations.

Framing futures knowledge as a network of concepts is connected to the typology of futures knowledge. The concepts represent articulated and codified knowledge, reflecting the embodied knowledge of the agents. The concept network is modified by out-of-radar knowledge in three ways: changing the emphasis, making new connections between concepts and introducing new concepts. New framings, new connections and new concepts in the network can be seen as manifestations of out-of-radar knowledge.

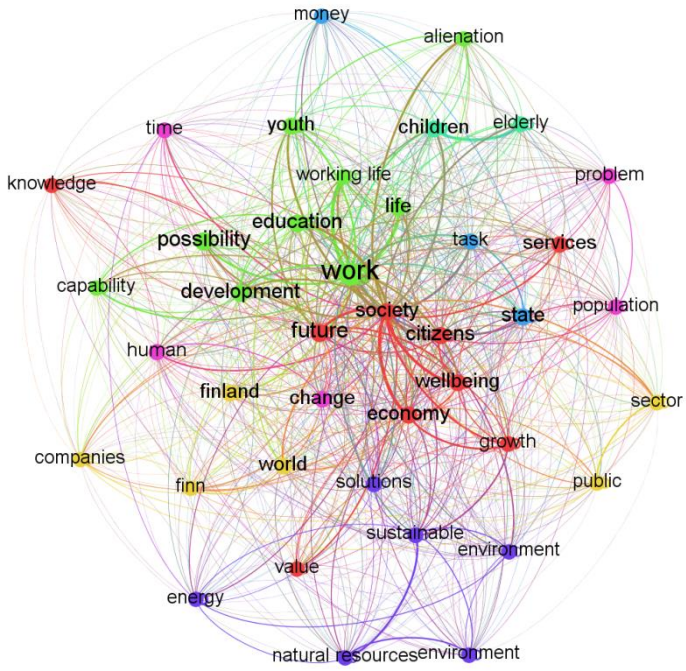

Figure 3. Example of a network of concepts used in the making of the Finnish government's Report on the Future, translation from Finnish.

3.5 Futures knowledge creation

Based on the typology of futures knowledge and the network view, and in response to the main research question, I present two complementary views of knowledge creation in this dissertation. The first view is focused on futures knowledge itself, and is presented in detail in article I (Knowledge creation dynamics in foresight: a knowledge typology and exploratory method to analyse foresight workshops). It builds on the SECI model (Nonaka et al., 2000; Nonaka, 1994) and its further developments (Uotila et al., 2005) and describes a cycle of knowledge conversions between four different types of knowledge: codified, articulated, embodied and out-of-radar (Figure 4). Thus there are six types of conversions:

- Reflecting: out-of-radar knowledge is embodied by an agent reflecting it against the cognitive schemes of the agent. Uotila et al. (2005) call this visualisation.
- Sharing and articulating: embodied knowledge, along with experiences, is "articulated" using "theory" and "codes" shared by the agents (Håkanson, 2007). Theory refers to existing cognitive frames or in terms of the foresight

system, to cognitive schemes. Codes are “coding schemes and other symbolic means of expression” (Håkanson, 2007, p. 63). Articulated knowledge is shared with other agents, similarly to socialization and externalisation phases in the SECI model (Nonaka & Takeuchi, 1995).

- Abstracting and synthesizing: articulated knowledge is codified using codes that are commonly used and encapsulated as memory objects. It can also be combined with data from other sources. This conversion is similar to the combination phase in the SECI model.
- Connecting and interpreting: codified knowledge, such as documents or written scenarios, is interpreted in the context of the foresight process and connected to current discussion. This has similarities to the internalisation phase of the SECI model, although the focus is on interpretation and not in embodying the knowledge.
- Learning: articulated knowledge is embodied by the agents through challenging existing cognitive schemes and perceptions about alternative futures. This is similar to expansive learning (Engeström, 1987), meaning learning that takes place in the development activities in everyday working situations. Expansion means “exceeding the initially given context of specific problems and refocusing on the wider context that generates those problems” (Halonen et al., 2010, p. 131).
- Broadening and associating: Changes in cognitive schemes can open up new insights into out-of-radar knowledge by broadening what is considered relevant and creating new associations, or as in the potentialisation phase of the rye-bread model “sensing future potentials and seeing what does not yet exist” (Uotila et al., 2005, p. 860).

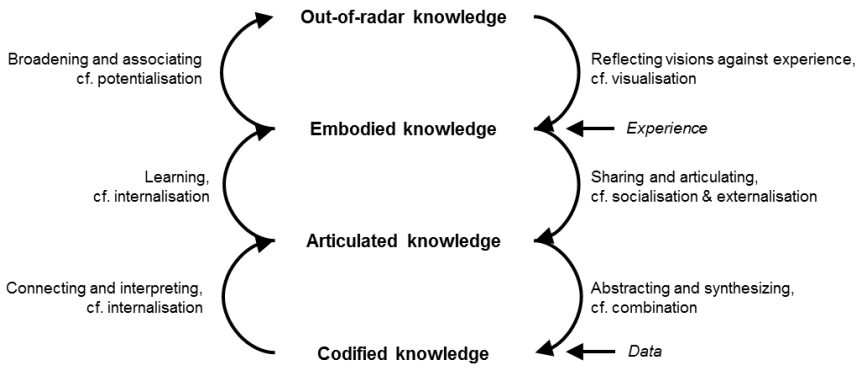

Figure 4. Conversions between the types of futures knowledge.

The conversions take place through the interaction of the agents. An intensive interaction and an atmosphere encouraging listening and building upon others' ideas are conducive to reframing, challenging assumptions and thus embodying and articulating out-of-radar knowledge.

The second view takes a systems perspective and views futures knowledge as a network of concepts. Knowledge creation in this view is about shaping the network: changing the emphasis of concepts, creating new links between the concepts and to a lesser extent introducing new concepts. In article I, the process of futures knowledge creation is analysed in a workshop setting, focusing especially on out-of-radar knowledge. One of the key findings is that new insights do not emerge from revelatory statements by visionary agents, but are rather gradually built in the interactions between agents. Therefore, it is hard to pinpoint the source of the new insight to any single agent; it emerges from the process itself. In article IV, a similar conclusion is made on the level of an innovation system: the shared perceptions about futures are gradually shaped in the interaction between agents from existing perceptions. Creation of new knowledge about futures is a gradual process building upon existing knowledge. Furthermore, new knowledge is not necessarily replacing the old perceptions, but rather creating new additional perceptions.

3.6 Results summary

The main research contribution of the articles is summarised in Table 3. The articles support the postulates I outlined in Section 1.2. Firstly, the concept of foresight system is described more fully as well as its benefits compared to the process view. The systems view highlights the interaction between agents as a key factor in understanding futures knowledge creation. This brings to the fore the impact of who is involved and through what kind of processes, but also the influence of past and parallel foresight exercises. The systems view thus broadens a process view and positions the foresight process to a larger context.

A view of futures knowledge as a network of concepts used to talk about the future is elaborated and illustrated in the articles. The network consists of explicit knowledge in the form of memory objects, articulated knowledge in the form of metaphors and embodied knowledge in the form of agents' cognitive schemes. There are thus different perceptions of the network based on the mindsets of the agents. Furthermore, the network is not static, but constantly evolving as a result of agent interaction. The process of shaping the network is the source of out-of-radar knowledge.

Futures knowledge creation means, on the innovation system level, changing the emphasis or linkages between the concepts in the network. Through intensive interaction this can result in a reframing of a concept or even an introduction of new concepts. On a group level, this means building upon the ideas of others and challenging existing assumptions, not just articulating and sharing embodied knowledge.

Table 3. Summary of the research contribution of the articles.

Article	Systems view to foresight	Multiple, nested layers	Futures knowledge as a network	Knowledge creation in foresight
Knowledge creation dynamics in foresight: a knowledge typology and exploratory method to analyse foresight workshops	Futures knowledge creation is presented as an interaction between participants to a foresight process	Focus on individual and group processes in futures knowledge creation	Futures knowledge created by building upon the ideas of others: foresight workshops as temporal gatherings, where the network of futures knowledge is shaped	Futures knowledge is created by challenging assumptions, reframing and cumulative discussion flow
Elements in the construction of future-orientation: a systems view to foresight	Foresight system consists of agents, their cognitive schemes, mediating events, strategic objects, metaphors and memory objects	Foresight system is nested in innovation system layer and consists of agents on the organisational and individual layers	Futures knowledge as a network consists of memory objects, metaphors and cognitive schemes.	Futures knowledge is created in the interactions between the agents
Multi-layered foresight: lessons from regional foresight in Chile	The context of foresight consists of nested systems	Description of the four layers: landscape, innovation system, organisation and individual	Futures knowledge as a network is a snapshot of foresight contributions to knowledge and differs from layer to layer	Foresight contributes explicit knowledge, relations and capabilities (tacit knowledge) to different layers
Emergence of shared perceptions of futures in a foresight system	Foresight defined as a complex adaptive social system	Focus on interactions between agents in the innovation system	Perceptions about the futures described as a network of concepts used when talking about the future	Shared perceptions emerge from and are shaped in the interaction between agents

4. Implications for strategy and policy making

Foresight has developed from relatively straightforward expert-based technology assessments to a multi-layered and multifaceted collection of methods and approaches, reflecting the growing complexity in the context of policymaking (Miles et al., 2008; Schoen et al., 2011; Köhler et al., 2015). Foresight is conducted in an increasingly interconnected and interdependent environment. For example, issues such as climate change, aging, poverty and unemployment are interconnected, and actions taken to combat problems in one issue affect the others. Furthermore, the issues cross disciplinary, sectoral and political boundaries and thus cannot be handled by a single agent in the system.

In addition to the issues, the agents such as ministries, regional governments, NGOs, companies and research institutes are also interdependent and interconnected, i.e. they form a complex adaptive system. No single agent can control or guide the development of the system, but rather the change emerges from the combined effect of direct and indirect impact of the agents. Shaping the future cannot thus be "outsourced" to any single agent, which means that broad participation becomes ever more important. In order to better facilitate the participation it is important to understand the interdependencies between the agents and the functioning of the system.

In terms of knowledge production, the tendency has been to think that more is better, and that better research or foresight will lead to better decision making (cf. HLEG 2002). However, in the world of "big data", trend databases and a large number of publicly documented foresight exercises, information is not scarce. Rather, the problem is what to do with that information: how to manage and interpret it? Related to the issues of interdependency and participation, there is also a need to understand the sources of knowledge and the hidden assumptions in it. Relevant questions include who has been involved and in what kind of a process.

The systems view of foresight and the concept of futures knowledge as a network help provide answers to the challenges and questions mentioned above. The main implications are summarised in Table 4 and contrasted against the process view. In this section I elaborate the implications on four overlapping themes:

- Futures knowledge production
- Context dependency of futures knowledge
- Futures capability
- Participation and expertise in foresight

After discussing these themes, I also suggest some ways of organising foresight from the systems view.

Table 4. Differences between the process view and systems view of foresight

Topic	Process view	Systems view
Purpose of foresight	Create knowledge about the future	Shape the perceptions of futures and debate which is preferable
Organisation of foresight	Tendency is towards large, separate projects	Flexible and continuous processes interacting in a foresight system
Starting point	Needs of the decision maker or other process owner	Previous and parallel foresight processes, the current perceptions of futures
Control	Process is controlled by foresight practitioners or process owner	A foresight system cannot be controlled, but perceptions of futures can be influenced through strategic objects and mediating events
Participation	Narrow expert-focused participation or broad consensus-focused participation	Broad and inclusive participation encouraging disparate views
Capability building	The capability to think about alternative futures is embodied by foresight practitioners, who facilitate the process	Futures capability accumulates in the foresight system through continuous activities
Outcome and impact	A foresight process produces futures knowledge, which is then used by decision makers	The changes in the way future is perceived influences the actions of the agents

4.1 Futures knowledge production

If futures knowledge is seen as a network of concepts used to talk about the future, then it could be said that foresight processes build on the existing perceptions about the futures. Images of the futures are constructed using old concepts, or based on old images of the futures. The network of concepts continuously evolves as a result of foresight activities through changes in the emphasis of concepts, through the reframing of concepts and to a lesser extent by introducing new concepts. In the policy making context, this means that 1) the foresight activity is often a debate about what concepts to emphasise, 2) reframing concepts requires intensive interaction between a broad set of agents and 3) new concepts can be introduced, if the process and topic are kept open.

The agents in the foresight system have different perceptions as to what is important in the future. This is reflected in different emphases in the network of concepts used to talk about futures. Therefore, a foresight activity in the political con-

text is often about “debating the future” (cf. HLEG 2002). In a critical debate the focus should be on opening up possibilities and discussing what kind of society is preferred by the agents. However, often the approach is more instrumental and while multiple agents may be involved, the “official” outcome is decided by the owner of the foresight process. The outcome may reflect a consensus, but it is useful to be aware of who has had the last word in encapsulating it, i.e. whose perception it mainly represents. This often receives little attention in foresight, with the risk of the exercise becoming a legitimization process or a strengthening of “futures imperatives”, such as “we need growth or else all will fall” (see Ahlqvist & Rhisiart 2015). Explicating the different perceptions of the network of concepts in terms of differences in the emphasis of and linkages between different concepts helps make these futures imperatives more visible and highlights the differences in views.

Reframing requires challenging existing perceptions and seeing new connections between different concepts. This seems to be facilitated by intensive interaction. For example, in the “Water in Antofagasta 2040” project, water scarcity was reframed as a research opportunity and selling point instead of merely a barrier during an intensive workshop session. Reframing is essential for moving away from an instrumental use of foresight and opening up the discussion around a topic (cf. Stirling, 2007). While a thorough answer to what common topics in foresight should be reframed is well outside the scope of this dissertation, I can illustrate the main point with some examples. There seem to be issues that are political taboos and are thus usually not part of discussions at least in national policy-oriented foresight. The assumptions about constant growth, and related to that the existence of the economic system as it is should be open to discussion when imagining alternative futures. Other examples could include the relationship between employee and employer and the meaning of jobs in general, the basis of nationality (e.g. geographic or virtual), the structure of the political decision making process, and the aim and meaning of progress.

In addition to changing emphasis and reframing, it is also possible to introduce new concepts. This seems to be facilitated by reframing and challenging assumptions and requires flexibility in terms of both process and content. A restrictive process does not encourage the exploration of the topic and free associations emerging from this exploration, allows too little time for this kind of divergent phase or sets the agenda such that the perceptions are anchored in a narrow mindset. In such a process, there may not be enough time or the right atmosphere to broaden and build upon existing ideas (Fredrickson, 2001; Nonaka et al., 2000). And if the topic is kept too narrow, the range of sources for new concepts is restricted. New concepts in the network signal a major change in the way of thinking, an opening up of a new narrative. For example, in the South Australian cellulosic fibre value chain project, the concepts of nanocellulose and biobased polymers, among others, helped generate alternative narratives for the future of the region (see Ahlqvist, Kettle, et al., 2013).

I argue that the value of foresight processes is in rethinking what is important and preferred, and the ways to achieve preferred futures. This links back to the

argument by Polak (Polak, 1973) about having an image of the future worth striving for. In futures research, there is a tradition of considering not only what is possible or probable, but also what is preferable, e.g. what is a good society or what do we mean by “human betterment” (Bell, 2004). The idea of debating about preferable futures is also present in many definitions of foresight and to some extent also in practice, especially in topics such as the Grand Challenges. However, the dominant mode of foresight has been argued to be “instrumental”, i.e. focused on ”optimising gains and offsetting risks within the dominant (extant) system”, rather than “emancipatory”, i.e. about “revealing some meta-level knowledge about the human condition in order to change the behaviour of human beings and societal entities towards a more sustainable direction” (Ahlqvist & Rhisiart, 2015, p. 95 - 96). I argue that being aware and opening the concepts taken for granted when talking about alternative futures is a necessary step in moving away from used or disowned futures (Inayatullah, 2008) and creating a future worth having. Just doing more foresight on predefined topics with a closed process does not lead to more futures knowledge or more preferable futures.

4.2 Context dependency of futures knowledge

In a foresight system, knowledge embodied or codified in one process is used as an input for another. The processes may operate in different contexts with different purposes. However, because futures knowledge is context-dependent (Piirainen & Gonzalez, 2015; Hage et al., 2010), this can create a mismatch between what was intended and what was interpreted. For example, a scenario exploring different technological possibilities might be taken to represent an assessment of the technology readiness level. Using the typology of futures knowledge I differentiate between three sources of mismatch: the reinterpretation of codified knowledge, the diversity of embodied knowledge and the nature of the process of embodying out-of-radar knowledge.

Codified knowledge is a snapshot of the network of concepts, taken from a specific viewpoint and with a specific purpose in mind. Therefore, it has a specific context inherently attached to it. However, it might be interpreted in a different context. This creates a mismatch that may have negative or positive consequences. For example, using a scenario made for a specific country might ignore some key aspects of another country. On the other hand, it might also open new possibilities by highlighting future developments that would otherwise have been missed due to being too tied to the local context. From an emancipatory view, making explicit the context inherent in encapsulated codified knowledge is important in order to reveal the power structures and values implicit in it.

The second source of mismatch is the different backgrounds of the agents in the system. This is reflected in the diversity of embodied knowledge. When embodied knowledge is articulated, its inherent context is brought into the discussion. An example of this would be when agents from different backgrounds are “not talking the same language”. Making the context explicit is essential for enabling

constructive dialogue between agents in the foresight system. Increasing the diversity of embodied knowledge, i.e. including agents with diverse backgrounds, can lead to conflicts and problems in the interaction between agents, but also brings new ideas, viewpoints and associations to the process. In the terminology of complex adaptive systems, this diversity increases the energy of the system. As with codified knowledge, the mismatch can lead to misinterpretations or to the broadening of the discussion.

Out-of-radar knowledge illustrates a third aspect of context dependency in futures knowledge: that of the influence of the nature of the foresight process. As stated above, more intensive interaction seems to enable reframing and thus the shaping of the network of concepts. Those agents who are part of this intensive interaction are able to embody the out-of-radar knowledge, while it may seem either trivial or out of scope for other agents. The agents in the foresight system are thus at different positions related to the ability to use the futures knowledge depending on their level of participation.

4.3 Futures capability

Futures capability, defined in section 3.2, highlights two key ways of seeing capability in foresight from a systems view:

- The outcome of a foresight process not as an object but as an increase in capability.
- Foresight as a continuous action to increase and maintain this capability.

Futures knowledge as a network encompasses both the codified memory objects produced in a foresight process and the accumulation of futures capability. A snapshot of a futures knowledge as a network from one viewpoint may be captured in e.g. a scenario document, but it is the comparison of different perceptions of the network and the shaping of the network that can increase futures capability. Seeing the connections between different concepts, seeing how they change and how they differ between various viewpoints enhances the ability to think about futures in the plural and to connect to the larger context. In terms of the futures knowledge typology, futures capacity is the ability to embody “out-of-radar” knowledge and bring it to the discussion in a meaningful way so that it opens up new directions and insights about alternative futures.

4.4 Participation and expertise in foresight

In a foresight system, no-one is in control and capable of creating a future by themselves. Rather, the images of the futures (represented by the network of concepts) and consequently the actions to achieve one or more of those futures emerge from the interaction between agents. A foresight system is a complex adaptive system which operates best if it is at the “edge of chaos” (Kaufmann, 1995; Stacey, 1996). Policy makers or other users of foresight should not be de-

luded into thinking that they can order an image of the future to their liking by doing a foresight study; or to be more precise, to think that this image of the future would be shared or agreed upon by other agents. Knowledge creation in foresight – the shaping of futures knowledge – is a gradual, continuous process of discussing and, more importantly, listening. Broad participation ensures that different agents in a foresight system can have an opportunity to shape the dominant perception of alternative futures, represented as the network of concepts. For example, in horizon scanning, broad participation enables the collection of various and diverse signals as well as the joint structuring of these signals into meaningful groups (Könnölä et al., 2012).

Increasing participation has been topical in foresight for some time (Van der Helm, 2007). Participation is described as one of the key characteristics in both the newest wave of corporate foresight (Daheim & Uerz, 2008) and in foresight aimed at informing or influencing public policy and decision making (Miles et al., 2008). However, the nature of participation and stakeholder ownership has received less attention (Soste et al., 2015). For example, there has been a tendency to highlight how many experts and how many experts of "high quality" were included in a foresight process as an indication of the quality of the results (Kettunen, 2014).

From the viewpoint of futures knowledge as a network, I describe three approaches to participation in foresight: legitimation, expert opinion and broad engagement. These vary based on their assumptions about the purpose of foresight, the nature of participation and power relations (see also Salo et al., 2009; Könnölä et al., 2009). The three approaches described here are not a comprehensive set of modes of participation in foresight, but rather help illustrate the different assumptions made about futures knowledge. By legitimation I mean an instrumental use of foresight to support a pre-set agenda. In this approach, the future has been "decided" already and the role of participation is to inform and persuade others to adopt this "official future". Foresight is thus more of a ritual of strengthening "futures imperatives" than an inquiry into the futures (cf. Ahlqvist & Rhisiart 2015). The aim is to strengthen the network of concepts as perceived by the "owners" of the foresight process, for example the funders or policy makers who have initiated the process.

In the "expert opinion" approach, future is not fixed, but something that is "out there" to be explored and found. A selected group of key experts are gathered to have their say on what the future will be (see e.g. Bauer & Pregernig 2013). This process will strengthen the concepts and linkages in the network that the experts see as most probable. While this does bear some resemblance to forecasting, experts can take into account non-linear developments and surprises. Still, the view is that of an objective future to be found, not necessarily something that is produced or shaped during the process. This does not mean that this type of participation would not be useful. Depending on who is counted as an expert and what the nature of the interaction is, this approach can produce views that would be hard to get from a broader participation. A small but diverse group, focused on a specific topic may come up with new linkages and reframings more quickly than

a broad heterogeneous group. The question is then how to present these perceptions in a meaningful way to other agents. On the other hand, if the experts come from relatively similar backgrounds and the process does not encourage voicing "out-of-radar" ideas, the outcome will probably be the strengthening of the current dominant view in the network of concepts and focus on short-term conventional actions (cf. Weber et al., 2009). Such a process will easily lead to groupthink (Janis, 1972).

The question of expertise in foresight, in the systems view, is not only a question about specific substance matter knowledge, but also about the ability to understand interconnections and change, think differently and embrace plural views. In other words, it is about the futures capability described in section 3.2. Substance matter expertise is often narrow in terms of understanding interconnections in a broader innovation system. Thus, the perception of what the relevant system is can be narrow and consequently the basis for understanding changes and future development in the system is also narrow. In a complex system where many things are interconnected, as is the case with many current policy challenges, understanding future developments requires a broader view of the system. Part of this understanding comes from analysing the past and current developments in the system. However, this has to be balanced by critical reflection on the current assumptions that might not hold in the future. Exploring the plural views of futures is one way to bring the assumptions to surface. This means exploring different perceptions as to what the future is, expressed as differences in the emphases and linkages between concepts in the network.

These questions about expertise are also relevant in the "broad engagement" approach to participation, where the emphasis is on trying to get as many agents involved in the process as is feasible. Broad participation does not automatically mean fresh ideas and radical changes in the perceptions about futures. The end result can be a consensus which does not satisfy anyone. In terms of the futures knowledge as a network, this would mean an "average" view of the network, which removes radical views and only slightly complements the dominant view with some divergent aspects. The aim for consensus is symptomatic of the process view. If foresight is seen as a process, the focus is on thinking what methods to use in different parts of the process in order to enhance participation and to end up with an outcome everyone can agree upon. As participation takes resources, there is a need to carefully consider when and how to strive for broad participation and what is the role of the participants (see e.g. Brummer, 2010). In contrast, from the systems view the focus is on building relationships between the agents and enabling them to take part in shaping the future. A systems view thus focuses on changing the structure of the system so that it encourages a broader and more inclusive participation also informally and outside a specific foresight process. However, this does not necessarily lead to a more coherent common view of futures. In the terms used in systems intelligence (Hämäläinen & Saarinen, 2004; Hämäläinen et al., 2014), the aim is to deconstruct systems of holding back and enhance positive spirals of expectations. The keys to do that lie in systems thinking, being open to alternatives, embracing ambiguity and uncertainty as natural

characteristics of a complex system and enhancing intensive interaction between a broad set of agents. In the next section, I will suggest some ways of implementing foresight from the systems view.

4.5 Organising foresight in the systems view

The foresight system is embedded in the innovation system. By this I mean that it has partly the same agents and its role is both to anticipate and shape the changes in the innovation system. Anticipation means identifying current conflicts, tensions and drivers and revealing hidden assumptions in order to get an idea of how the system might change in the future. Shaping the innovation system means influencing the perceptions of alternative futures by introducing strategic objects and mediating events. Through changing the perceptions the aim is to encourage action towards achieving preferred futures. It is worth emphasising that the concept of a foresight system is not meant to create more boundaries, e.g. between foresight and non-foresight activities, but rather to frame foresight as a natural part of the activities in an innovation system.

The function and added value of foresight is to shape existing perceptions of futures, illustrate the differences in perceptions and introduce new perceptions. This is achieved through changing the emphasis, reframing and introducing new concepts, as described in section 4.1. Thus the aim is not so much to say what will happen in the future, but rather help agents in the system to articulate, share and create perceptions about alternative futures. Shaping existing perception of futures influences the behaviour of agents and thus also shapes the future. While foresight does inform policy, facilitate its implementation, embed participation, support policy definition, help reconfigure the system and serve a symbolic purpose (Da Costa et al., 2008), I frame these functions through the concept of futures knowledge as a network. I argue that this helps to see foresight as part of existing activities in the system, not as a separate process of gazing into the future.

Because foresight is a system that operates through foresight processes, it is continuous. The processes can be large or small, participatory or expert-based, short or long, as long as they are flexible in process and scope. This can be achieved for example by an adaptive and iterative process (see e.g. Eriksson & Weber, 2008) or through modular process design (see e.g. Brummer, 2010; Könnölä et al., 2009). The key thing is the interaction between the processes, through the interactions between the agents. The processes are part of a continuum of foresight activities in the system, all shaping the network of concepts. Instead of putting all the resources into one big foresight project, it might be more effective to have many small processes and to see them through the systems view. As an example, Vilkkumaa et al. (2015, p. 186) argue that an optimal policy for fostering breakthrough technologies is to

> *"experiment on a large number of projects for some time and, based on this experimentation, commit resources only to those few projects which appear best."*

Likewise, Eriksson and Weber (2008) propose an adaptive approach to foresight, in terms of learning from experience, adjusting strategies based on new information and finding a balance between shaping and adapting to alternative futures.

The balance between shaping and adapting is relevant in the systems view of foresight. While the foresight system cannot be controlled, it can be influenced through strategic objects and mediating events. The nature of interaction between the agents can be influenced by mediating events: for example who is included in a process, how and when. Strategic objects guide the focus to specific topics and help establish a common ground among foresight processes. However, they are not a tool for control: not all foresight activity will focus around a specific strategic object. Furthermore, a strategic object may be given interpretations that were not intended by those who introduced it. These interpretations can be a source of new insights as well, as described in section 4.2.

The strategic objects and mediating events help shape the network of concepts used when talking about futures. Strategic objects shift the emphasis to certain concepts and may introduce some new linkages. Redefining the linkages between concepts and reframing concepts can be carried out in a process with intensive interaction among the agents. This can be achieved by appropriate mediating events, for example open workshops instead of surveys or including agents with conflicting views in a constructive setting. Introducing new concepts and thus radically new perceptions requires futures capability from the agents, which accumulates through their involvement in the foresight processes.

Increasing futures capability can be achieved by embodying both articulated knowledge (through learning and internalising) and out-of-radar knowledge (through visualisation and reflection), experiencing how the network of concepts changes and seeing different perceptions to it. As stated before, continuous involvement in the foresight processes is necessary, but not sufficient in itself. In addition, reflection is needed, both about own perceptions to futures and about the process and the perceptions of others. Through reflection the view of futures knowledge as a network expands and the ability to see plural perceptions increases.

The main recommendations for changing the current way of conducting foresight are summarised in Table 5. Instead of large all-encompassing projects, the systems view encourages flexible and continuous foresight processes, which are seen as parts of a larger whole and which interact with each other. While the system cannot be controlled, it can to some extent be influenced by strategic objects, which influence the content, and mediating events, which influence the interaction between agents. Futures capability accumulates in continuous foresight processes and requires reflection. The continuous foresight processes shape the network of concepts and thus the perceptions about futures, which in turn influence present actions.

Table 5. What should be done differently in the practice of foresight?

Question	Change
What kind of projects?	From separate projects to continuous ones. Scale, duration and size may vary, as long as the projects remain flexible.
Who should organise?	From centralised control to a foresight system, where foresight activities initiated by various agents are connected.
How is the project run?	From strict scope and process to adaptive and flexible process. Intensive interaction is needed in order to reach out-of-radar knowledge.
Who should participate?	From broad participation in terms of quantity to broad in terms of diversity of agent backgrounds. System structures support informal networking and ensure the opportunity to take part in the discussion on preferred futures.
Who is an expert?	From subject matter experts to experts capable of embracing and articulating multiple perceptions of the future of an issue.
What is produced?	From documents to reframing the discussion, represented as the changes in the network of concepts used to talk about futures.

5. Theoretical implications

The main theoretical contribution of this dissertation is advancing the systems view of foresight and using it to describe futures knowledge creation. In particular, the typology of futures knowledge, elements of a foresight system and futures knowledge as a network of concepts help describe knowledge creation in foresight. In addition, the concept of multi-layered foresight provides a structure for positioning different foresight approaches.

Operationalizing new conceptual models has required developing and modifying research methods. These include:

- the codification of phrases in a foresight workshop based on the typology of futures knowledge in order to analyse the flow of the conversation and manifestations of futures knowledge (see article I),
- text mining written documents in order to trace the changes in a network of concepts (see article IV), and
- analysing case studies based on the elements of a foresight system and the framework of multi-layered foresight (see articles II and III).

In this section I describe the implications of these contributions for theory in more detail. I also consider the limitations and avenues for further research.

5.1 Foresight as a system

The theoretical basis of foresight has been criticised (Piirainen & Gonzalez, 2015; Hideg, 2007; Öner, 2010). Among other shortcomings in theory, there is little understanding of the process of futures knowledge creation (Slaughter, 2001). This dissertation contributes to the on-going discussion on the theoretical underpinnings of foresight and especially to the question of how futures knowledge is created in foresight. I have used the systems thinking frame, mirroring recent proposals by Saritas (2013) and Andersen & Andersen (2014). Systems thinking is a useful theoretical frame for foresight, which aims at understanding and shaping the future – a complex adaptive system if any. Framing foresight itself as a system and analysing futures knowledge creation from this frame is one of the main theoretical contributions of this dissertation.

The aim in innovation system foresight (Andersen & Andersen, 2014; Andersen et al., 2014) is to integrate the current understanding of innovation, as described in innovation studies, to foresight.. I build on this work by positioning foresight as a part of an innovation system (cf. Brummer, 2010). However, I also base the definition of what a foresight system is to systems thinking approaches, especially complex adaptive systems theory (Kaufmann, 1995; Stacey, 1995). An innovation system is the context for a foresight system, but the system itself is described using terms and theory adapted from systems thinking. This is also the main difference to the work by Saritas on Systemic Foresight Methodology (Saritas, 2013). I build on many of the concepts suggested by Saritas, such as continuity, but also describe the elements of the foresight system in more detail. Likewise I use the insights on the influence of individual, organisational and individual capacities in a FTA systems (Weber et al., 2012), but focus more on the interaction between agents. Amanatidou and Guy have defined a foresight system in the context of "participatory knowledge societies" (Amanatidou & Guy, 2008). However, their aim with the foresight system is to support the impact assessment of foresight, while my focus is on understanding knowledge creation and the practice of foresight.

One important distinction that I make, following Andersen and Andersen (2014) is between a foresight system and a foresight process. I suggest definitions for both of them and describe their interdependence: a foresight system operates through foresight processes. This distinction is useful for theory for three reasons:

- it positions foresight processes as part of a larger system,
- it positions the ample literature on ideal foresight processes to the systems view, and
- it helps to understand the context dependence of foresight by illustrating that the process does not start from a "blank slate".

The systems view of foresight means that the focus shifts from "ideal processes" to "ideal systems". The elements of a foresight system are one description of the structure of a foresight system. The concept of multi-layered foresight provides further structure by helping focus on different layers where foresight has an effect: landscape, innovation system, organisation and individual. The knowledge typology helps to understand the nature of knowledge in a foresight system, especially from the viewpoint of an individual.

A system is defined both by its structure and its functions or dynamics. In this dissertation, I have focused on the dynamics regarding futures knowledge creation. The conversions between different knowledge types describe dynamics on the level of individual interaction. I have also described the interactions between the elements of a foresight system, again with a focus on knowledge creation: knowledge emerges from the interaction between agents, is embodied as capabilities which in turn affect the interaction. These descriptions combine insights from the theory of knowledge management to foresight, and build on previous work, such as the "rye-bread model" by Uotila et al. (2005).

5.2 Typology of futures knowledge

The typology of futures knowledge is a further link between the literatures on knowledge management and foresight. It brings more detail to the analysis of futures knowledge creation compared to the simple tacit-explicit split. In addition to incorporating self-transcendent knowledge (Scharmer, 2001), redefined as out-of-radar knowledge to be more suitable for the context of foresight, the typology also makes a distinction between codified and articulated. This is relevant for foresight, where knowledge does not only reside embodied in experts or codified as documents, but is also "live" in the process. Thus, the typology is more apt for identifying futures knowledge in a foresight process than the tacit-explicit split or the division to implicit, explicit and self-transcending knowledge used e.g. by Uotila et al. (2005).

The typology of futures knowledge also acts as a bridge between the view of futures knowledge as detached nuggets of information and the network view as described in Section 3.4. The network view of futures knowledge is especially suitable for a systems view of foresight, as it describes futures knowledge as continuous, plural and multi-faceted network constantly shaped by interaction between agents in the system. This brings a new angle to the study of futures knowledge. Instead of focusing on the outcomes of foresight, or on its philosophical underpinnings, the object of study becomes the change in the perceptions of futures expressed by the agents in a system. These can be represented as a network of concepts and further analysed using the typology of futures knowledge.

5.3 Multi-layered foresight for positioning approaches and methods

While I use the term foresight to refer to activities aimed at anticipating and shaping alternative futures in general, it is worth noting that it covers many different approaches with slightly different aims. The concept of multi-layered foresight helps to position the many foresight approaches in relation to one another and structure the contributions of foresight exercises. As foresight has diversified in response to different demands, it has become difficult to understand the different connotations attached to foresight. The multi-layered foresight concept is one approach to positioning the foresight approaches. However, it should not be taken to be an umbrella term for all foresight – rather it is one tool for comparing different approaches.

The concept of multi-layered foresight contributes to determining the focus and scope of research on foresight. First, the layers help to structure where the dominant focus in a foresight process is: on the landscape (external developments), innovation system (dynamics between organisations and institutional arrangements), organisational (dynamics within an organisation) or even on the individual level (personal futures). Second, the three facets of foresight: knowledge, relations and capabilities, highlight that there is more to the effects of foresight than just

knowledge. Furthermore, the frame should prove to be useful for positioning different methods in their context. Foresight research has been argued to be "dominated by a commitment to research methods" (Karlsen et al., 2010, p. 61), but there has been a lack of contextualising of these research methods (Ahlqvist & Rhisiart, 2015). Being explicit about which layer the method is primarily aimed at, and being aware of how it contributes to the other layers may help to take the wider context into account.

5.4 Contributions to research methods

In this dissertation I propose four conceptual frameworks for thinking about the knowledge creation in foresight: the typology of futures knowledge, elements of a foresight system, foresight knowledge as a network and multi-layered foresight. In order to reflect the empirical case studies against these conceptual frameworks, I have developed or modified research methods. In article I, I operationalized the typology of futures knowledge by coding the phrases uttered during a foresight workshop. This included categorizing the phrases as divergent, convergent or neutral phrases and using a more detailed version of the typology to further classify the phrases. The codification allowed the analysis of the flow of the conversation as well as exploring how out-of-radar knowledge manifested itself in the discussion. This method is applicable to analysing the discussions held during a foresight process and seeing when the discussion opens up to new directions and when it converges towards a joint outcome.

In article IV, I used text mining to create concept maps of written documents in order to analyse the changes to perceptions about futures. The co-occurrence of words was calculated and presented as a concept map. This provided a way to mitigate researcher bias in getting a first impression of the key concepts and their evolution during the process. Text mining was followed with a more qualitative analysis of the changes in the network of concepts. Such a research method is applicable for analysing futures knowledge as a network and seeing how it changes.

I have also used conceptual models to guide the analysis. In article II, I used the elements of a foresight system to identify key aspects of two empirical case studies. Likewise, in article III the multi-layered foresight framework helped to structure the many contributions identified in the case study. Both of these conceptual models can be used to analyse other foresight processes.

5.5 Limitations

This dissertation is about futures knowledge creation in foresight. This has meant that the focus is on futures knowledge, although I have also touched upon other related aspects of foresight, such as relations, futures capability, participation and expertise. However, many aspects of foresight have remained outside the scope of this dissertation, such as methodological developments, the functions of

foresight in general as well as a more detailed look at participation and expertise. Most notably, I have not included the evaluation and impact of foresight, which has been a much discussed topic both in policy and research (see e.g. Amanatidou 2011). However, the conceptual models I present, such as the elements of a foresight system and especially multi-layered foresight, could prove useful for assessing the impact of foresight.

The theoretical basis is on foresight, innovation systems, systems thinking and knowledge management. This means that several relevant approaches to knowledge creation have been left out. For example, views from psychology and cognitive science have been omitted, although I frame knowledge creation essentially as emerging from the interaction between individuals. Likewise, considerations of group dynamics and the influence of agent demographics have been beyond the scope for this dissertation, but could prove to be interesting avenues for further research. Although I briefly review the discussion of futures knowledge from the viewpoint of the philosophy of science, this view has also been left to a minor role.

Although this is a dissertation about foresight and futures knowledge creation, I have not explicitly discussed the time dimension, especially in relation to systems. Systems change over time. The elements of a foresight system help describe foresight as a system at one point and can be used to compare the system at different times. However, the elements do not directly depict why the system has changed or the mechanism of that change. Thus it is worth keeping in mind that the foresight system as an analytical, relatively fixed construct is just a perspective to foresight activities at one point in time.

The research method is based on grounded theory (Glaser & Strauss, 1967; Glaser, 2011) and case studies. This approach can be criticised for providing a weak basis for generalization. There can always be more case studies. However, I argue that the range and scope of the case studies included in this dissertation provide a good general snapshot of current foresight practices, at least as practiced in Finland, which is one of the forerunners in policy-oriented foresight (Köhler et al., 2015; OECD, 2015). That said, it should be acknowledged that the findings in this dissertation assume the context of foresight in an innovation system, and that other contexts could have nuances that are unaccounted for.

5.6 Avenues for further research

As noted in the limitations section, there can always be more case studies. Especially applying the typology of futures knowledge, analysing the evolution of network of concepts and using the frames of foresight system and multi-layered foresight could benefit from more case studies. This would most likely improve the conceptual models and expose aspects that they do not capture. Related to the additional case studies, longitudinal studies of a foresight system spanning multiple foresight projects and processes could prove interesting for further developing the systems view. Focusing on a specific organisation could provide insights to the

accumulation of futures capability as well as its transfer across organisational borders.

Applying the conceptual models in other fields could also prove useful. For example, the elements of a foresight system have been developed with the context of foresight in mind, but they could be applicable to the field of strategic management as well, especially in cases where the focus is on long term strategy development or learning. Finally, as suggested in the limitations section, the findings of this dissertation could be complemented by research from psychology and cognitive science.

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Article I

Dufva, M. & Ahlqvist, T. 2015. Knowledge creation dynamics in foresight:
A knowledge typology and exploratory method to analyse foresight workshops.
Technological Forecasting and Social Change, 94, 251-268.

Technological Forecasting & Social Change 94 (2015) 251–268

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Knowledge creation dynamics in foresight: A knowledge typology and exploratory method to analyse foresight workshops

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ARTICLE INFO

Article history:
Received 5 April 2014
Received in revised form 30 August 2014
Accepted 11 October 2014
Available online 11 November 2014

Keywords:
Foresight
Workshop
Knowledge typology
Futures knowledge
Knowledge creation
Foresight process

ABSTRACT

A typical foresight process involves stakeholders exploring the futures and interpreting the results to present actions. In other words, participants create knowledge about the future. Interaction between the participants is a key ingredient of foresight, yet this dynamic interaction has rarely been studied from the perspective of knowledge creation. In this paper, we aim to fill this gap by looking at how, and through what kinds of dynamics, knowledge is created in a foresight workshop; how it is manifested; and what are the special characteristics of futures knowledge. We develop a typology of knowledge in foresight workshops, and construct an exploratory methodological approach for analysing the knowledge creation dynamics in transcribed workshop discussions. Based on the results from the analysis of two workshop discussions, we argue that futures knowledge is founded on the knowledge base formed by the participants and new knowledge is created both through cumulative discussion flow and revelatory statements which reframe the discussion or challenge implicit assumptions. We argue that the typology of knowledge as well as the exploratory method aid in understanding futures expertise and support the planning of foresight processes.

1. Introduction

Participation is a key characteristic of foresight (Van der Helm, 2007; Miles et al., 2008; Cagnin and Keenan, 2008; Glenn and Gordon, 2003). A typical foresight process involves stakeholders exploring the futures and interpreting the results to present actions. Stakeholders usually engage in the foresight process and actively construct outputs of the process, commonly in the form of scenarios, roadmaps, visions or recommendations for future actions. In other words, the participants create the knowledge about the future (cf. Hines and Gold, 2014). The interaction between the participants is a key ingredient of foresight, yet this dynamic interaction has rarely been studied from the point of view of knowledge creation. In this paper we aim to fill this gap by analysing how knowledge about the future is created in the foresight process, and specifically in a foresight workshop.

What, then, is knowledge about the futures, or futures knowledge, and how is it constructed through such a process? These questions have previously been approached from at least two viewpoints: from a theoretical viewpoint (e.g. De Jouvenel, 1967; Bell, 2003; Kuusi, 1999; Malaska and Masini, 2009; Gabriel, 2013; Sardar, 2010) and from an output-oriented viewpoint (e.g. Eerola and Miles, 2011). The theoretical viewpoint analyses the specific nature of futures knowledge, its ontological and epistemological foundations, and the limits to this knowledge. The output-oriented viewpoint considers what kinds of knowledge can be created in a foresight process, such as forecasts, descriptions of future possibilities, or perceptions of the future, and aims at understanding the consequences of actions (Eerola and Miles, 2011). However, less research has focused on understanding

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http://dx.doi.org/10.1016/j.techfore.2014.10.007
0040-1625/

futures knowledge as constructed in the actual foresight process (Slaughter, 2001).

In this article, we propose a third approach that focuses on knowledge creation dynamics in the foresight process, from the lens of knowledge in action. Specifically, we look at how knowledge is created, and through what kinds of dynamics, in a foresight workshop; how this knowledge is manifested; and what are the special characteristics of futures knowledge. We aim at developing a typology of knowledge that could prove useful in analysing the knowledge creation dynamics in foresight processes, and especially in participatory futures or foresight workshops. Workshops are widely used in foresight for both the creation and synthesis of knowledge, and for fostering the imagination on possible alternative futures (see e.g. Jungk and Müllert, 1996; Boulding, 1991; Phaal et al., 2007; Kerr et al., 2013; Carlsen et al., 2014). We illustrate how the aspects of creation, imagination and synthesis are revealed in the knowledge dynamics of a foresight workshop. In order to realise this, we have developed a knowledge typology and, based on this typology, we have also constructed an exploratory methodological approach for analysing the knowledge creation dynamics in workshop discussions.

Our typology is grounded on three theoretical lineages: the first of these is the classical SECI model (socialisation, externalisation, combination, internalisation) by Nonaka and Takeuchi (1995) and Nonaka et al. (2000), and its further developments in the field of foresight (Uotila et al., 2005). The second is the so-called transformative or critical lineage in foresight that aims at problematizing and challenging the commonly held assumptions in foresight, such as the aim towards group consensus (Inayatullah, 2008; Staton, 2008; Slaughter, 2002). The third lineage is based on the practice-oriented turn, emerging in social sciences, that focuses on social practices as primary sources of insight and interpretation in different social contexts (e.g. Bourdieu, 1977; Cetina et al., 2005; Ibert, 2007; Moodysson, 2008; Kornberger and Clegg, 2011). Our aim was to construct a typology that would be applicable in describing the knowledge creation dynamics as they unravel in the course of social interaction in a specific context, that is, in the context of participatory foresight processes.

In our view, a foresight workshop can be defined as a temporary socio-spatial crystallisation of expertise, with a particular sort of socio-spatial group dynamics, in which different instruments and tools are deployed in order to endorse knowledge creation. Workshops are usually part of a wider process flow in a foresight exercise, and in this wider flow the workshops are to be viewed as a 'hermetic' and intensive temporary phases for knowledge creation. Thus, a workshop is a spatially and temporally intensive locus of knowledge gathering and creation. In-between these intensive knowledge creation phases the process usually contains more reflective phases, during which background knowledge is accumulated and necessary back-office analytics are realised. However, here our analytical focus is primarily on the participatory phase of the foresight workshop.

The article is structured as follows: after this introduction, in Section 2 we describe the typology, knowledge conversions and their theoretical background. In Section 3 we outline our method for analysing the workshop discussions and the results from the analysis. In Section 4 we discuss the results and Section 5 concludes the article.

2. Typology of futures knowledge and foresight workshops

Plato is usually credited with defining knowledge as "justified true belief" (Fine and Carpenter, 2003). The nature of futures knowledge can be reflected against this definition. To begin with, statements about futures are neither true nor false (Gabriel, 2013; Wright, 2009). This is firstly because a future has not yet been realised and thus is not pre-determined. Secondly, this is because futures knowledge is created by learning beings, which, according to Kuusi (1999), have the following features: a learning being "can change its behaviour as the result of its experiences", "has interests, which direct its behaviour" and "has an active memory, where its experiences are stored". This means that realisation of futures is contingent on our actions.

A common motivation for activating futures knowledge through the foresight process is to broaden the horizon on what is deemed to be relevant or possible in the present by challenging widely shared positions and existing worldviews (Inayatullah, 2008; Staton, 2008; Slaughter, 2002; Blackman and Henderson, 2004; Aaltonen and Holmström, 2010). Therefore, one aim of the foresight process is to test the limits of the futures horizon, that is, the scope of what is thought to be plausible and possible, or what is deemed to be the relevant domain of inquiry about the futures. In a foresight process participants may explore alternatives that none of the participants actually believe will happen as such, but could be plausible under certain conditions and with justifiable assumptions (cf. Gabriel, 2013). Futures knowledge could thus be defined as "justified contingent plausibilities": it deals with alternative images of the futures, and the rationalities behind these images under certain plausibility assumptions, and scopes how present actions could affect these images.

Knowledge as a form of understanding can be connected either to a thing or to a process (Zack, 1999). It can be an outcome of the foresight process, for instance a scenario, or it can be the interpretation of that scenario from the perspective of action planning. This division has similarities with a perspective of strategy planning called strategy-as-practice, which makes a distinction between strategy as something that an organisation has and strategy as something people do (Whittington, 1996). The practice-oriented view is dominant also in the concept of strategy crafting, that is, strategy as something that organisations and people actively construct (see e.g. Mintzberg, 1987; Whittington and Cailluet, 2008). In the so-called knowledge-based view of the firm, the knowledge is usually defined as a strategic asset or resource of a firm (Bollinger and Smith, 2001; Grant, 1996; Eisenhardt and Santos, 2002), or even as a "meta-resource", meaning that it coordinates the mobilisation of other resources (van den Berg, 2013). Following this view, futures knowledge would be focused on the outcomes of foresight process, that is, how scenarios, roadmaps, visions and related action recommendations help in the prioritisation of present activities in order for the firm to reach a desired future state. In other words, the emphasis is on knowledge as crystallised into a thing such as a strategy document, statement, visualisation and so on. Nonaka et al. (2000), however, suggest a more action-based view of knowledge and define it as "a dynamic human process of justifying personal belief toward the truth". How then are "contingent plausibilities" justified in a foresight workshop? In

order to answer this question, we need to consider different types of knowledge that are produced in a foresight process.

As Boisot (1998) asserts, knowledge can either reside in individual brains and related praxis, or it can be codified into documents, or, alternatively, it can be embodied in physical artefacts. Because our focus is on a specific form of knowledge we here call futures knowledge, we focus on the first two categories, and thus follow a commonly used division of knowledge into tacit knowledge (embodied in the expertise of the individual) and explicit knowledge (articulated in some form by an individual or a group) (Nonaka and Takeuchi, 1995; Polanyi, 1997; Karlsen and Karlsen, 2007). In Nonaka and Takeuchi's classic SECI model (acronym for socialisation, externalisation, combination, internalisation) (Nonaka and Takeuchi, 1995; Nonaka et al., 2000), these two categories are used in describing how knowledge is created through a spiral of knowledge conversions. Although the SECI model has received praise (e.g. Hauptman and Neuringer, 1997), it has also been critiqued as being too simplistic and ambiguous, and not founded on empirical evidence. Some scholars have assessed that it is conceptually flawed (Gourlay, 2006). The knowledge conversions have been evaluated as mechanistic and deterministic, omitting problem formulation, analysis and debate (Gourlay, 2006; Engeström, 1999; Zhu, 2006; McAdam and McCreedy, 1999). The model has also been critiqued for setting too heavy emphasis on managerial aspects instead of analytical rigour (Gourlay, 2006; Poell and Van der Krogt, 2003). Furthermore, the categorization of knowledge used in the SECI model has been perceived as problematic because of following three shortcomings: firstly, the model fails to distinguish implicit knowledge from tacit knowledge (Li and Gao, 2003); secondly, the model frames tacit knowledge as constructivist and explicit knowledge as positivist (Yolles, 2000); and, thirdly, the model makes an assumption that all tacit knowledge can be externalised to explicit knowledge (Kimble, 2002).

Building on these constructive critiques as well as the original SECI model, we propose an alternative typology of knowledge connected to foresight workshops. By focusing on the workshop setting, and building on the actual and empirically verifiable flow of arguments produced by workshop participants, the definitions in the original SECI model can be made less ambiguous. Engeström (1999) argues that despite the conceptual flaws "Nonaka and Takeuchi's categories may themselves be used productively to analyse different types of knowledge representation that are employed in the course of collaborative knowledge creation." We therefore take the tacit–explicit split as a starting point, and propose a division of both the explicit and tacit knowledge into two subcategories based on the workshop dynamics. In the workshop, explicit knowledge can be presented either in the form of codified knowledge, that is, crystallised in the form of documents, or in the articulated form, filtered through the perspectives and practices of a participant. In the same setting, tacit knowledge can either refer to the professional competences and experiences of the participants, or it can refer to the visionary insights and imagination of the participants. In other words, tacit knowledge can either be embodied knowledge or self-transcending knowledge, that is, a sort of implicit knowledge about "the sources or 'place' from where thought and action come into being" that is not-yet embodied (Scharmer, 2001). Self-transcending knowledge could also be defined as "the ability to sense the presence of potential, to see what does not yet exist" (Uotila and Melkas, 2008).

Based on these grounds, we propose the following knowledge types to be relevant for foresight workshops: codified knowledge, articulated knowledge, embodied knowledge, and "out-of-radar" or self-transcending knowledge (see Table 1). *Codified knowledge* is a somewhat generic form of knowledge that is expressed either in written or visual form. Examples of codified knowledge in a foresight process include background materials, such as reports and databases, narrated outcomes, such as scenarios, recommendations for action, and standardised pictorial presentations. Codified knowledge has similarities to what has been called explicit knowledge or information (van den Berg, 2013) or "knowledge that" (Gourlay, 2006). It is also close to what Karlsen and Karlsen (2007) define as codifiable implicit knowledge, that is, something that "can be understood in terms of concepts previously developed and applied". Codified knowledge is "transferable", meaning that it has the possibility to be understood equally by a larger group and the participants of a workshop (cf. Hedlund, 1994; García-Muiña et al., 2009). Although codified knowledge deploys common codes and concepts, it is always "sticky" to some extent, that is, its interpretations are dependent on the shared contexts (Uotila et al., 2005). Therefore, we are not claiming that all codified knowledge is straightforwardly objective or that all tacit or implicit knowledge could be straightforwardly externalised. What we are claiming, instead, is that these different types of knowledge are used in multiple tactful ways as construction material, as resources, for building novel and interpretative futures knowledge in a workshop situation. How this process of construction advances, and what kinds of routes the process takes, depends on many factors, like workshop methods, quality of process facilitation, and competence and experience of participants.

Articulated knowledge comes close to codified knowledge, but it is more dependent on the workshop setting and the related process. Articulated knowledge can be positioned between codified knowledge and embodied knowledge, that is, it can either be codified knowledge that has been contextualised in a workshop process or embodied knowledge that has been expressed and articulated in the workshop setting. For example, an existing report can be reflected upon in the workshop, or a participant may take a perspective on it based on their competence and experience. Articulated knowledge can be presented as visualisations, pictures or keywords. However, in these cases the meanings are trickier to transfer, because they are more dependent on the context and on the particular situation in which they become expressed or articulated. Understanding the meanings requires that one has the access to the original context, which usually means participation in the foresight process. Articulated knowledge is more susceptible to misunderstandings than codified knowledge, since the codes and their references are coupled with the process context.

Embodied knowledge refers to the skills, competence and expertise of the participants. It is knowledge about "things we do" as opposed to explicit knowledge about "things" (Scharmer, 2001). Gourlay (2006) brings together different terms such as procedural knowledge, know-how, implicit knowledge and skills under the term "knowledge-how", which comes close to

Table 1
Typology of knowledge in a foresight workshop.

Type of knowledge	Relevant dimensions (adapted from Karlsen and Karlsen, 2007)	Description	Form/expression	Access
Codified knowledge	Codifiable	Knowledge that is generic, that is, not dependent on the workshop context	Documents, papers, databases	Accessible in written or visual form to larger groups than workshop participants
Articulated knowledge	Expressible, instantaneous	Knowledge that is expressed in and explicitly fixed to the workshop context	Narratives that position knowledge explicitly in the workshop context	Accessible in written or visual form to workshop participants
Embodied knowledge	Exclusive	Knowledge embodied by participants, skills, know-how, expertise	Action, mental models, intuition	Accessible in conversations or interaction in workshop
Out-of-radar knowledge	Future-oriented, novel, incremental	Knowledge that seems irrelevant in the context, knowledge that is ignored or outside the scope	Wild cards, weak signals, free associations	Not directly accessible in the initial context, requires challenging participants' mental models

what we mean by embodied knowledge. However, as noted earlier, we make the distinction of whether the knowledge has been articulated or not. In this case, the articulation refers to practices in a workshop. Embodied knowledge is unravelled through the workshop activities and expressed as the actions, mental models and implicit assumptions of participants. Thus, embodied knowledge is actually the most common type of knowledge present in foresight workshops, and the aim of taking advantage of the embodied knowledge, to use the expertise and competence of the participants, and to collect their comments, ideas and insights, is among the main reasons for starting a participatory foresight process in the first place.

Foresight workshops do not only aim at sharing existing knowledge, but also at creating new futures knowledge. We call this form of knowledge "out-of-radar" knowledge. *Out-of-radar knowledge* is the main source of novel insights on the futures. It is something that may seem irrelevant and is thus often ignored. It is incremental in the sense that it "moves the knowledge frontier" (Karlsen and Karlsen, 2007), and stretches the boundaries of the futures horizon. The definition of out-of-radar knowledge comes quite close to what Staton (2008) calls "monstrosities". Out-of-radar knowledge challenges the status quo, orients the workshop towards new exploration and expands the range of possible futures. In workshops, out-of-radar knowledge could be activated and reflected on by using "wild cards", "black swans" (Taleb, 2010) and "weak signals", but in a workshop context – and this is our key message here – out-of-radar knowledge is not something that can always be categorically identified as a revelatory appearance of a "wild card" or a "weak signal" (cf. Schwarz et al., 2014). Quite the contrary – we argue that in a foresight process, out-of-radar knowledge is commonly revealed through a set of incremental statements that are built phrase by phrase in the flow of discussion; it could be a set of utterances that are somehow "out of joint", statements that unexpectedly change the perspective or locate commonplace objects in surprising contexts. It could also be based on speculative imagination, even touching the unknown unknowns (cf. Schippl and Fleischer, 2012; Elahi, 2011; Ringland et al., 1999). Dator (2007) has somewhat humorously stated that "any useful statement about the future should at first appear to be ridiculous" and this is also a definition that can be used to describe out-of-radar knowledge. While the same definition is sometimes used as a criterion to identify a "weak signal", the key difference is that out-of-radar knowledge may seem ridiculous if it is separated from the discussion flow, but in the context of the discussion it might seem like a highly logical step. Out-of-radar knowledge is thus something that is actively constructed *through the flow of workshop practices*. This form of knowledge is not primarily activated through analytical reasoning, but through imagination and creative actions aimed at freeing the participants of the existing "sticky" worldviews.

A workshop setting includes both the personal knowledge and the social networks brought to it by the participants, as well as codified artefacts (cf. Powell and Ambrosini, 2012). Codified knowledge can be accessed by a larger audience than just the workshop participants, and does not require the process insight of the participants for the knowledge to be transferred. Articulated knowledge, on the other hand, requires the process of insight of the participants for knowledge transfer, because it is dependent on knowing the frames of

interpretation defined in the workshop, although it can also be presented in written or in graphic form like codified knowledge. Therefore, it is accessible to the social network of the participants. Embodied knowledge is accessible only to the participants of the workshop via face-to-face interaction and through articulation of professional competence and skills. Accessing out-of-radar knowledge requires changing the framing of the problem or changing the context by challenging mind-sets, worldviews or hidden assumptions.

Table 1 summarises the types of knowledge, typical forms of knowledge in that category and the degree to which it is accessible. In Section 3 we test the categorisation through empirical material from foresight workshops.

Our knowledge typology is loosely related to the levels (litany, social/system, worldview, myth) in Causal Layered Analysis (CLA) (Inayatullah, 1998). Codified knowledge exists often on the level of litany; it needs to be brought into discussion in order to reveal the systemic connections in a specific context. Articulated knowledge is usually about the social or system level considerations. Worldviews are included in the embodied knowledge, while out-of-radar knowledge can be seen to be about finding new myths. As in CLA, the vertical movement between the knowledge types is an important dimension in the process. In the practice, futures knowledge is created in the dynamic conversions between the knowledge types of one into another. In the next section, we discuss these knowledge conversions in more detail.

2.1. Knowledge conversions in a foresight process

Workshops provide a space for both articulating and embodying knowledge. Håkanson (2007) has described the articulation and codification of knowledge as interplay of theory, codes and tools. Theory describes the cognitive frames and mental models used in the articulation. In the workshop context, this means that the statements of participants are based on and influenced by their worldviews and mental models. Codes are the "symbolic means of expression and communication" (Håkanson, 2007), such as language, pictures or physical objects. The most common code in the workshop is language, but a workshop participant may use any type of code, like expressions or movements, depending on the task at hand (cf. Heracleous and Jacobs, 2008). Tools are the instruments used in the articulation. In the workshop these may be, for instance, white-boards, pens, post-its and laptops.

Knowledge can be embodied in face-to-face interaction (socialisation in the SECI model). It could also be embodied from data. When a context is added to data, it becomes information, and when information is critically analysed and its connections are understood, it becomes knowledge (Zack, 1999; Uotila et al., 2012). As Ansoff argues in his classic filter theory (Ansoff, 1984), data and information pass through three kinds of filters: a surveillance filter (what is perceived), a mentality filter (how well the perceived fits into the mental models of the person) and a power filter (what is considered relevant).

Both the articulation and embodying of knowledge is presented in the SECI model (Nonaka and Takeuchi, 1995; Nonaka et al., 2000), which describes a spiral of knowledge creation consisting of four phases: socialisation (knowledge transfer via shared experiences), externalisation (articulation of experiences, ideas and thoughts), combination (synthesizing the articulated knowledge into systematic sets) and internalisation (embodying the articulated knowledge; "learning by doing"). To better fit the knowledge creation process in foresight, Uotila et al. (2005) have added two more phases to the spiral: *potentialisation* (sensing future potentials and seeing what does not yet exist) and *visualisation* (embodying new visions, mental models etc.).

The types of futures knowledge mentioned in Table 1 are converted into other types through the processes presented in Fig. 1. Out-of-radar knowledge is embodied by reflecting it against a participant's own experiences, mental models and feelings in the "visualisation" phase. This embodied knowledge is further converted into articulated knowledge by sharing experiences and articulating them by using the tools and codes available in the workshop situation. This corresponds to the "socialisation" and "externalisation" phases of the SECI model. Articulated knowledge is then abstracted and synthesized in the "combination" phase to form codified knowledge.

Obviously, the conversions also work the other way. Codified knowledge is converted into articulated knowledge by connecting it to and reflecting it against the specific workshop context. Articulated knowledge can be embodied in the workshop by learning and constructing new mental models in a phase similar to "internalisation". New mental models can open up new insights into out-of-radar knowledge by broadening what is considered relevant and creating new associations.

There are also two "external" sources of knowledge that are relevant in the workshop situation. The first is data, which can be contextualised to form codified knowledge. It can be also perceived as part of codified knowledge. The second is experiences accumulated during the workshop, which can become part of the embodied knowledge of the participant. This is related to learning and the conversion of articulated knowledge and out-of-radar knowledge to embodied knowledge.

As was mentioned at the beginning of Section 2, the SECI model and its spiral of knowledge creation has been criticised for being too mechanistic and deterministic, omitting problem formulation, analysis and debate and putting too much emphasis on the role of management. In our typology and method, we do not assume that knowledge conversions realise mechanistically or automatically through a pre-determined spiral, but instead they are crafted outcomes of different activities and interpretations of participants, realised in a workshop setting. These activities and interpretations are partly premeditated, that is, controlled in advance by the selected workshop methodology, and partly emergent, that is, insights borne out of genuine cross-breeding and collision of different perspectives. In other words, the conversions are realised through practices conditioned by the workshop context: its methods, facilitation, interaction, dialogue, and so on. In this view, the problem formulation and debate can be seen as part of sharing and articulating, and analysis as abstracting and synthesizing. Furthermore, all the participants are treated as equal contributors in the workshop and we do not make a distinction between managers and workers.

Above we have briefly described how knowledge can be converted from one type into another. It is obviously clear that this does not happen by itself, but always through the actions of participants. The descriptions above open up a perspective onto

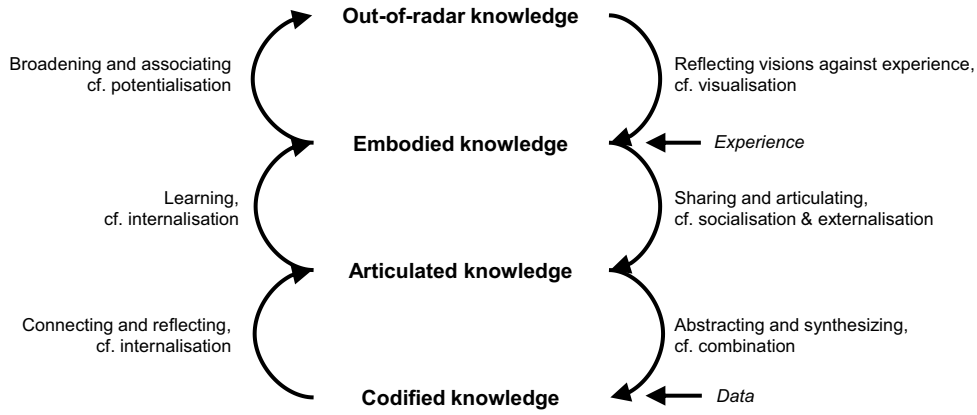

Fig. 1. Knowledge conversion processes in workshops.

the futures in-the-making, i.e., how individuals convince first themselves and then others to take up their ideas. Experts may ignore, modify, deflect, corrupt or transfer the ideas of others (cf. Latour, 1987). The conversions happen in the social interactions between experts. Nonetheless, in the following case study we will focus only on the knowledge types and conversions. Thus, while they are important, in this paper we will not emphasise, for example, the cognitive styles of the participants (Franco et al., 2013), or the power structures or demographics related to the workshop setting. In the next section, we present our exploratory method for analysing the knowledge creation dynamics in a foresight workshop.

3. Exploratory method for analysing workshop discussions using the knowledge typology

To test the applicability of the knowledge typology, we analysed the transcriptions of a discussion in a workshop held in the building services roadmap project of VTT Technical Research Centre of Finland on 15 June 2006. The goal of the project was to produce a roadmap for building services, focusing on technological and market opportunities (Paiho et al., 2007). The project was divided into four phases: 1) gathering and synthesizing background material, 2) exploring the drivers and technologies in building services, 3) identifying the actors and markets, and 4) combining everything into roadmaps.

Because the workshop was part of a project realised quite a long time ago, it is possible to contextualise the project and assess its impacts retrospectively. The main impact of the project was intra-organisational, that is, the project influenced VTT's strategy formation in the building sector and in the context of built environment. However, the building services roadmap can also be positioned in a wider unofficial cluster of future-oriented exercises realised around 2006–2009 in Finland, launched by e.g. VTT and Tekes (the Finnish funding agency for technology and innovation), that aimed at understanding the variegated roles that building sector, and the built infrastructures in general, play in the context of technology-related innovation activities. Other examples of the projects in this cluster are, e.g., a project that studied the future potentials of information technologies in the built environment (Paiho et al., 2008) and a project that mapped the advanced technology services in the context of transport infrastructure (Tuominen and Ahlqvist, 2010). It can thus be said that these exercises, among others, played minor instrumental roles in the cascade of events that finally culminated in the formation of the Finnish Strategic Centre for Science, Technology and Innovation focused on built environment, called RYM Ltd., in 2009 (Built Environment Innovations|RYM, n.d.). Since its foundation, the RYM strategic centre has been the central organisation for drafting a joint national research agenda for universities, applied research organisations and companies in the field of built environment. Also, on a more general level, this cluster of exercises, among others, had an impact in changing the focus of Finnish public policy perspective concerning the building sector and built environment: the perspective shifted from a technology oriented regulation-driven view towards a more holistic innovation-driven view. In Finland, this view is currently discussed, for example, through the concepts of "Smart City" and "Internet of Things" in the urban context.

In this paper we will focus on the second phase of the building services roadmapping process, built around the first workshop of the project. The workshop aimed at producing new insights into the emerging technologies in the field of building services. The participants were all experienced subject matter experts from the same research organisation and were also familiar with future-oriented strategic thinking.

The workshop was held on 15 June 2006 from 9 a.m. to 2 p.m. There were 18 participants, all researchers from VTT. The workshop started with an introduction to the topic and aim, followed by a presentation on the definition of building services, which was discussed. After this discussion a draft vision for the building services roadmap, made on the basis of the background material, was presented and discussed. The participants in pairs then prioritised drivers identified from the background material. For the final part of the workshop the participants were divided into two groups, both of which included 8 participants. The expertise of the participants ranged from building materials and building services to energy systems and eco-efficiency in districts. Both groups had a similar set of experts, except that in the second group there was also one foresight expert. The tasks of the groups were to fill out a table of the emerging technologies related to building services

(Fig. 2) and assess their level of development (from state-of-the-art to emerging to the R&D phase). The workshop ended with the presentation of the tables and description of next steps. The results of the workshop were used as input to the technology level in the final roadmap. The results also influenced the identification of actors and markets.

The discussions and results of the workshop were documented, and the final group work discussion recorded and meticulously transcribed. The thorough documentation of the discussions enabled us to analyse the case study 8 years after the workshop, resulting in a retrospective view. Our analysis is based on this transcribed data. In the analysis, we focused on the final group work phase in more detail so as to identify the different knowledge types from the transcriptions. The results are based on the authors' interpretations of this discussion. The retrospection allowed us to position the case study as a part of a larger continuum and thus gave a broader context for the interpretation.

3.1. Description of the method

To analyse the flow of the discussion we developed an exploratory method based on the knowledge typology presented in Section 2. Our goal was to determine at what stage, and through what kinds of dynamics, different knowledge types emerged in the workshop, and how they were linked to the divergent and convergent forms of thinking. In order to answer these questions, we codified the transcribed discussions using two categorisations: divergent and convergent phrases (Table 2) and articulated knowledge types (Table 3). Although our exploratory method is somewhat based on a quantitative type of analysis, it is good to bear in mind that it is meant to be more a robust heuristic for interpreting the flow of discussion than an objective calculation method. The codification is based on our interpretation of the phrases, and is therefore subjective.

At the first stage of analysis, we divided the transcribed discussion into phrases, that is, utterances by participants containing a statement, comment or question. In the flow of discussion, one participant could utter many consecutive phrases; in these cases they were all analysed separately. The outcome of this analytical stage was that the first group discussion contained 466 phrases, and the second 359. In the first group, it was possible to combine the phrases with the actual persons who uttered them. However, in the second group this could not be done reliably, as this information was incomplete in the transcription.

At the second stage of the analysis, each phrase was first categorised as divergent, neutral or convergent based on whether the phrase broadened the scope of discussion or narrowed it. However, we soon found that it is necessary to distinguish between two types of divergent phrases: phrases that open up a new topic or otherwise radically broaden the scope, and phrases that iterate on the existing topic and incrementally broaden it. We call these two subcategories introductory and elaborative, respectively. We put each phrase into one of these four categories (see Table 2).

We used the coding to illustrate the discussion flow by treating each introductory divergent phrase as $+1$ and each convergent phrase as -1 and drawing a cumulative sum. Thus, a phrase that opens up a new topic is shown in a figure to be one unit higher than the previous phrase. It is worth noting that we did not try to quantify how convergent or how radically divergent a phrase was; the illustration does not, therefore, reveal the level of the discussion's divergence in total. Sometimes a single divergent phrase might open the discussion more than ten divergent phrases. However, the illustration can be used to describe the flow of the discussion in terms of when new topics were brought into the discussion and how long they were discussed relative to one another. In other words, it is a heuristic to make sense of the flow of the discussion. The purpose is to illustrate the general sequence of divergence and convergence in the discussion, not to quantify how divergent a discussion was. The results are shown in Fig. 3. We want to emphasise that the purpose of the figure is to illustrate the divergence and convergence of the discussion flow and should not be used to compare the positions of specific non-consecutive phrases in the y-axis. The difference in ordinates

	Building services systems and equipment ("hardware")	Building services ICT and automation ("software")	Connections of building services to buildings and internal spaces	Connections of building services to infrastructures	Building service business models and service concepts
***State-of-the-art* now**					
Emerging technologies					
Technologies on R&D stage					
Potential disruptive factors and innovations (external to building services)					

Fig. 2. Technology matrix used in the workshop.

Table 2
Categorisation regarding divergence and convergence of the discussion.

Category	Description	Phrase example
Divergent: introductory	Phrases that open up a new topic or radically broaden the scope of the discussion	"Is it too far-out idea that there would not be a need to change the air?"
Divergent: elaborative	Phrases that iterate or incrementally broaden the current topic	"So if there is a transition in building technologies, the need for energy, heating etc. decreases significantly"
Neutral	Phrases that are not clearly divergent or convergent	"Could you repeat that?"
Convergent	Phrases that narrow the discussion and close a topic	"I wrote here: regulation often restricts services, the scale is not feasible for services"

is thus meaningful only when looking at consecutive phrases and the discussion as a whole.

Since we are interested in how the knowledge is created and converted, we have also categorised the phrases using the typology of knowledge described in Section 2. Since the transcribed discussion is a documentation of the articulated knowledge, we have focused on the sources of the articulated knowledge: for example, was it based on existing material, professional competence, experience or the opinions of the participant, or perhaps reframing of the topic or challenging assumptions? The second categorisation used in the coding is presented in Table 3.

As was stated in Section 2, codified knowledge is the most tangible type of knowledge in a workshop. The workshop produced codified knowledge in the form of a table of key emerging technologies that was filled out during the group discussions. In the discussions the participants used terms rather loosely and explained themselves by using examples, but specific attention was paid to what was written in the table that they had to complete. In the first group, the participants were active in defining the right phrases by saying, for example, "you could write sensor networks without a power source". In the second group, the facilitator was more active in choosing the phrases, but kept the others up to date by saying, for example, "I wrote here: regulation often restricts services, the scale is not feasible for services". We interpreted these "crystallisations" of the discussion as examples of codified knowledge produced by the participants.

Codified knowledge can also be articulated by interpreting it in the current context. For example, at the beginning of the workshop an existing definition of building services was presented and discussed. This provided a shared basis for further discussions and explorations; it oriented and scoped the following discussions. An example of how codified knowledge was brought to the discussions was how a participant referred to an existing report that he had on hand: "I took it [communication between building service components] from this intelligent building roadmap, which is being updated, here are things such as wiring and there these fibre technologies are mentioned". The report, entitled "Intelligent building roadmap", is used as a source of codified knowledge that is relevant to the current discussion; it moves the discussion forward. We interpreted the phrases that referred explicitly to the existing document, report or similar as articulated codified knowledge. However, in the discussions the main source of articulated knowledge was the professional competence and experience of the participants, i.e., embodied knowledge.

In the discussions, three types of embodied knowledge can be distinguished: 1) professional competence of the participant, 2) experiences from projects or events and 3) opinions of the participant. We interpreted most of the phrases to represent the first type. The participants, firstly, drew from

Table 3
Categorisation of knowledge types in the discussion.

Category	Description	Phrase example
Codified knowledge produced	Crystallisations of the discussion	"You could write sensor networks without a power source"
Articulated codified knowledge	Referring to reports, documents etc. and interpreting them in the discussion context	"I took it [communication between building service components] from this intelligent building roadmap, which is being updated, here are things such as wiring and there these fibre technologies are mentioned"
Professional competence	Phrases based on the expertise and professional competence of the participant	"Now there is this emerging technology, these configurable systems, especially in the controller systems, the whole content can be reprogrammed"
Direct referral to experience	Referring to projects, events or other experiences	"In this one project we did interviews about what is needed in building services…"
Opinions	Phrases that are explicitly stated to be opinions	"In my opinion RFID technology exists at some stage of development, it is studied and partly applied, but it is still in its infancy, there are a lot of questions"
Reframing	Suggesting a novel view of the topic without changing the topic	See Section 3.3.
Challenging assumptions	Stating and challenging underlying assumptions	See Section 3.3.
Cumulative	Phrases that build on previous phrases and describe new insights and ideas	See Section 3.3.
Facilitation	Phrases related to timekeeping, group work guidance or other facilitation tasks	"Could you repeat that?"

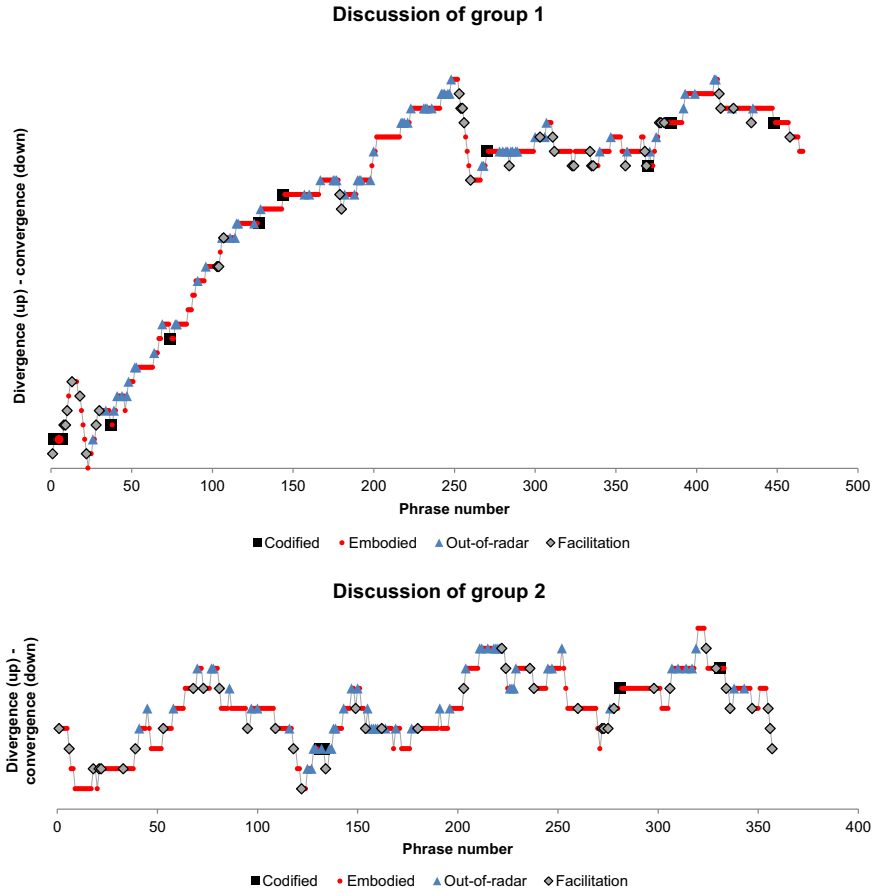

Fig. 3. Codification of the discussion of groups 1 (above) and 2 (below). The y-axis shows the divergence and convergence of the discussion, the symbols represent different aggregated knowledge types, and the x-axis shows the phrase number.

their own expertise, for example, on their views on what was happening in their domain: "Now there is this emerging technology, these configurable systems, especially in the controller systems, the whole content can be reprogrammed". The second source of knowledge was their views on the common practices in their field: "Previously it was thought that let's not do thicker walls, because they are away from the sellable area of the apartment, when building technology increases, air conditioning and other things, they are quite big spaces they require". The participants also referred directly to their project experiences: "In this one project we did interviews about what is needed in building services…" In those cases we categorised the phrase as "direct referral to experience". In some cases it was not clear if the phrase referred to an actual case or a hypothetical one. In those cases we categorised the phrase as professional competence.

While the phrases based on professional competence or experiences were expressed more or less as kinds of "objective truths", sometimes the participants also explicitly asserted that the statement was nevertheless based just on their opinion. This was especially the case on more speculative issues, such as in the case of emerging technologies: "In my opinion RFID technology exists at some stage of development, it is studied and partly applied, but it is still in its infancy, there are a lot of questions". Of course, it could be argued that most of the phrases are just opinions of the participants which might be based on professional competence, whether or not they explicitly state it. However, we categorised the phrase as an opinion only if it was clearly stated as an opinion.

Out-of-radar knowledge is the hardest to distinguish in the transcription of the discussion, but it can be found indirectly, for example as a reframing of the issues, challenging assumptions and building on each other's ideas. In reframing, the topic is discussed from a new, different viewpoint, and that opens up room for new insights. In this case the topic stays the same, but it is approached from a different angle. We used this category when the phrase suggested a novel view of the topic, i.e., it had not been considered before and it opened the discussion more than elaboration without changing the topic.

The category of challenging assumptions is similar to reframing, but it does not provide an alternate frame to approach the topic. It makes some of the assumptions explicit,

and questions whether they are valid or not. We used this category when conventional thinking about a topic was challenged and it produced further insights into a topic. Both reframing and challenging assumptions are sorts of "revelatory interventions", where one phrase changes the direction of the discussion and challenges what is thought to be relevant. The process can also move more iteratively towards out-of-radar knowledge. We categorised a phrase as "cumulative" if the ideas presented build on previous ideas leading to something new, and were not just an elaboration of the topic.

In addition to the categories based on the typology of knowledge in foresight workshops, we defined one additional category called "facilitation". This category includes phrases that were directly related to the process of the workshop, for example time keeping, describing group work tasks, or reminding the participants of the task at hand.

The phrases we categorised as representing out-of-radar knowledge are most subject to our interpretation of the discussion and the border between, for instance, reframing and professional competence is sometimes ambiguous. To better illustrate what we mean by out-of-radar knowledge in the discussion, we analyse two segments of the discussion in Section 3.3. Before that we give a graphical overview of the two discussion groups.

3.2. Analysis of the discussion flow: two groups in the workshop

The results based on the divergence–convergence codification are shown in Fig. 3. As can be seen, the flow of the discussion differed between the two groups. In group 1 several topics were opened in the first part of the discussion until most of the new ideas were presented. These were then elaborated in no specific order. There was no clear closing of the topics, but the main results were written to the table of key emerging technologies. However, this is not shown in the transcription of the discussion and is, therefore, also missing from the illustration.

Group 2 had a more sequential discussion flow, and the discussion utilised the table of key emerging technologies, taped on the wall, loosely as a structure. Different topics were opened, elaborated, built upon and then closed before introducing new topics. This can be seen in Fig. 3 as a sort of stepwise alternation of divergence and convergence. This dynamic is most likely due to the stronger role of the facilitator, who constantly clarified and summed up the key ideas in the discussion before writing them to the table of key emerging technologies. If we focus on the phrases used by the facilitator (Fig. 4), we can see that at the start of the discussion the facilitator introduced new topics to the discussion or opened up the discussion, and once the discussion started rolling the emphasis shifted to convergent phrases. The facilitator in group 2 was a foresight expert, who did not have expertise in building services. In other words the facilitator was not a substance area expert, but rather an expert on foresight methods. Therefore it seems logical that he would assume a role of conducting the discussion rather than contributing to it.

Based on the analysis of the phrases by an individual, we can identify different ways of participating and activating the discussion. In addition to the facilitator, who tried to keep the balance between opening new topics and coming to conclusions on already opened topics, there were participants who mainly stated new ideas, focused on elaborating existing topics, said just a few phrases usually aimed at summing up, or both opened up, elaborated and closed the topics. Some participants were much more active than others. However, a more detailed analysis of the individual roles of the participants is outside the scope of this paper.

3.3. Analysis of knowledge types: comparing two discussion segments

To describe the interplay between the knowledge types in the discussion, we focus on two detailed segments in the generic flow of discussion. According to our codification, the majority of the phrases in the discussions were articulated embodied knowledge. However, for our purposes it is more interesting to analyse the phrases related to out-of-radar knowledge. The phrases in these statements are not independent of the phrases around them, and it is, therefore, reasonable to give the context in which they were said. The segments illustrate how sequences of reframing and challenging of assumptions develop in the discussions. For reframing, there were 8 possible segments to choose from (6 in group 1 and 2 in group 2), and for challenging of assumptions 12 possible segments (7 in group 1 and 5 in group 2). We had two criteria in choosing the segments to describe here. First, the segment should be short and easily understandable so that they can be understood without the knowledge of the whole discussion. Second, both groups should be represented in order to make interpretive comparative assessment of how the workshop setting and facilitation conditioned and structured the flow of dialogue in two groups. The first segment (segment 1.1) is from group 1, and shows how a discussion is reframed. The second segment (segment 2.1) is from group 2, and illustrates how challenging assumptions can bring about new ideas and directions to the discussion. The phrases in the segments and their categorisation are listed in Appendix A. It is worth noting that the segments represent only a small portion of the entire discussion (segment 1.1 contains 2% of the total number of phrases and segment 2.1 3%).

In segment 1.1 (Fig. 5), the phrases shown built on an earlier discussion about remote reading of sensors and introduced two new ideas to it. First, a participant proposed that the information from the sensors could be integrated and read at the same time (phrase 47). A second participant then built on that by associating the idea with house information systems (phrase 48), which were then elaborated based on professional competence and referring to an earlier project related to them (phrases 49 and 50). The next two phrases reframed the discussion by first stating that the key problem is that "the information is not on the level of an apartment, but on the level of a house" (phrase 51), and this was then clarified by another participant who said that "the focus should then be on apartment information systems, not house information systems". This stimulated a further idea of motivating the occupant by different prizes (phrase 53) and some elaboration based on professional competence (phrases 54 to 56).

Segment 1.1 accentuates the principle of intertextuality in a workshop, that is, how the phrases build on other phrases. Even though we have categorised phrase 52 as the reframing phrase, it would not have made sense, or reframed the discussion, without the preceding phrases. In general, segment 1.1 shows

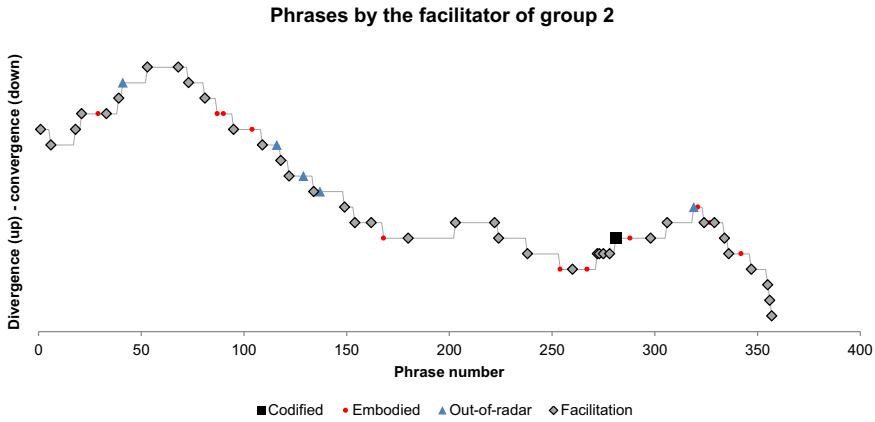

Fig. 4. Codification of phrases used by the facilitator of group 2.

that our categorisation helps to identify interesting points of knowledge accumulation in the discussion, which can then be further analysed.

Segment 2.1 (Fig. 6) shows how challenging assumptions open new topics, how participants develop the ideas further, and how the discussion of the topic comes to a close. One participant proposed an idea of a totally self-sufficient house (phrase 125). This was then elaborated by drawing an analogy to the closed water cycle of paper mills (phrase 126) and relating self-sufficiency to the needs posed by resource scarcity (phrase 127). Based on these phrases, another participant proposed to go one step further and imagined that buildings could become the main source of energy (phrase 128). This was elaborated (phrases 129 and 130) and codified by using a crystallising term of "energy-producing buildings" (phrase 131). The consequences of this idea were further elaborated by associating it with decentralised energy production (phrase 132) and reflecting it against an existing report (phrase 133). Finally, the facilitator closed the topic by asking where to place it in the table of emerging technologies (phrase 134).

Challenging the assumptions about what is the role of a building in relation to its environment opened the discussion towards the connections between the building and the energy grid, and finally it led to the idea of the house itself as an energy producer. If in segment 1.1, the cumulative phrases, building on the previous ideas, enabled the reframing of the topic, then in segment 2.1, challenging the assumptions enabled further cumulative phrases. Segment 2.1 also shows how codified knowledge is shown in the phrases as crystallisations of the topic.

4. Case discussion

Our analysis of the discussions presented in Section 3 gives insights into how knowledge, especially out-of-radar knowledge, is created and articulated in a foresight workshop. We focused on the articulation and codification of knowledge (the right-hand side of Fig. 1). It is worth noting that analysing the internalisation of knowledge or learning in the workshop is not possible based solely on the transcriptions of the discussion, but would require a more long-term observation of the

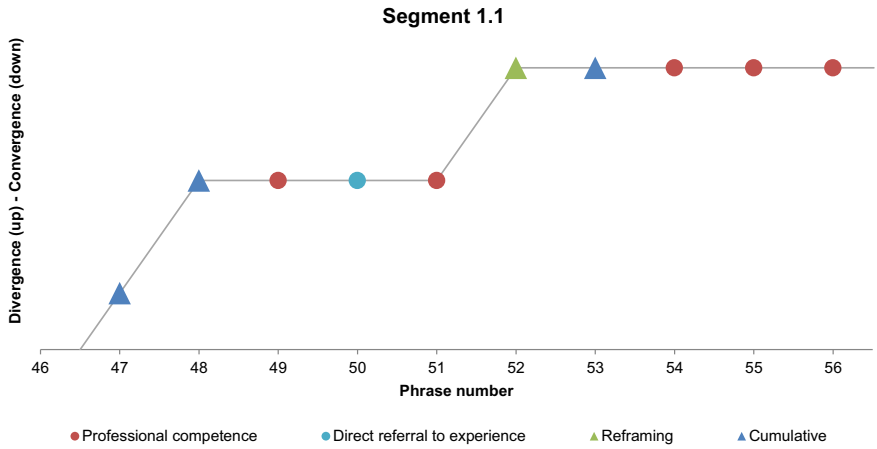

Fig. 5. Illustration of a segment of discussion from group 1 showing the categories of phrases and the divergence in the discussion.

process. However, the aspects of internalisation and learning are outside the scope of this paper.

As the analysis of the overall discussion showed, the discussions in the two groups differed in how many topics were open simultaneously. Group 2 was more strongly facilitated and had a more sequential discussion flow moving from one topic to another, while the discussion in group 1 opened many topics simultaneously. Our examples indicate how facilitation affects the discussion flow in a foresight workshop. In a participatory process, a common knowledge base, "a joint view of the system", is created via the interactions of the participants. This common knowledge base forms the bedrock on which participants construct new ideas and create out-of-radar knowledge.

Our examples indicate how facilitation affects the discussion flow in a foresight workshop. The analysis suggests that facilitation may help in focusing this process by keeping the discussion around one topic long enough for a shared understanding to emerge among the participants. While the share of divergent phrases was of the same order in both groups, the distribution was different. In the group that had a stronger facilitation, the divergent phrases were spread more evenly, which can be seen in Fig. 1. However, based on the analysis it is not easy to assess which of the groups produced more apposite or "better" results; both groups produced new ideas and out-of-radar knowledge. The number of phrases that we categorised as "out-of-radar" was higher in group 2 (both absolutely and relatively), so one conditional conclusion could be that facilitation orients and directs the discussion more towards out-of-radar knowledge. A facilitator has to keep a balance between steering the discussions and allowing the participants to raise new issues (cf. Salo and Gustafsson, 2004, p. 266).

The analysis of the overall discussion helped us to identify segments that seemed most interesting for further analysis. We presented two exemplary segments of how out-of-radar knowledge was constructed in the praxis of discussion flow. As became clear from the segments, out-of-radar knowledge is not connected to a single phrase but more to the wider flow of discussion and the interaction between the participants. New associations and insights are gained by listening to others and building on their statements, either by adding new ideas to them, questioning the assumptions behind the statements, or reframing the discussion by suggesting a new perspective. This processual nature of constructing out-of-radar knowledge is one justification for the need for participatory methods, such as group discussions, in foresight.

As the case example shows, the knowledge typology can be used to analyse the discussion in a foresight workshop and thus to better understand its knowledge creation dynamics. However, it also became evident that there needs to be subcategories to the four knowledge types, leading to a more detailed typology as shown in Table 3. For articulated knowledge, the categorisation is directly derived from the knowledge conversion process: articulated knowledge can emerge either by articulating embodied knowledge or by framing the discussion with some sort of codified knowledge. For the other knowledge types, the categorisation is based more on the workshop process. Since we analysed only one workshop process, the categorisation is not comprehensive, but rather indicative of our case example. However, we believe that the subcategories proposed in Table 3 are useful heuristics also for analysing other kinds of workshops.

In the knowledge typology presented in Table 1, instead of using the concept of tacit knowledge we chose to use the concepts of embodied and out-of-radar knowledge. These two categories reflect the two aims of the workshops: to synthesize the knowledge that participants have and to facilitate the creation of new knowledge. Focusing on out-of-radar knowledge helped in understanding how novel ideas emerge from the process. In our case example, out-of-radar knowledge was manifested in the process as kinds of revelatory statements or cumulative discussion flow. While the discussions were mostly around the embodied knowledge, that is, the professional competence, experiences and opinions of the participants, there were a few examples of out-of-radar knowledge. In the cumulative process, the different ideas fed new, more radical ideas until the participants started imagining and reflecting on novel things and combinations that they had not thought of before. However, the revelatory aspects of the foresight process

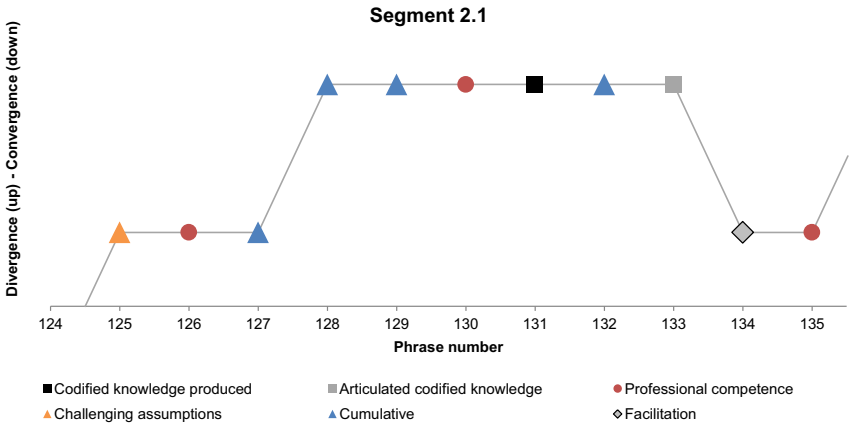

Fig. 6. Illustration of a segment of discussion from group 2 showing the categories of phrases and the divergence in the discussion.

are tricky to unravel from our empirical material, and it would require other complementary data to be fully understood, such as workshop videos, observation diaries and so on. The key questions in analysing revelatory statements, for example, could be the following: What happens before and after a participant's reframing or assumption-challenging statement, and what kinds of workshop dynamics enable it? Basically, what are the prerequisites of the creation of new knowledge, and what is needed to reach the out-of-radar knowledge and produce something new? Proposals for such prerequisites can already be found from the literature, for example, playfulness, randomness and collaboration (Oksanen and Ståhle, 2013; Heinonen and Hiltunen, 2012). However, the discussion of the prerequisites for the creation of new knowledge is outside the scope of this paper.

The specificity of futures knowledge created in the foresight process depends on the process aims. In some foresight processes, the aim is just to gather the best available views on what the future might look like. In that case, the processes could be focused on synthesizing the embodied knowledge of the participants. However, the aim is often to challenge the existing views, change the mind-sets of the participants, and to create new images of the future. Then the process, in addition to synthesizing the existing embodied knowledge, is about reaching, embodying and articulating out-of-radar knowledge. Out-of-radar knowledge loads the results with unpredictability and ambiguity, and reveals surprising aspects of futures knowledge. On the other hand, because the process aims at imagining the future, the future-orientation enables the out-of-radar knowledge to be brought into the discussion.

In our typology, we separated articulated knowledge from codified knowledge. This is to emphasise that, even though something is written down in a workshop, it is not necessarily understandable as such to people who did not participate in the process. Articulated knowledge needs to be abstracted to codified knowledge using common codes. It also needs to be packaged as an understandable outcome from the workshop. This means that, when clarifying the outcomes of the workshop in the packaging phase, special attention should be paid to the needs of the organisational context. The packaged, codified information should be relevant for the organisation, and it can also act as an input for further workshop processes.

The packaged, codified information is the tangible outcome from the workshop. However, it does not necessarily represent the consensus of the participants, since it is a simplification of the articulated knowledge, which again is a combination of the articulated embodied knowledge and out-of-radar knowledge. If a consensus is reached in a singular workshop, it is often more of a temporal general agreement conditioned by the workshop agenda and time pressures than an alignment of deeper insights or perspectives of the participants. Obviously this deeper alignment is also a possible, and indeed an eligible target for a foresight process, but usually these kinds of integrated insights require more time and contemplative "thinking space" than is available in a single workshop. Thus, our typology and method is mainly helpful in analysing the *workshop process* that led to a certain outcome or result. For example, one can look at how often a topic was reframed or assumptions were challenged, since this might mean that the participants had to reflect upon their mental models and implicit assumptions, and thus go beyond a superficial agreement. On the other hand, if the discussion is mostly about articulating embodied knowledge, it might signal that the participants did not engage in a genuine dialogue, that is, listen to each other and constructively build on each other's ideas.

4.1. The novel aspects of the method

We are not aware of any other method that would directly focus on the analysis of the flow of discussion in a foresight workshop process. However, there are some methods that are focused on facilitating the discussion and knowledge creation in a participatory setting. An apt example of this kind of method – that also comes quite close to our knowledge typology – is presented in the paper by Pässilä et al. (2013). The authors describe the use of research-based theatre to aid in future-oriented collaborative knowledge creation. From our viewpoint it is interesting that they used the rye-bread model (Uotila et al., 2005), an extension of the SECI model, as their theoretical basis. This means that the basis of their typology of knowledge is somewhat similar with ours. However, although they illustrate the benefit of the research-based theatre method with a snippet of discussion, they do not describe how the typology could be operationalized to analyse the discussion. In contrast, we use the typology as the basis for coding and analysing the evolving flow of discussion, and use the resulting semi-quantitative results as a heuristic tool in assessing the dynamics of knowledge creation and conversion in the discussion.

There is a long discourse analytic tradition in social and political sciences to study how language and texts, be it e.g. prose, media materials, interview data or group discussions, construct and are embedded in their social contexts (for example Schiffrin et al., 2001; Chilton, 2004; Fairclough, 2010; Alasuutari et al., 2008). However, discourse analysis is not a common part of the methodological toolbox of foresight (cf. Popper, 2008), and thus examples are rare in the context of foresight literature. However, one example that comes close is the paper by Niinikoski and Moisander (2014). They describe a method called serial and comparative analysis (SCA) that can be used to study policy transformation and the formation of policy objects. The method includes a discursive analysis of data such as reports and interviews. However, the purpose of the method is to analyse policy change in specific institutional settings, not knowledge creation in foresight, and thus it does not consider the different types of knowledge or their conversion.

There are also methods, such as the fuzzy cognitive mapping (Jetter and Kok, 2014), which use content analysis to create a formal description of the topic. However, these methods do not commonly analyse how the content of a dialogue evolves as a process. Neither do they focus on the development of discussion dynamics through which the novel ideas and insights are produced. We therefore argue that there are three novelties in our method compared to others: 1) the method focuses explicitly on foresight workshops, 2) it builds on a knowledge typology that is specifically crafted and thus relevant in the context of foresight workshops, and 3) it operationalizes the knowledge typology to create a coding of the discussion, which can then be used as a heuristic tool to

analyse the creation and evolution of futures knowledge in the workshop discussions.

Our method provides a way to analyse foresight workshop discussions and draw insights about futures knowledge creation in order to improve foresight practice. However, there are obviously some limits to our method. Firstly, the coding of the discussion can be laborious and is subject to researcher bias. Nonetheless, the bias can be reduced by having several researchers do the codification independently, which of course then takes more resources. Secondly, the results should be used to guide the analysis of the discussion, not as results in themselves, as we pointed out in Section 3.1. While the typology might be useful for foresight processes more generally, it has been developed specifically for foresight workshops. Thirdly, it should be clearly acknowledged that workshops are distinctive stages, albeit crucial ones, of a wider process of futures knowledge creation, and thus the workshops should be positioned in this wider process chain. The method elaborated here, for example, does not currently address the questions of what happens before or after the workshop. Fourthly, in its present stage the method does not pay enough attention to the demographics of a workshop or to the power structures always present in social processes. However, when embedded in the wider process chain of knowledge creation, we argue that the method could be useful also for analysing the foresight process in general, as well as the power structures present in the process. This is because the method makes the knowledge conversions and knowledge sources transparent, enables one to analyse phrases of a single process participant, and shows how the outcomes of the workshop were created *through* the discussion flow.

5. Concluding remarks

In this article, we have proposed a typology of knowledge in foresight workshops and described an exploratory method for analysing workshop discussion using the typology. Our typology builds on, and is complementary to, selected existing lineages to analyse knowledge creation dynamics, such as the SECI model and its applications in foresight. Instead of directly adopting the SECI model, we have taken into account its critique and focused on the special case of foresight workshops. Compared to the relevant research in foresight literature that has, for example, applied the SECI model in the context of regional foresight and regional planning (Uotila et al., 2005), our target has been the micro-level social dynamics of a foresight workshop. The typology is in line with the tacit–explicit split or continuum (Nonaka, 1991; Nonaka, 1994), but gives a more specific description of the knowledge types in a workshop setting. By using four categories instead of two, and focusing on foresight workshops, we have brought more clarity into what is meant by tacit and explicit knowledge. The division of explicit knowledge to codified and articulated, and tacit knowledge to embodied and out-of-radar (or self-transcending) might be beneficial also outside the somewhat narrow social context of foresight workshops.

Aside from the knowledge typology, we have also described knowledge conversions, again using the SECI model as a starting point, but redefining the conversions to take into account our modified typology, the context of foresight workshops, and the critique of the SECI model. Instead of treating the knowledge conversions as a deterministic spiral of interacting knowledge types, we have described the conversions in terms of actions of the participants, the sequence of which is process-related and thus not predetermined. The conversions, together with the typology, help to analyse workshop discussions.

In the field of foresight, the process of futures knowledge creation is still not something that is widely studied or well understood. This is somewhat surprising when considering the fact that most of the foresight exercises use some kind of expert-oriented methods, that is, methods in which the outcomes are highly conditioned by human expertise and specific social processes. Thus, our contribution complements the discussions on the ontology and epistemology of futures knowledge on one hand, and outcome-oriented discussions on foresight methodology on the other. Our approach differs from the former in that we focus on the praxis of foresight – how foresight is actually conducted – rather than on the ontological and epistemological foundations of futures knowledge. By this we mean that our primary goal was not to define the ontology of futures knowledge through logics or theoretical analysis, but rather to study the *social processes* of knowledge creation in a foresight workshop. An additional aim in our method was to focus on the *dynamics of knowledge creation*, and thus bring to the fore the "creative messiness" of the social process that results in production of futures knowledge.

We have shown how the typology can be used to analyse foresight workshops. Yet it is also possible to use it in the design of foresight workshops by thinking how different tasks might endorse the participants to reach more insights and ideas in the level of out-of-radar knowledge. On the other hand, the typology has more emphasis on the actual process than the outcome-oriented approach, which sets its main focus on the results and methodology of foresight. Instead of focusing on the benefits and pitfalls of different methods, we have described the process based on theory and a case study. This description might be beneficial for choosing or evaluating different methods.

Our analysis shows that futures knowledge is socially constructed in an interactive process, but usually in its final stage refined towards normative recommendations (cf. Andreescu et al., 2013; Fuller and Loogma, 2009). This means that while futures knowledge constructed in a participatory process is constructivist by its nature, it is often used and framed in a positivist manner, especially when presenting the outcomes to public policy-makers and wider audience. Thus one could assert that in the context of foresight and futures studies, constructivism and positivism could be perceived as different dimensions of futures knowledge, and not as a fundamental epistemological antagonism. Futures knowledge is, in its core, interpretative and speculative knowledge. It is something that is always embedded in the historical bedrock and heavily affected by the weight of the present, but simultaneously it has the capacity to be partially open, the potential to become. We argue that it is this partial openness towards the future, the aspect of "potential becomingness", that makes it possible to view the same fragments of futures knowledge either through a lens of constructivism (emphasising alternative interpretations) or through a lens of positivism (making more narrow normative claims). To reiterate, in our view these different dimensions should not be perceived as an epistemological fallacy that dwells

in the heart of foresight, but rather as two ineluctable dimensions of futures knowledge.

Obviously, these different dimensions of futures knowledge are far from being unproblematic. Quite the contrary: this epistemological latitude charges futures knowledge with critical ethical risks. From our perspective, a major risk is connected to the potential bias caused by asymmetric power positions of stakeholders participating in the foresight process. This means that even though the foresight process would be planned as interactive and explorative as possible, there is always the possibility that a powerful actor, or an actor that cleverly lobbies a biased view as a sort of natural common sense, may try to directly affect the outcomes of a group process, or push the group towards a biased and "false" consensus, or even totally by-pass the results of the process and come up with fabricated normative interpretations. Tackling these kinds of issues calls for a well facilitated process and experienced facilitators, but also now with our typology and method the process can be made more transparent and analysed in detail. For example, an analyst could evaluate how different types of knowledge are converted in the process, how these conversions direct the flow of discussion, and through what kind of interaction these conversions take place. This increases the transparency of the process and helps to identify gaps between the constructive process and its (most likely) normative outcomes.

Our typology highlights two special characteristics of knowledge in foresight workshops. The first characteristic is the future-orientation of embodied knowledge: in a foresight workshop the images of the future that the participants have, based on their worldviews and mind-sets, are articulated, discussed and synthesized to form a shared collage of futures. This may sometimes reveal more about the worldviews held by the participants than about actual possible futures, but it is still one valuable outcome of the workshop and one on which different actions or further explorations can be based. In order to increase transparency between the actual social process and the outcomes of the process, a critical analysis is needed, one in which our typology can help as we indicated in Section 4. By deploying the typology, it is possible to answer such questions as how much did the participants question their implicit assumptions, did they reframe the topic in some way, or did they genuinely build upon each other's ideas during the process. In addition, one could analyse how much emphasis was laid on articulating the professional competences of the participants (sharing knowledge) and how much of the process was devoted to exploring the consequences of different ideas or to creating new ideas.

The second characteristic is the imagination of radical and novel ideas about the future, revealed in the form of out-of-radar knowledge. To some practitioners and scholars (see e.g. Staton, 2008) this is the essential ingredient of foresight, the characteristic which distinguishes foresight from other practices. Our knowledge typology and exploratory method enables one to assess the balance of these two characteristics (embodied and out-of-radar knowledge) in the context of a foresight workshop, and ask such questions as how much the discussion is based on articulating and sharing of existing knowledge, or to what extent the discussion builds on the ideas of each participant, and in what kinds of ways it challenges pre-existing assumptions or reframes the topics with novel insights?

While out-of-radar knowledge is not necessarily a unique feature in foresight, the practical setting common in a foresight workshop – emphasising a structured process to catalyse future-orientation, imagination, ideation, openness, and an atmosphere detached from daily routines – enables one to explicitly focus on out-of-radar knowledge in discussions, and thus to emphasise its key role in creative strategic thinking and planning. Because the future is open and contingent upon our actions, we are allowed, if not even obliged, to explore the different possibilities that could radically differ from the present mainstream perspectives. The consideration of a broad range of alternatives is the value that out-of-radar knowledge brings to foresight: the better we are at creating a diverse set of coherent future images, the better prepared we are for the unfolding of the future.

Understanding the different types of knowledge in a foresight workshop, as well as their role and interaction in creating futures knowledge, is beneficial for both the practice of foresight and its research. The knowledge typology and exploratory method increase the understanding, and enable a systematic analysis, of the assumptions and the process that are behind the future images, pathways and alternatives created in the workshop. Based on our case analysis, the out-of-radar knowledge is manifested in the interactive flow of discussion between the participants, not just through singular ideas or phrases. Occasionally, the chain of discussion delves into the banal minutiae of a topic, and yet sometimes it boldly enters the uncharted territories of creative exploration. Our analysis provides further grounds for discussing the nature of futures expertise in the foresight processes: To what extent, and in what kinds of process settings, is futures expertise a property of an individual? In what kinds of settings and to what extent is it a capability of a group? What kinds of settings enable individuals and groups to grasp out-of-radar knowledge? Is it more dependent on the imagination and flexibility of participants, or could it be fostered through a robust process methodology? What are the roles of the facilitator in enabling futures expertise?

On the more practical side, the knowledge typology and description of knowledge conversions helps practitioners to better design the foresight workshops. For example, practitioners may consider questions such as how is the exploration and inclusion of out-of-radar knowledge facilitated in a specific workshop, or should there be a phase to codify the articulated knowledge? However, the typology of knowledge is only one part of the knowledge creation process. More research is needed, for example, to understand how to combine several foresight workshops in order to catalyse out-of-radar knowledge, how knowledge spaces in an organisation could be connected with the foresight process (see Ahlqvist et al., 2012), and how to design foresight processes and workshops in such a way that vertical movement between the knowledge types would create the best possible combinations for different purposes.

Acknowledgements

An earlier version of the knowledge typology was presented at The 5th ISPIM Innovation Symposium — Stimulating Innovation: Challenges for Management, Science & Technology, Seoul, Korea on 9–12 December 2012. Financial support from the VTT Graduate School is acknowledged (Mikko Dufva).

Appendix A

Phrases and their coding of a segment of discussion from group 1 (segment 1.1)

If we think about remote reading of sensors, district heating meters and water meters, each have their own systems; they could exchange information, you would think that it would be practical to read them all at the same time and send the information to the right place, however, it does not seem to work this way at the moment	Introductory	Cumulative
What about these house information systems in general, they would also come to homes	Introductory	Cumulative
Yes, in apartment buildings these are starting to be introduced	Elaborative	Professional competence
We have been developing them, now it is about the implementation	Elaborative	Direct referral to experience
But that is the problem with those apartments that service log exists, but it is on the level of the building, not the apartment, that the system would be on the level of the apartment, that does not exist, it would require a lot of devices and would be much more expensive, and that is what interests the occupant more	Elaborative	Professional competence
Then it is not about the building information system but the apartment information system	Introductory	Reframing
That could motivate the occupants, there could be an "energy saver of the month" or "energy-guzzler of the month"	Elaborative	Cumulative
But if we think about detached houses, the water consumption is much lower; there has to be some reason; there is no need for prizes; if it shows in their bank account they will act differently	Elaborative	Professional competence
And that is the reason, we need to measure it on the level of the apartment	Elaborative	Professional competence
Exactly	Neutral	Professional competence

Phrases and their coding of a segment of discussion from group 2 (segment 2.1)

One critical driver is this self-sufficient house with connections to everything; it is energy self-sufficient, water self-sufficient…	Introductory	Challenging assumptions
In a paper mill there is already a closed water cycle. I don't know if this would ever be feasible, but could be something that is coming	Elaborative	Professional competence
As the resources grow more scarce in the world, there will be less water and that creates a need to be self-sufficient and produce one's own energy with, for example, photovoltaics and burning the waste, etc.	Elaborative	Cumulative
Then one step forward is that all energy is produced in the buildings; they are connected to the infrastructure but only for production	Introductory	Cumulative
Could you say that we will begin selling energy [produced by buildings]?	Elaborative	Cumulative
That is another option	Elaborative	Professional competence
Energy producing buildings	Elaborative	Codified knowledge produced
So, in a way, a decentralised energy production will emerge; energy will be produced locally	Elaborative	Cumulative
In the building technology vision for 2030 there was a mention of energy producing buildings	Elaborative	Articulated codified knowledge
So it is beyond 10–15 years?	Convergent	Facilitation
Yes	Elaborative	Professional competence

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Article II

Dufva, M. & Ahlqvist, T. 2015. Elements in the construction of future-orientation: A systems view of foresight. *Futures*, 73, 112-125.

Futures 73 (2015) 112–125

Contents lists available at ScienceDirect

Futures

journal homepage: www.elsevier.com/locate/futures

Elements in the construction of future-orientation: A systems view of foresight

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ARTICLE INFO

Article history:
Received 14 January 2015
Received in revised form 24 August 2015
Accepted 25 August 2015
Available online xxx

Keywords:
Foresight system
Complex adaptive systems
Innovation systems
Future-orientation

ABSTRACT

Foresight is currently perceived as a critical activity in the development of innovation policies and corporate strategies. While there are many descriptions of the benefits of foresight, there is little research into how these benefits are created. In addition, although the view of innovations has shifted towards a systems understanding, the same has not happened with foresight, which is largely seen as a process. The process view and focus on the outcomes has created a situation where the dynamics between agents involved in foresight is still not well understood. One emerging approach to improve the understanding of the dynamics of foresight, and to embed foresight more closely with innovation management and policy, is the systems view. In this paper, we build on the systems view of foresight, and study what the elements in foresight as a system are and how they contribute to the creation of futures knowledge. Based on the literature, we propose six elements that are useful for understanding a foresight system and the creation of futures knowledge: agents, cognitive schemes, strategic objects, mediating events, memory objects and metaphors. We illustrate the systems view, the elements and their interaction with two case examples: one on creating future-orientation in a research and technology organisation and one on renewing a forest industry through roadmapping. Based on the elements and the case studies, we argue that the strategic objects and mediating events are important leverage points when steering foresight as a system.

1. Introduction

Foresight is conventionally perceived as a process, often even a linear one (see e.g. Martin, 1995; Horton, 1999; Becker, 2002), although systems thinking has been influential in foresight at least since 1970s (Kuosa, 2011a). The systems thinking in foresight, in conjunction with this "process view", is usually manifested in two ways. First, foresight is defined as a *systematic* practice for exploring futures (Habegger, 2010; Kuosa, 2011b; Miles, Harper, Georghiou, Keenan, & Popper, 2008; Miles, 2010; Yuan, 2010). This means that in a foresight process a set of methods is applied in a planned and rigorous way in order to understand consequences of future developments. Second, foresight processes are commonly perceived to be *about systems*, targeted on a specific system setting (Coates, 2010; Miles, 2010; Rohrbeck & Schwarz, 2013; Yuan, 2010). In a foresight process the topic is often framed as a system, and interdependencies between the sub-systems and system parts

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http://dx.doi.org/10.1016/j.futures.2015.08.006
0016-3287/$ – see front matter

are scrutinised in order to understand present system behaviour and to shape future behaviours in a system. A foresight process is perceived as an intervention to a system (Treyer, 2009).

In this "process view", foresight is seldom fully integrated into the innovation system or organisational practices, or perceived as a continuous strategic activity (Keller, Markmann, & von der Gracht, 2015; Treyer, 2009; Köhler et al., 2015; Dreyer & Stang, 2013). For example, a survey of Austrian firms found that less than 3% of the firms had integrated strategic foresight systems (König, Sedlatschek, & Wallner, 2014). On the policy side, attention has mostly been on explicit foresight processes, such as national foresight programmes, where foresight is used as an input into policy making. The focus on separate foresight processes might be one reason why there is little understanding of how the long-term accumulation of futures knowledge (Dufva & Ahlqvist, 2015) is being created, although there are many proposals and lists of what the key contributions of separate foresight exercises are (see e.g. Irvine & Martin, 1984; Salo, Könnölä, & Hjelt, 2004; Georghiou & Keenan, 2006; Rohrbeck & Schwarz, 2013).

Recently, some authors have claimed that foresight practice has been shifting towards more systems oriented approaches (Daheim & Uerz, 2008; Rask, 2008; Köhler, 2015). In this "systems view", foresight is seen as dependent on and influenced by other processes taking place simultaneously (Mendonça & Sapio, 2009). There have been attempts to define foresight itself *as a system* or as a part of a system (Amanatidou & Guy, 2008; Andersen & Andersen, 2014; Barre, 2014; Saritas, 2013). A systems view has also been deployed in the evaluation of foresight (Amanatidou & Guy, 2008; Georghiou & Keenan, 2006; Miles, 2012; Piirainen, Gonzalez, & Bragge, 2012). However, these efforts have not yet offered a crisp description of what foresight as a system consists of, and what its key dynamics are. A notable exception is the conceptual model presented by Uotila et al. (2012), which distinguishes acquisition, assimilation, transformation and exploitation of knowledge in an integrated system combining different foresight approaches (explicit, emergent and embedded), knowledge brokerage and absorptive capacity.

In this paper we argue that, in order to understand the foresight system, especially from the perspective of long-term accumulation of futures knowledge, there is a need to identify the core elements of the foresight system and explicate their interactions. This identification facilitates analysis of the dynamics in the foresight system, which again opens a fresh perspective on unravelling how the contributions of foresight are created. We build on existing systems perspectives on foresight and study what the elements of the foresight system are, and how these elements help in explaining the dynamics of futures knowledge creation (see Dufva & Ahlqvist, 2015). Following the categories set by Salmenkaita and Salo (2004), we focus more on emergent or embedded foresight with less emphasis on individual foresight processes and more on the interactions and relations between the stakeholders.

We base our theoretical framework on the literature on complex adaptive systems (e.g. Kaufmann, 1995; Stacey, 1996; Anderson, 1999) and innovation systems (e.g. Lundvall, 1992; Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007; Alkemade, Kleinschmidt, & Hekkert, 2007), but also draw on other fields such as knowledge management (e.g. Nonaka, 1994; Cacciatori, 2008; Håkanson, 2007), strategy (e.g. Mintzberg, 1987; Whittington, 1996; Heracleous & Jacobs, 2008) and foresight (e.g. Miles et al., 2008; Martin, 1995; Saritas, 2013; Fuller & Loogma, 2009; Uotila et al., 2012). The complex adaptive systems literature builds an overall foundation of what a system is and how it functions. The innovation systems approach opens specific insights into how regulation, industrial interactions, and societal structures affect foresight practice. Thus, the innovation systems approach functions as a context in which the complex adaptive system of foresight operates.

The paper is structured as follows: in the second section of the paper below, we outline the elements of foresight as a system, as well as their key interrelationships. In the third section, we illustrate the systems view and the elements with two case studies: one on creating future-orientation in a Finnish research and technology organisation (RTO) and one on renewing a South Australian forest industry through strategic roadmapping. In the fourth section, we wrap up the key aspects of the case studies and reflect them against the theoretical framework formed in the second section. While our focus in on analysing foresight processes through the systems view, we think that the elements and the frame we describe will be useful in designing and conducting foresight projects and connecting them to a larger context. This is further elaborated in the fifth section, where we also provide general conclusions and outline potential avenues for future research.

2. The theoretical framework: elements in building future-orientation

In our approach, we view foresight as a system embedded in the wider innovation system. By system we mean a functionally indivisible set of interconnected, interdependent agents, which together generate aggregate behaviour that is

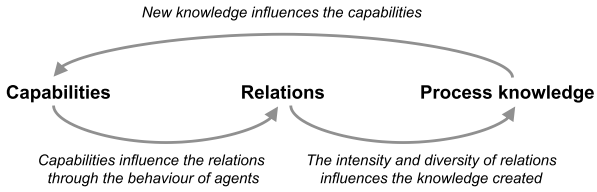

Fig. 1. Interplay between process knowledge, capabilities and relations.

not attributable to any single element (Ackoff, 1974). We define foresight system as a transient ensemble of agents, set up to catalyse future-oriented insights, decisions and actions in a certain context. Foresight system operates mainly through foresight processes, which we here define as dynamic and provisory analyses of the components of present and potential drivers of change, in order to understand the present contexts and particularities of present conditions, and, through these insights, build robust, accessible, plausible and disruptive future alternatives (cf. Bishop, Hines, & Collins, 2007; Godet, 2000; Schwartz, 1991). On a conceptual level, a foresight system can be seen as an interplay between three components: knowledge, capabilities and relations (see Dufva, Könnölä, & Koivisto, 2015; Salo et al., 2004). To put it bluntly, the interrelated dynamic between the components is the following: knowledge shapes capabilities, capabilities influence the relations and interactions between the agents, and relations affect knowledge creation (Fig. 1). Before describing this dynamic in more detail, we define what we mean by knowledge, capabilities and relations, and outline the analytical elements that help in understanding the dynamic between these three components.

A common division of knowledge is between tacit knowledge (professional non-codified competence of an individual) and explicit knowledge (knowledge codified or articulated in some form by an individual or a group) (Polanyi, 1967; Nonaka & Takeuchi, 1995; Karlsen & Karlsen, 2007). Building on this division, knowledge in a foresight system can be thought to be "justified contingent plausibilities" and to consist of the codified outputs, articulated ideas and perspectives, embodied competences and processes that have the potential to lead towards "out-of-radar" considerations, that is, novel future-oriented insights (Dufva & Ahlqvist, 2015). In other words, knowledge in foresight can be codified, articulated, embodied or "out-of-radar". In a foresight process, knowledge converts from one type to another: for example, codified knowledge in the form of a document can be articulated in a discussion. Articulated knowledge thus refers to a knowledge that is articulated, i.e., uttered or brought into discussion through some other means in an actual setting of participatory interaction, such as workshop or expert dialogue session. Therefore, articulated knowledge is always reflexive and tied to a certain context in which it is expressed. It is also worth emphasising that the four categories are meant to be a heuristic tool for understanding knowledge flows rather than a normative categorisation.

In our framework we make a further distinction between knowledge produced or shared during a foresight process (articulated and codified knowledge), and of that embodied by the participants of the process (embodied knowledge). The latter is included in the capabilities, while the former we refer to as "process knowledge" in the rest of the paper when we want to highlight this distinction. Capabilities represent the mind-sets and mental models through which the agents in the system act and shape their understanding of the system (cf. dynamic capabilities by Teece, Pisano, & Shuen, 1997). Relations cover the existing strong ties that the agents have and the weak ties that are potentially formed during a foresight activity (cf. Granovetter, 1973). Relations also emphasise both more even relational structures and the "structural holes" (Burt, 1992), the critical gaps between several loosely connected groups of agents. Bridging these structural holes makes it more likely for new ideas to emerge (Burt, 2004; Uotila et al., 2012).

In order to understand the system and the interplay between process knowledge, capabilities and relations, we propose six elements for characterising foresight practice as a system. However, it is worth pointing out that we are not advocating a reductionist viewpoint. We view the elements as analytical constructs, not ontological entities. The task of the elements is to emphasise different aspects in the system and to help us focus on varied phenomena that arise from the systemic interaction. Also, our view is based on the principle of synergy: the whole system and its interactions are something more than just a straight sum of its separate elements. The elements are presented in Table 1.

The system consists of agents who act according to their cognitive schemes. By agent we mean an individual, a group, an organisation or other entity that acts, in other words, that has agency in the context of the system (see Anderson, 1999; Lane & Maxfield, 2005). The cognitive scheme is a set of mental constructs, which includes perceptions of who the other relevant agents in the system are, the attitudes towards the other agents and the foresight process, and an understanding of how the system

Table 1
Description of the elements in building future-orientation.

Element	Description	Examples	References
Agents	Individuals or groups in the foresight system	A foresight expert, workshop participant, funder of a foresight process, foresight project team	Anderson, 1999
Cognitive scheme	A set of mental constructs about operational environment, the agents who populate it and its dynamics	Perceived role of co-workers, attitude towards foresight, opinion of the goal or purpose of an organisation	Lane and Maxfield, 2005; Ericson, 2001
Strategic object	A deliberately constructed boundary object that acts as a focal point for the interaction of the agents	A research program, a foresight project, a stated focus of an organisation	Ahlqvist, 2012
Mediating event	A structure mediating the interaction between the agents	Workshops, seminars, associations, websites	Lane and Maxfield, 2005
Memory object	An encapsulated crystallisation of the outcomes of foresight	Roadmap, scenarios, forecasts, trends	Cacciatori, 2008
Metaphor	A heuristic for thinking about complex issues through the use of analogies, similes or images	Scenario names or illustrations, a reframing of the context, a shorthand for describing an approach	Lakoff, 1993; Heracleous and Jacobs, 2008; Thibodeau and Boroditsky, 2011

can change and how foresight is contributing to that transformation (Lane & Maxfield, 2005; Ericson, 2001). The cognitive schemes represent the mental models the agents have of the environments in which they operate. Examples include the perceived role of co-workers, the joint understanding of the generic purpose of an organisation or shared conceptions of a particular subject field, such as foresight. These cognitive schemes are not static; they change and evolve in the interaction between agents (Ericson, 2001). Cognitive schemes cannot be directly changed, but they can be influenced by constructing focus points for the interaction. We call these focus points strategic objects.

A strategic object is "a boundary object that is deliberately constructed to form the basis of an epistemic community" (Ahlqvist, 2012). It can, for example, be an R&D project of strategic importance for an organisation, or a strategic foresight project that aims at creating novel shared practices in an organisation or between several actors in the innovation system. The key aspect of the strategic object is that it aims at integrating knowledge in a new way by crossing the existing organisational silos or by combining the routine-like division of labour in the innovation system. The strategic object builds on Star and Griesemer's (1989) classic notion of "boundary object", but sets it more directly in the context of organisations and strategic management. The strategic object is an attractor around which different agents convene. It gathers agents together around a specific topic and, thus, brings this topic to the attention of the agents. It also acts as a signal of what is acceptable or preferable in the system. In this way, it influences the cognitive schemes of the agents. While the strategic object is deliberately constructed, it may be interpreted in different ways by the agents, according to their cognitive schemes (cf. sensemaking, Weick, 1995). The interaction between the cognitive schemes and the strategic object thus goes both ways: the strategic object influences the cognitive schemes through the interaction of agents, and the cognitive schemes influence how the strategic object is perceived.

The interaction between agents is mediated by different scaffolding structures (Lane & Maxfield, 2005). In order to make the difference between system structure and these scaffolding structures more clear, we call these *mediating events*. These can, for example, be annual trade fairs, expert workshops exploring a futures topic, or websites gathering information and providing a discussion forum on a topic. Mediating events have two functions. Firstly, they provide a place for sharing and challenging cognitive schemes. As agents interact, they constantly shape their cognitive schemes. Secondly, the mediating events influence the interaction via their structure. The mediating events might be oriented towards enabling a search for new solutions, disseminating information, interpreting existing information or creating new knowledge. In other words, they are characterised by both space and agency. They enable the creation of temporal weak ties (cf. Granovetter, 1973), relations between the agents that are specific to the foresight context. The increase in relations brings the system further from stability towards the "edge of chaos" where new knowledge can be created (Kaufmann, 1995; Stacey, 1996).

Knowledge is created in the interaction between the agents (on knowledge construction in foresight, see Dufva & Ahlqvist, 2015). It is an emergent property of the system. This knowledge could, for example, be new perceptions or ideas about the future or alternative narratives about future developments. The tangible outcomes of foresight include forecasts, descriptions of future possibilities, different perceptions of the future, and an understanding of the consequences of actions (Eerola & Miles, 2011). Additionally, it has been argued that foresight builds up towards an ability to adopt alternative perspectives (Rohrbeck & Schwarz, 2013), and broadens the context to give a wider picture of the issue under scrutiny (Halonen et al., 2010). Therefore, we do not consider the knowledge only as tangible outcomes, but also as ideas that foster the building of new capabilities.

Following the typology of knowledge presented earlier, we consider two ways by which process knowledge is captured in the system: memory objects (Cacciatori, 2008) and metaphors (Lakoff, 1993; Heracleous & Jacobs, 2008; Thibodeau & Boroditsky, 2011). The memory objects relate to the tangible outcomes of the process (codified knowledge), while the metaphors refer to the learning and sensemaking process as such (articulated knowledge).

Memory objects are encapsulated crystallisations of the outcomes of the foresight process. They are tangible presentations of knowledge or practice. They can be explicit knowledge about the alternative futures, for example in the form of scenarios or roadmaps, or, alternatively, they can be depictions or templates for a successful foresight practice. A key issue is that a memory object is easily transferable across projects. Memory objects thus enable the outcomes of one project to be used as the inputs in another project. Also, memory objects enable the circulation of good practices or novel methods across different foresight projects. What is required in both the transfer of explicit knowledge and good practices is that they are codified and encapsulated. This means that they need to use commonly used codes and be packaged as coherent and identifiable entities (cf. Håkanson, 2007).

Metaphors, on the other hand, offer a heuristic for thinking about complex issues; they are conceptual devices to transfer a notion or a meaning from one domain to another (Lakoff, 1993). Metaphors influence the framing of and approach to an issue, although often we are unaware of these effects (Thibodeau & Boroditsky, 2011). In our framework, metaphors, like memory objects, can represent process knowledge about futures or foresight practices. For example, a scenario can be presented, and entitled, as "the blossoming garden" or "a desolate wasteland". Also, a foresight practice can be described as "navigating the wild seas" or "scanning the horizon". The difference between memory objects and metaphors lies in their form. Memory objects are tangible and packaged outcomes of a foresight process (codified knowledge), while metaphors are intangible, interpretative and somewhat open-ended mental images articulated during the process (articulated knowledge, see Dufva & Ahlqvist, 2015). Metaphors, here, are deliberately perceived in the context of a foresight process, as shared crystallisations of the interactions between the agents. They are thus reflexive and context-dependent. A metaphor can be codified and packaged into a memory object by describing its context as well as interpretation. Similarly, a memory object can be interpreted as a metaphor by articulating it in the context of a discussion. Metaphors are shared significations tied to a

context, in contrast to the memory objects, which try to include a description of the context in which they were created. Understanding a metaphor requires some knowledge of the context to which it relates. Thus, when communicating metaphors from one context to another, there is always a possibility for transformation of interpretation. Obviously, this interpretative potentiality is also a creative strength of metaphors: they can be used as stepping stones for the construction of new ideas and meanings.

In our framework, both memory objects and metaphors represent knowledge created, and shared, during a foresight process (process knowledge). The notion of cognitive scheme can, then, be defined through a difference between knowledge embodied in the agent (embodied knowledge) and knowledge in the process (articulated knowledge). A metaphor emerges from the interaction between the agents, but it is not necessarily embodied by the agents – it is an attribute of the system. A cognitive scheme, on the other hand, is embodied by an agent – it is an attribute, a sort of 'internal lens' of an agent for interpreting memory objects and metaphors. Metaphors emphasise the process, while the cognitive scheme emphasise the agent. A similar distinction can be made between a strategic object and the memory object or metaphor. A strategic object is created outside the foresight process to influence the process. Memory objects and metaphors both emerge during a foresight process.

The elements highlight different aspects of a foresight system (Table 2). Thus they offer a comprehensive picture of the different dynamics of foresight. By explicating who the agents are in a foresight system it is possible to analyse who is included and who is left out, as well as what are the connections between the agents. Identifying different clusters of agents, that is, groups of agents that are in close cooperation also outside of a specific foresight process, sheds light on the power relations inherent in foresight. Thus identifying the agents also makes it easier to understand whose futures the outcomes represent.

In addition to who is involved in foresight, the framing and scope also influence the outcomes of foresight. The cognitive schemes represent the different mindsets and worldviews the agents have. Thus, studying the cognitive schemes helps in understanding the different interpretations the agents have of the context and topic of a foresight process. The cognitive schemes highlight the implicit framing and scope. The strategic objects, on the other hand, represent the explicit framings and scope. The agents may interpret the strategic object in various ways depending on the diversity of their cognitive schemes. Together the cognitive schemes and strategic objects give a comprehensive picture of the different framings and understandings of the scope of a specific foresight process.

If the agents refer to who is involved and the strategic object and cognitive schemes highlight what the focus of the process is, the mediating events focus on how the agents interact and how that influences the dynamics of foresight. The assumption we make here is that the medium through which the agents interact has a significant influence on the outcomes. For example, a foresight process with an emphasis on wide stakeholder participation through a series of workshops will probably have different outcomes than a process that approaches the same stakeholders through a questionnaire.

The results of a foresight process are crystallised in the memory objects and metaphors. Here the main benefit is not so much in the separate concepts, but rather in how the memory objects and metaphors together capture different aspects of futures knowledge. Memory objects capture the tangible, explicit outcomes that are easy to see after a foresight process, and emphasises how they can be used in other processes. Metaphors, on the other hand, capture the intangible outcomes that are trickier to transfer as such, but anyway have direct influence on the cognitive schemes of the agents, and thus might implicitly influence further foresight activities.

The elements we describe here help to analyse the foresight system, but what is more important is the interaction between the elements (Fig. 2, see also Fig. 1). Knowledge, created and shared in a foresight process and encapsulated in memory objects and articulated as metaphors, influence the cognitive schemes of the agents by challenging existing mental models or providing new ones. The cognitive schemes in turn have an effect on how the agents interact, since they describe how the agents in the system perceive their environment. The quality of the interaction is also an important factor: as new

Table 2
The benefits and key questions raised by the elements.

Element	Key question	Benefit for understanding the dynamics of foresight and futures knowledge creation
Agents	Who are the key actors in foresight, both formally and informally?	Highlights who is included and who is ignored and what are the connections between the participants
Cognitive scheme	How do the agents view the world, other agents and foresight?	Explicates the context of foresight as seen by different agents
Strategic object	How is a foresight process framed?	Encapsulates the scope and aim for a foresight process
Mediating event	What are the methods of interaction used in a foresight process?	Highlights the influence of ways of interaction on a foresight process
Memory object	How are the tangible outcomes of a foresight process presented?	Describes the explicit outcomes as transferable objects to be used in other foresight processes
Metaphor	What new images or ways of talking about the present or futures are created?	Highlights the intangible outcomes of foresight

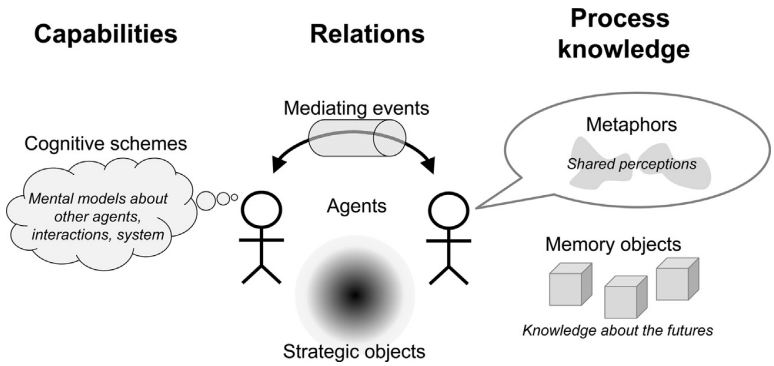

Fig. 2. Schematic of the foresight system and its elements.

knowledge is created through the interaction between agents, who interacts with whom and how this interaction affects the knowledge creation process makes a difference. This continuous systemic interaction can be presented as a cycle between the capabilities of an agent (represented by the cognitive schemes), the relations between agents (represented by the mediating events and strategic objects) and the knowledge created (represented by the metaphors and memory objects).

Another way to understand the connections between the elements is to consider the question they mainly contribute to. The metaphors and memory objects represent the content that is being produced in foresight. The agents are the actors producing the content. The mediating events and to some extent also the strategic objects focus on how that content emerges in the process, and the cognitive schemes provide insights into why the agents perceive these activities to be worthwhile. This is, of course, a rough formulation; in order to provide richer answers to, for example the why-questions, a detailed characterisation and an analysis of the entire system is required.

The interaction between the agents creates emergent phenomena in the system. Examples include the emergence of new knowledge or shared perceptions, the change in the absorptive capacity of the organisation or the shaping of the dominant logic in the system. New knowledge could be captured in the memory objects; shared perceptions could be crystallised in metaphors, and dominant logic reflected in the cognitive schemes. In our view, these phenomena differ from the elements in that they are the outcomes of the interactions in the system. Of course, in a system it is hard to delineate the cause and the effect, as things are interconnected. Therefore, our distinction between the system elements and emergent phenomena should not be taken as a statement about the ontology of the system, but as a pragmatic hermeneutic for analysing the system. In the next sections we will illustrate how the elements of the foresight system can be used in the context of two case studies.

3. Systems view and the elements of foresight in two case studies

In this section we present two case studies on foresight and analyse them using the systems view and the elements presented in the previous section. The case studies differ in their scale and focus. The first case study is about building foresight capability in a Finnish research and technology organisation (RTO). The project in the second case study focused on the renewal of the forest industry in South Australia. The case studies thus demonstrate the applicability of the systems view in different spatial scales and systemic contexts: the organisational scale and regional scale. In the first case study, the system is intra-organisational and the representative actors are singular experts in an organisation. In the second case study, the system is regional and the actors are different companies and organisations active in the regional context.

For both case studies we describe the process from a systems perspective using the elements of the foresight system. We both define the system structure and how it functioned and evolved during the process. We use the term “system configuration” whenever we refer to the situation or structure of the system. While the focus in both case studies is on a specific foresight process, we position it as part of the activities of a foresight system. Our aim in these case studies is not to conduct a complete analysis of the system, but rather to present an interpretation of what the systems view to foresight means and what can be achieved with it.

The systems view emphasising the context was essential in both of the case studies. It should be noted that we conducted the detailed analyses using the elements described in Section 2 ex-post, that is, after the projects were finalised and, therefore, the analyses work as demonstrations of how the elements can be deployed in the context of different types of foresight exercises. Through these analyses, our aim was to articulate the intuition we had about the systems perspective when conducting the cases, and to provide a systematic framework for conceptualising different foresight exercises with a systems perspective. We used the elements of a foresight system as tools for analysing and illustrating what the systems perspective means in different foresight contexts.

3.1. Organisational scale: enhancing foresight capabilities with the foresight network project in a Finnish RTO

As a first case study we provide an interpretation of a foresight exercise on an organisational scale. The aim of the case project was to create a foresight network in a Finnish RTO. The project started in January 2012 and ended in December 2013. The first main activity was a foresight training program held in the spring of 2013 for members of the organisation interested in foresight. After the training, the embedding of foresight practices continued with four workshops aimed at solving a foresight-related problem of an on-going project (so-called "foresight case clinics"). The foresight network project also included an annual foresight seminar, other networking activities and the creation of an online platform and knowledge repository.

The main agents were the members of the organisation, although also foresight practitioners from other organisations were involved through the networking activities. The members of the organisation can be divided into three groups for the purposes of our analysis: (1) the foresight team, which was responsible for coordinating the project, (2) domain experts – mainly experts in different technology fields – who had experience or were interested in foresight, and (3) other members of the organisation. During the project, a foresight network was formed from experts (for example, younger and more senior scientists and experts in business support division) of the organisation practising foresight and interested in learning more about foresight methods and practices. The network gathered some 200 persons, which is about 7% of all the employees of the organisation. The foresight network acts as a bridge between the futures professionals in RTO's foresight team and the technology experts in the organisation (cf. Hines, 2003).

From the system perspective of this paper, we perceive the foresight network as a strategic object. It was the key locus for creating a more embedded understanding of foresight in the organisation, and it provided both a networking space and a physical space for enhancing the future-orientation of the organisation. The foresight network was deliberately constructed and proposed as an internal project by the foresight team, because the members of the team, as well as some key members of RTO's management, saw that there is, firstly, a need to create a joint organisational understanding of foresight in order to build up strategic futures knowledge in the organisation. The second reason for setting up the project was to gather the foresight experience of the organisation under the same conceptual "umbrella".

There were two key mediating events in the project organised around the strategic object, the foresight network: the foresight training and the foresight case clinics. The foresight training was focused on increasing the foresight capabilities of the organisation and on creating a common understanding of what foresight means among the network participants. It provided a structure for an exchange of ideas and questions about foresight. It also enabled experts to discuss how foresight practices could be connected to the day-to-day work in the organisation. The foresight training was a forum for channelling and shaping the foresight culture of the organisation.

During the training it became apparent that there were two differing views of foresight that reflected two different cognitive schemes. The participants of the foresight training were both curious and sceptical as to how the foresight team could claim to "know the future". From the perspective of foresight experts, this position showed, to put it bluntly, that commonly held misconceptions about foresight and futures studies as "hazy crystal ball gazing" still existed in one form or another also in an expert organisation with highly advanced R&D capabilities, and it reflected a situation in which the systemic functions of foresight in the organisation were not clearly explicated and communicated. This perception of foresight was in stark contrast with the second view, the perception by the organisation's foresight team. The experts in the foresight team did not see that they had ever espoused such a conception of foresight, but instead had communicated a view of foresight as a critical component of organisational strategic practice that sought to catalyse futures imagination through exploring alternative futures in different contexts together with technology experts. Thus, the foresight team had never claimed to "know the right answers", but instead the experts in the foresight team saw themselves as accelerators of thinking about future alternatives and pathways. Therefore, the focus in the foresight training was to bridge this surprisingly widely shared gap in the organisational culture that defined technology expertise in an engineering fashion as something that had "clear boundaries" and an "exact foundation", and foresight was considered as a vague practice of "knowing the future" instead of perceiving foresight as a critical part of an organisation's strategic culture.

In contrast, the expectation from the foresight team was that the other experts in the organisation would adopt the same understanding and aims about foresight as the foresight experts had, while the other experts were keener on seeing how to apply foresight in their own work, and were not that interested in the dimensions of foresight as such. There were, therefore, different positions and attitudes in the organisation towards foresight that were consequently taken into account by considering the motivations from the individual, project and organisational viewpoints (see Dufva, Myllyoja, & Ahlqvist, 2013).

However, quite rapidly during the project the foresight network itself became a sort of common denominator for the agents. When the project advanced, the feedback gathered from the training and other activities in the foresight network was very positive, also including a positive attitude towards foresight in general. From our perspective, this feedback reflects a situation in which a common ground between participants has started to develop. It would thus seem that, despite the differing initial positions, the foresight network project was able to create some shared understanding about foresight against which to mirror the personal views of the participants. However, it must be stated that we have no systematic data on the cognitive schemes of the agents at the start or end of the project, and thus we cannot directly analyse how the cognitive schemes might have changed during the project.

Another set of critical mediating events were the four foresight case clinics, which continued the organisational discussion of what foresight is from the training program. While the training dealt with the day to day work of the

organisation by means of concrete examples and case exercises, the foresight case clinic was designed to embed foresight into the knowledge-producing practices of the organisation. All the case clinics held were connected to on-going projects in the organisation, but they also aimed at creating new concepts that would be applicable in other projects and thus enhance the participants' capabilities to use foresight in other project settings. Although the results of the foresight case clinics were made available to the whole network, they reached a smaller number of experts in the organisation than the actual foresight training.

Interestingly, the foresight case clinics became a sort of key source of metaphors, although this was not the original intention. The original target of the foresight case clinics was to produce generally applicable concepts and tools for solving problems in different projects. The case clinics were aimed at producing memory objects about the pragmatic solutions one could use during project-based work. Instead, the main empirical outcome of the foresight case clinics was not pragmatic solutions, but novel and constructive metaphors such as “positive envy points”, “GMO theme parks”, etc., which have the potential to evoke differing views towards the future, but could be somewhat cryptic for someone who has not participated in the initial production process.

The training and case clinic produced material and concepts that were encapsulated as memory objects and used in subsequent projects. The foresight training produced easily accessible learning materials on foresight and templates and tools for group work on scenarios, roadmapping and trend analysis. These have been used in various projects and are part of the “foresight artefacts” of the organisation. The case concept was further developed to be a quick, low-risk and easily implementable service for SMEs interested in exploring the future. Thus, the outcomes of the foresight network project have been directly utilised in other processes.

While the project was not directly connected with the strategy making of the organisation, during the realisation of the foresight network project a new RTO-level strategy was published, which raised foresight and innovation policy among the key strategic perspectives in the organisation. This new strategic position of foresight marked quite a drastic change in the preceding organisational strategy. Therefore it would seem that the activities around the foresight network were one influence to this change in strategy.

A simplified depiction of the process of the foresight network project from the systems perspective is presented in Fig. 3. The starting systemic configuration in the organisation was fragmented: the foresight practice was mainly perceived as a separate “competence island” and there were several different mind-sets through which to approach the practice. These aspects were challenged in the foresight training, which enabled the dialogue between different members of the organisation on what foresight is, what it could be, and what it means for the organisation as a participatory strategic and explorative practice. This dialogue was continued in the foresight case clinics, which further embedded this participatory

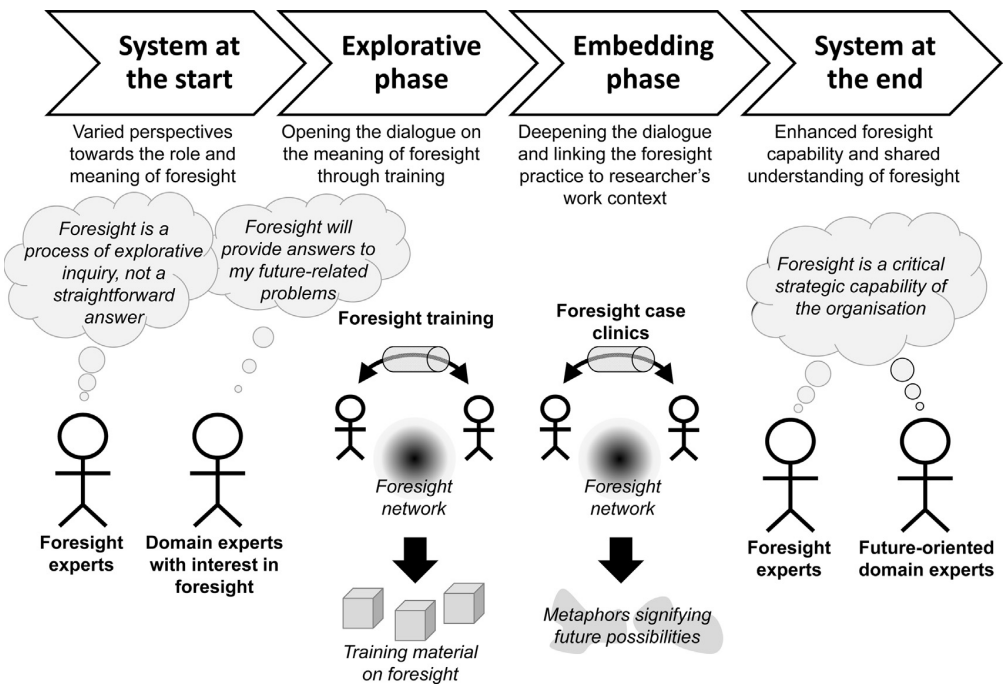

Fig. 3. Summary of the foresight network project from a systems perspective.

foresight mindset into the organisation. Parallel to these activities in the foresight network, a shift in organisational strategy emerged which emphasised foresight as a key cross-cutting practice in organisational research and development activities. The outcome of this shift was new internal projects and enhanced foresight capability, but also an increased embedding of foresight as part of strategic research.

3.2. Regional scale: opening regional lock-ins in a South Australian roadmapping project

Our second case study provides an interpretative analysis of a foresight exercise on a regional scale, that is, in a system of multiple organisations. The case study project aimed to renew the cellulosic fibre value chain in South Australia, through strategic technology roadmapping (see Ahlqvist et al., 2013). The project was conducted in 2012 and 2013 in the Limestone Coast region, South Australia, which forms part of a wider region known as the Green Triangle. The project included interviews with local companies, assessment of the transformative capabilities of the local industry, creation of strategic roadmaps in expert workshops, value chain analysis, creation of future pathways for the region and developing concrete recommendation together with the stakeholders.

The key question was how to renew a traditional regional industry that has been locally oriented, based on a quite low technological level, and is currently faced with global competition that challenges the industry to its core. It can be said that the regional system in the Green Triangle was in a severe lock-in configuration: the local companies perceived themselves mainly as players engaged in a heavy local competition, and thus there was a common distrust and lack of confidence towards the joint development of the region. The main agents in the project were the local forest industry companies, regional government and Finnish foresight and forest industry technology domain experts. The local companies were divided into four categories: (1) forest owners; (2) hauliers and harvesters; (3) sawmills; and (4) specialised suppliers. At the beginning of the project the focus was on the analysis of the local system by conducting 23 company interviews, which from a systems view were the first key mediating events. It became evident already from the first interviews that there were serious challenges in fostering the interactions between the agents. The local companies saw each other as competitors rather than collaborators, and the regional government was distrusted. From a systems perspective, the system structure created a behaviour that was not beneficial to any of the agents in the system. Therefore in order to renew the local industry it was not enough to focus on one company at a time, as had been the approach thus far, but rather to try to change the system structure.

Based on the interviews three main cognitive schemes were identified: (1) the main competitors are the local companies, (2) the regional government, based in Adelaide, is not interested in development of the regional "periphery", i.e., the Green Triangle region and (3) the current problems are mainly caused by unpredictable and abstract demands of an external, and sort of elusive, operational environment – manifested as continuous raises in electricity prices and corporate taxes, incessant claims and manoeuvres made by the South Australian state government, and steadily on-going plant closures relentlessly decided by faceless foreign owners – and not by the activities, or inactiveness, of the regional forest industry system itself, formed by local companies and policy actors. Simply put the perspective of the regional system was restricted to the local operational environment, the negative outcomes were "out-sourced", and reduced, as the function of the abstract and hostile external environment, and thus the opportunities in the space beyond the immediate local reach were largely ignored. This perspective, and the systematic avoidance of critical development activities resulting from it, had caused a lock-in situation in a regional system. The outcome of this situation was that the local industry was some 10–20 years behind the global technological state-of-the-art.

The interviews, in addition to being a source of information, were also a medium for raising interest and confidence in alternative regional futures and starting steps for challenging the current system configuration. For example, the interviewees were shown state-of-the-art products such as bioplastics and transparent films made from cellulose fibre. The interviewees were also encouraged to keep asking the government about the results of the project and concrete next steps, so that the results for the project would not be left unused. There were thus actions to embed the process to the regional system already from the start.

After the interviews and the assessment of local capabilities the project focus turned to exploring the global state-of-the-art in technologies. A second mediating event, a set of expert workshops, was held in Finland, with the aim of producing strategic technology roadmaps. In the workshops several memory objects created in previous strategic exercises were applied. Especially a "lens-based approach" (Kettle et al., 2012; MW, 2012) was instrumental in structuring different views about the alternative future developments in the field. The workshops produced four different roadmaps corresponding to four "lenses": mass, energy, molecular and atomic lens. From the systems perspective the roadmaps can be perceived as memory objects that capture the state-of-the-art in the relevant technological domains, while the lens-based approach as such became a strategic object through which experts from different backgrounds found a common ground.

The roadmaps, or more specifically their translation to the local context, became a further strategic object. The translation was realised mainly through a set of local seminars. The seminars were another key mediating event which enabled new interaction between local stakeholders, and dialogue with the foresight and domain experts from Finland. This interaction was crucial in embedding the roadmaps in the local context. In a sense two systems were integrated in these seminars: that of the Finnish R&D experts gathered around the strategic object of the lens-based approach and the regional system in its current lock-in systemic configuration, emblematised by a narrow systemic perspective, distrust among players and general

lack of confidence. Based on the discussions and feedback from the seminars, as well as from meetings with the regional government, a set of policy recommendations, structured in seven short- to medium-term pathways, was created.

The set of policy recommendations was a key memory object created in the project. A tangible demonstration of the project's regional and industrial impact is a recent strategy by the South Australian Forest Industry Advisory Board, an influential coalition of local forest industry experts, that used the results of the project as a bedrock for building a blueprint for the future of the forest industry in the Green Triangle region (see SAFIAB, 2014). This in turn led to the instigation of a South East Forestry Partnerships Program—the Second Phase where over 10 million Australian dollars were available to support projects consistent with the recommendations made in the case study project. It could be thus concluded that the project was successfully embedded into the local system and managed to at least support its transformation. The main elements in the project are depicted in Fig. 4.

4. Discussion

The two case studies described in Section 3 illustrate a systems view to foresight. In both cases the foresight process – the activities in a specific project – were framed as part of a larger system. In the foresight network case the foresight training and other activities were taking place at the same time as the upper management of the organisation was reconsidering the organisational strategy. From a pure process point of view there were no explicit connections between the new strategy and the foresight network process. But from a systems perspective the foresight network process, as well as the generic renewal of the organisational strategy, were connected through agents involved in both activities, through joint motivations and through a word-of-mouth practice in the organisation.

In the South Australian case the benefit of the systems view is perhaps even clearer than in the first case study. Because the configuration of the regional system was locked-in by multiple knots, a straight-forward futures process of the type "expertise in, futures out" would not have been very beneficial. Instead, there was a need first to analyse and understand the regional system, that is, how the systemic configuration and the cognitive schemes of the agents condition the behaviour at the system level and results in lock-ins that, in the end, no particular actor produced or desired. Obviously, this type of systems view – foresight for catalysing the regional system or foresight as a strategic intervention – is, as such, not new in foresight, as noted in the introduction. What is special in our approach is that we considered the foresight process as being part of the regional system. In other words, we contextualised and embedded the exercise. This means that we as the foresight practitioners and process facilitators considered ourselves, as best as possible, actors inside the system, and not as

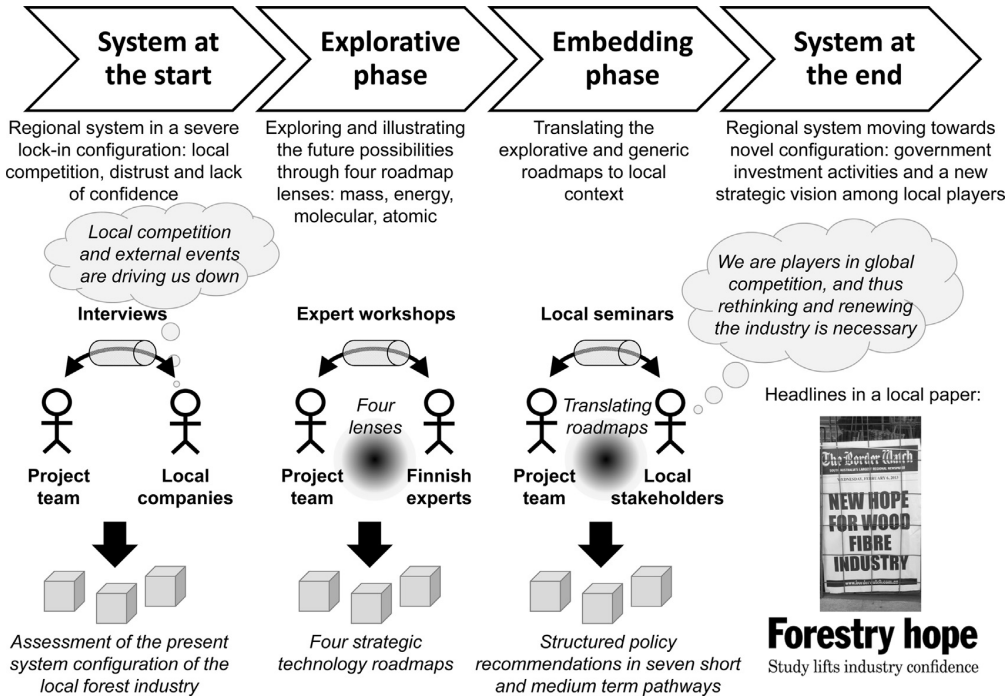

Fig. 4. Summary of the South Australian roadmapping project from a systems perspective.

outside analysts or experts. Therefore the challenge was to identify the lock-ins and leverage points from the inside, which required being aware of the biases inherent in our own cognitive schemes.

The South Australian case also illustrates the clustering of agents into subsystems. Because of the geographical gap between Finland and Australia, the analysis of the regional situation, the exploration of the global state-of-the-art, and the embedding of this state-of-the-art into the local realities were rather sequential. While from a process perspective this would only mean more clarity, from a systems perspective this meant that there was a need to understand the connections between two systems: that of local stakeholders and that of Finnish experts. The local situation needed to be translated into the context of Finnish experts exploring the state-of-the-art, and the roadmaps needed to be translated back into the local context. Partly because this need was identified and acted upon, the project had a clear impact on regional policy making.

From a systems perspective, both of the case studies were not just about producing project outcomes, such as roadmaps, but instead more about creating configurational changes in the systems. The foresight network case aimed to increase the foresight capabilities of the organisation and in doing so influenced the cognitive schemes of the agents by facilitating a dialogue on the meaning and role of foresight in the organisation. When the new organisational strategy was announced, more members of the organisation shared a common understanding of foresight than before the project.

There was a change in the cognitive schemes also in the South Australian case. The focus was broadened from local competition to new technological opportunities and being part of a global space of competition. However, this change did not come easily, but required both understanding the reasons for the initial cognitive schemes and the leverage points through which they could be influenced. As stated above, just introducing a memory object such as the roadmap was not enough. The roadmaps were translated into concrete steps forward, into pathways aligned with the current local context. This also supported imagining of more visionary ideas, and of what these ideas would mean for the interaction between the agents in the present. As a result, a mediating event, the second phase of the South East Forestry Partnerships Program, was instigated to support the implementation of the recommendations.

Table 3 summarises what the systems view meant in the case studies and what were the key elements. One could obviously pose the following critical questions: What were the particularities and added value of the systems view in these cases? Could the same results have been obtained without the systems view? For the foresight network case the main benefit from the systems view was positioning the project as part of overall changes taking place in the organisation and understanding the differences in the cognitive schemes related to foresight. Because of the different cognitive schemes, it became obvious that in order to build a common understanding of foresight, and related organisational capabilities, its role and meaning needed to be discussed. This discussion was realised through the training program and by introducing the foresight case clinics. Furthermore, it was understood that also the foresight experts coordinating the project needed to challenge their understanding of the role of foresight and of the role of domain experts. The foresight experts were not controlling the way foresight was understood and practiced (the foresight system) from the outside, but were also included in it and had their own particular understanding of it. Thus the system change needed to come from the inside, through the interaction with other agents in the system. For the South Australian case the systems view was instrumental in providing impactful outcomes. Instead of framing the process as a set of activities resulting in recommendations for the government (which it of course also was), the systems view emphasised the structure and reasons for being in an undesired situation and leverage points for changing the situation. The first step thus was to understand how the system configuration restricts the agents and creates unwanted behaviour. This required understanding the cognitive schemes that guided the actions of the agents. The aim then was to change these cognitive schemes by introducing new concepts in the form of the roadmaps. However, these concepts could not be force-fed into the system. The different contexts, that of the Green Triangle forest industry and Finnish RTO, needed to be taken into account. This tailoring of the message according to the system context required understanding of the system configurations and the foresight process with all its agents as part of it—in other words a systems view to foresight. The systems view can also be seen as a tool for contextualising foresight. As a practice, foresight is highly context-dependent (Cariola and Rolfo, 2004; Barré, 2002). Context is reflected in the cognitive schemes of the

Table 3
Elements in the foresight network project.

Element	Examples in the foresight network case study	Examples in the South Australian case study
Agents	Foresight team, foresight network, other experts in the organisation, external foresight practitioners	South Australian Government, regional companies, local media, substance matter and foresight experts from a Finnish RTO
Cognitive schemes	Attitudes towards foresight, the basic understanding of foresight	Sources of competition (local vs. global), reasons for local problems, technological opportunities
Strategic object	The foresight network	"Four lenses", translating the roadmaps
Mediating events	Foresight training and case clinics	Company interviews, expert workshops, local seminars
Memory objects	Training material, case clinic concept	Assessment of the local industry, roadmaps, recommendations as pathways
Metaphors	Case clinic results	"Four lenses" interpreted in the local context

agents and in the interactions between the agents. In the foresight network case, the foresight experts learned to translate the methodological foresight depictions to the variegated specific contexts of the technology experts, and also to structure the interactions during the process in a way that would be motivating and meaningful for both foresight experts and technology experts. Foresight was thus brought into the context of the technology experts through the mediating events of the foresight case clinics and foresight training. In the South Australian case the systems view helped in contextualisation of the state-of-the-art represented in the roadmaps to the local setting, as described above.

5. Conclusions

The systems view to foresight focuses on the system, as an interconnected operative entity, and not just on its specific agents or phenomena. Viewing foresight as a system positions separate foresight processes into a larger context. This means identifying different agents and their interconnections. The way agents are connected and how they interact forms the basic system configuration. Understanding this configuration helps in understanding why the system behaves in the way it does; how the structure conditions the agents to behave in a certain way instead of some other way. In this paper we have introduced six elements that help in understanding the structure and dynamic of a foresight system.

However, a foresight system cannot be understood objectively "from the outside". All participants of a foresight process are part of the foresight system and have a partial view of it. A system has its internal and external boundaries, and it has more vigorous and more withered linkages. Some things in the system could be consciously left unprocessed or silenced, while some emergent activities in the system could simply remain unidentified. Despite this incomplete view of the system, it is possible to act intelligently in the system. We thus follow the systems view described in the concept of systems intelligence (Hämäläinen & Saarinen, 2004; Hämäläinen, Jones, & Saarinen, 2014). This view is also in line with the approaches of anticipatory action learning (Inayatullah, 2006) and transformative foresight (e.g. Kahane, 2012; Inayatullah, 2008).

A key point in the systems view is to position a foresight process as part of a larger process of change. The foresight process can be parallel to the change or be an influence behind it, as was illustrated in the two case studies. The systems view thus gives a novel interpretation to the discussion around exploration and exploitation in foresight (see e.g. Staton, 2008; Uotila et al., 2012 Uotila et al., 2012). Exploration is broadening the view about what the system is (changing cognitive schemes), while exploitation is changing the internal structure and behaviour in the system through interaction (new strategic objects and mediating events).

The systems perspective on foresight enables one to identify key aspects in a foresight process as part of a larger system, and to emphasise the importance of boundary crossing expert interaction in the construction of organisational or regional future-orientation. The elements and the case examples enhance understanding of what foresight as a system is, and what are its key components and dynamics. Our paper thus contributes to the systems understanding that is currently emerging in foresight (Andersen & Andersen, 2014; Saritas, 2013; Amanatidou & Guy, 2008). We hope that our description of the systems view and the elements of a foresight system help in analysing the actor dynamics, power relations and responsibilities in the foresight exercises. In our opinion these aspects have not yet received the attention they deserve in the existing literature.

For managers and foresight practitioners, the elements of foresight systems offer a framework by which to identify key leverage points in foresight exercises. While a complex adaptive system, such as the foresight system, cannot be directly managed as such, it can be influenced, channelled and steered through the mediating events and strategic objects. Strategic objects can be used in order to gather agents together by a future-oriented theme. It can also be used to channel and stimulate the futures imagination of the agents. The mediating events can be used to influence the nature of the interaction. Together they offer the context in which agent interaction and thus knowledge creation takes place. Therefore, the elements can be perceived as leverage points through which policies or strategic actions can set up a virtuous cycle of agent interaction, knowledge creation and capability enhancement (cf. Fig. 1).

To conclude, the elements of a foresight system identified in this paper offer a starting point for further developing a systems understanding of foresight. We also see that our contribution could prove useful for understanding the complex knowledge creation processes in foresight and, thus, could help in planning foresight processes that have the correct scope, magnitude, and duration for different organisational contexts. Furthermore, we think that the frame could prove useful also in strategic management, especially when the aim is on the long term vision building and on increasing the capacity to anticipate alternative futures. Thus, our frame is applicable to strategic management contexts that consider long term strategic issues from multiple perspectives, that is, issues of long term planning, vision building, and building organisational capacities for scoping alternative futures. Strategic management contexts that come particularly close to our framework are corporate foresight (Rohrbeck, 2011) and organisational future-orientation (Rohrbeck & Bade, 2012). However, when it comes to other strategic management contexts, such as enhancing short or medium term competitiveness through finance and cost-based measures, resource allocations or short term action planning, there are probably nuances that our frame does not fully take into consideration. In our opinion, exploring these contexts and discussing how to apply this frame to different strategic management contexts could be an interesting subject of further analysis and contemplation.

Also, further research is needed to ensure that the elements cover all relevant aspects of foresight as a system and to provide more examples of how the elements are manifested in foresight practice. This could be achieved by conducting case studies of foresight exercises at both the national and organisational level, or by comparing the existing depictions of an ideal

foresight process with the idea of foresight as a system. Further research could also focus on the applicability of the framework in other fields than foresight, such as strategy development.

Acknowledgements

The authors would like to thank the State Government of South Australia, Commonwealth Govt DIICCSRTE, the Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE), Regional Development Australia Limestone Coast Inc, and PIRSA for their assistance and contributions in The South Australian Cellulosic Value Chain Technology Roadmap project. Financial support from VTT Graduate School is acknowledged (Mikko Dufva).

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Article III

Dufva, M., Könnölä, T. & Koivisto, R. 2015. Multi-layered foresight: Lessons from regional foresight in Chile. *Futures*, 73, 100-111.

Futures 73 (2015) 100–111

Contents lists available at ScienceDirect

Futures

journal homepage: www.elsevier.com/locate/futures

Multi-layered foresight: Lessons from regional foresight in Chile

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ARTICLE INFO

Article history:
Received 30 January 2015
Received in revised form 26 August 2015
Accepted 27 August 2015
Available online 29 August 2015

Keywords:
Foresight
Innovation system
Foresight design
Foresight evaluation

ABSTRACT

The design, management and evaluation of foresight is challenging firstly due to the vast diversity of foresight practices and secondly due to its embeddedness in the context of other policy processes. To help overcome these challenges we look at the contributions of foresight from multiple perspectives in a systemic way and propose the concept of multi-layered foresight, which analyses the contributions of foresight to knowledge, relations and capabilities on four layers: landscape, system, organisation and individual. We construct these layers building on earlier literature and illustrate them with a case example from the region of Antofagasta in Chile. We argue that foresight exercises benefit from considering multiple levels and respective different emphases in analysis. For instance, on the landscape layer the focus tends to be on contributions to knowledge while on the organisational layer it is more on capabilities. The layers help position the foresight exercise and its effects in relation to the broader context. Thus, we expect the concept of multi-layered foresight to support the design, management and evaluation of foresight.

1. Introduction

Foresight is used in national, regional and organisational contexts to anticipate the changes in the environment and create responses to them (Georghiou & Keenan, 2006; Uotila, Melkas, & Harmaakorpi, 2005; Rohrbeck, 2011). While the focus was at first on rationalist technology forecasting, the domain in which foresight is applied today covers science and technology policy, innovation system performance, organisational future-orientation and societal challenges (Rohrbeck, 2011; Von Schomberg, 2002; Salo, Konnola, & Hjelt, 2004; Miles, Harper, Georghiou, Keenan, & Popper, 2008; Kuosa, 2012; Andersen & Andersen, 2014). As the domain has broadened, the definition of "foresight" has become more ambiguous and generic (Miles et al., 2008; Da Costa, Warnke, Cagnin, & Scapolo, 2008; Harper, 2013; Hines & Gold, 2013), which has led to the use of more specific terms such as "fully-fledged foresight" (Miles, 2010), future-oriented technology analysis (Cagnin et al., 2008), corporate foresight (Rohrbeck, 2011), strategic foresight (Slaughter, 1997), innovation system foresight (Andersen & Andersen, 2014; Andersen, Andersen, Jensen, & Rasmussen, 2014), and national, regional and sectoral foresight studies (e.g. Georghiou & Keenan, 2006; Uotila et al., 2005; Grupp & Linstone, 1999). In addition, the terms within foresight are used to mean slightly different things (van der Helm, 2006). Still, several shared perspectives remain on the purpose, goals and contents of foresight.

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http://dx.doi.org/10.1016/j.futures.2015.08.010
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At the same time foresight has become more contextual and further embedded in policy processes (Harper, 2013). Foresight is seldom an end in itself, but rather a supporting and complementary process to other activities, such as policy making, strategic planning, priority setting or capacity building (Georghiou & Keenan, 2006; Miles, 2012). In addition, foresight has evolved from merely informing policy to being a policy instrument in itself (Da Costa et al., 2008; Habegger, 2010). A similar shift is observed to some extent also in the domain of business, where the practice of foresight has become more contextual and participatory (Daheim & Uerz, 2008).

The diversity of foresight practices, the emphasis on context, and the linkages to other policy processes have led to a situation where the management of a foresight process becomes challenging (Könnölä, Ahlqvist, Eerola, Kivisaari, & Koivisto, 2009). The planning and implementation of foresight can benefit from a multi-faceted approach, which looks at the different rationales and functions of foresight in a systemic way (Harper, 2013). This leads to our research question: *how can the effects of foresight be structured in a systemic way taking into account the differences in the foresight approaches*?

To answer the research question we elaborate on the concept of multi-layered foresight that perceives foresight principally as a system of knowledge creation constructed of four archetypal layers: landscape, innovation system, organisation and individual. To position the exercise and its contribution in a wider context, we suggest that these layers can be observed through three facets of foresight: knowledge, relations and capabilities. We relate our construction of the facets and layers of foresight to effects and benefits addressed in the foresight literature and illustrate them with a case example from a regional foresight exercise in the region of Antofagasta in Chile. We also emphasise some neglected aspects of foresight, such as capacity building. While some studies exist on the contribution of foresight to capacity building of individuals, these aspects need to be studied further as an integral part of foresight rationales. All in all, we expect the concept of multi-layered foresight to provide structure for the design, management and evaluation of foresight.

The article is structured as follows. After this Introductory section, in Section 2 we describe the rationales and contributions of foresight mentioned in the literature on the four layers using the facets of foresight. Section 3 illustrates the layers and the facets with a case example. Section 4 discusses the dynamics between the layers and Section 5 concludes.

2. Multi-layered foresight

2.1. Facets of foresight

While much of the discussion on the benefits (e.g. Irvine & Martin, 1984; Martin, 1995), functions (Da Costa et al., 2008) and objectives (Salo et al., 2004; Barré, 2002; Van der Meulen, De Wilt, & Rutten, 2003) of foresight has been driven by empirical observations, it can be argued that they relate to the notion of foresight creating new knowledge (see, e.g. Eerola & Miles, 2011). Further theoretical linkage can be made in particular with evolutionary and institutional economics, which consider knowledge as a consequence of interaction between individuals, organisations and their environment. Herein, the knowledge resides also in habits, routines (Hodgson & Knudsen, 2004) and skills (Nelson & Winter, 1982), thus pinpointing the importance of engagement of people in learning and participatory processes in foresight. Building upon the work of Barré and Keenan (2008) and Van der Meulen et al. (2003),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 we can derive three general dimensions of foresight contributions named facets of foresight: (i) knowledge (ii) relations and (iii) capabilities (see also Table 1).

2.1.1. Foresight creating knowledge

Perhaps the most defining characteristic of foresight is its orientation towards the future or long-term developments (e.g. Miles et al., 2008). While foresight systematically gains insights about alternative futures, it also improves understanding of the present and fosters participants to (re-) position themselves in the innovation system. In particular, foresight produces knowledge about alternative futures. This knowledge is different from the knowledge about the present or past in that it is contingent on present actions. Foresight can produce forecasts, descriptions of future possibilities or perceptions of the future, and an understanding of the consequences of actions (Eerola & Miles, 2011). This knowledge can then be used to, e.g.,

Table 1
Three facets of foresight.

Facet	Definition	Examples of effects
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 in the innovation system	Improved understanding of future developments articulated as forecasts, scenarios, roadmaps, weak signals, wild cards, emerging issues and recommendations
Relations	The creation of new connections between different stakeholders and across sectors, and the restructuring and enhancing of existing networks	Alignment of stakeholders (e.g. from industry, research and public sector) into joint envisioning, new contacts, enhanced networks
Capabilities	The learning of new capabilities that contribute to the future orientation of an organisation and the system at large	Changing habits and mindsets, and learning new skills and methods, which strengthen foresight and innovation capabilities

inform policy and create an awareness of future possibilities (e.g. Georghiou & Keenan, 2006; Da Costa et al., 2008; Havas, Schartinger, & Weber, 2010).

2.1.2. Foresight enhancing stakeholder relations

Because much of the knowledge about the innovation system is scattered among different stakeholders, enhanced networking may be needed. In order to assist mutual learning and joint actions, foresight activities need to promote enhanced relations among the stakeholders, for instance by catalysing personal contacts that did not exist before, or by deepening the qualities of previously established contacts. Foresight increases both the extensiveness and intensiveness of networking: it facilitates the making of new connections and deepens the qualities of existing connections (Salo et al., 2004). Foresight may even lead to the destruction of some existing networks that facilitate the creation of new value-networks (Könnölä, Brummer, & Salo, 2007).

2.1.3. Foresight improving capabilities

The main reason to explore alternative futures is not to know what will happen but rather to know what needs to be done in the present. In order to be beneficial, foresight needs to be connected to action (Harper, 2013; Calof, Miller, & Jackson, 2012). Many of the stated goals of foresight include this action-orientation, for example the aim to reorient the science and innovation system (Georghiou & Keenan, 2006), facilitating policy implementation and reconfiguring policy system (Da Costa et al., 2008), and creating the ability to adopt alternative perspectives (Rohrbeck & Schwarz, 2013). However, there is an important distinction between the action itself and the ability to act. Foresight can contribute also to the ability to act, and the actions themselves are part of the processes linked to foresight. Foresight is thus a learning process, which leads to action (Rohrbeck, 2011; Habegger, 2010; Havas et al., 2010).

2.2. Multiple layers in foresight

Foresight activities are conducted with different scopes and layers within innovation systems. For instance, foresight may focus on global, national or regional developments, an industry sector or a specific technology domain (Miles et al., 2008; Andersen et al., 2014; Cagnin & Könnölä, 2014). Likewise, the contexts of foresight range from national, international and intra-governmental issues to the interests of regional, private sector and NGO actors (Georghiou & Harper, 2008). Because the scope of foresight exercise can become excessively broad, it is not trivial how foresight takes these contexts into account.

To find the balance between a narrow enough scope and comprehensive coverage, it is useful to understand how the facets of foresight depend on the context and level of analysis. The context guides the foresight activities. For example, a foresight exercise focused on a regional level has a different outcome than national foresight or corporate foresight. However, even though a foresight exercise might be focused on a specific context, its contributions are relevant also in other contexts. For example, if the foresight exercise creates an increased understanding of the future developments on the global or national level, this facilitates the definition and positioning of actions on the local level. In other words, the level of analysis also determines what is seen as the contributions of foresight. In order to structure the contributions of foresight in a way that takes into account the context and different viewpoints, we propose a multi-layer structure.

We take the innovation system as a starting point in defining the layers. This is because the improvement of the science and technology system and more recently the innovation system has been the context in many foresight activities (Andersen & Andersen, 2014; Martin, 1995). Innovation systems can be framed as sectoral, regional, national or technological, and these different views are partly overlapping (see e.g. Carlsson, Jacobsson, Holmén, & Rickne, 2002; Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007). What is common to all of the innovation system views is that they highlight a specific structure and dynamics of how the innovation activities take place between different actors. Schoen, Könnölä, Warnke, Barré, and Kuhlmann (2011) identify the challenges of managing innovation systems in Europe and argue that the conduct, the funding and the strategic orientation of research and innovation have become a multi-level and multi-actor arrangement consisting of local, regional and (inter-) national levels. In other words, the activities need to be understood to take place on different levels and between different actors. To achieve this we position the innovation system as part of a broader context as well as zoom in on the actors involved.

Innovation systems interact with their broader environments that entail external, often global developments. These developments affect the innovation system but are themselves hardly affected by activities in the innovation system. We call this broader environment the landscape layer. The difference between the landscape and the innovation system layers is that the landscape focuses on the interconnections of innovation systems and their environments, while the innovation system layer focuses on the activities between actors in the innovation system. For example, on the landscape layer the focus could be on how the changes in the global economy and environment will affect the innovation system, while on the innovation system layer the question would be how the innovation system and its actors will change and respond to global changes. The landscape layer thus emphasizes external events and trends.

While the innovation system is embedded in a broader context, it itself consists of different interdependent actors (Carlsson et al., 2002; Alkemade, Kleinschmidt, & Hekkert, 2007). These can be, for instance, companies, research organisations, government ministries or interest groups. In our multi-layer structure we call these simply organisations. Compared to the focus on landscape or innovation system, emphasis on the organisations brings to fore the strategic actions and value creation that take place in the system. The organisation layer thus captures the contexts of strategic decision

making and action in organisations including, for example, strategy crafting (see e.g. Mintzberg, 1987; Whittington & Cailluet, 2008) and organisational future-orientation (see e.g. Rohrbeck & Bade, 2012; Hines & Gold, 2014).

Organisations, and ultimately also innovation systems, consist of individuals. As mentioned above in the introduction of facets of foresight, foresight is fundamentally interested in knowledge creation, which takes place in the interaction between people. Hence, we also include individual capabilities and capacities in our multi-layer structure. Individuals make sense of their environments and enact them (Weick, 1995). The capabilities of individuals influence the behaviour of the organisation as well as the innovation system. Likewise, the innovation system and organisation, being the context for action of the individual, shape the capabilities of the individual. A foresight exercise may bring new knowledge, relations and capabilities to an individual. While this "micro-level" dynamic is central to understanding the behaviour and changes in the organisations and also in the innovation system, it often receives less attention in the foresight literature.

The layers help in structuring the contribution of foresight as well as the effect of that contribution. Independent of any specific focus of a foresight exercise on a certain layer of the innovation system, the exercise can systematically explore its interrelations with the other layers in order to position the exercise in the multi-layered structure. In the context of building scenarios for higher education, Havas (2009, 2008) has suggested a multi-level structure in order to take the broader socio-economic system into account. Similar types of observations have been made in other fields that explore the role of multi-level governance (Hooghe & Marks, 2003; Kohler-Koch & Larat, 2009). In other words, the layers are not exclusive but rather connected and complementary. A foresight process might have a different emphasis on which layer is seen as the most important, but often foresight contributes to all layers, either by design or unintentionally.

Table 2 gives a general description of the contribution of foresight in the four layers. However, what is more important than the specific layers is the interrelations between the layers. Looking at the layer "above" and "below" aids in understanding what the layer consists of and what it is a part of. For example, an innovation system is embedded in the societal developments of the landscape layer, and consists of different organisations, which in part consist of individuals. In other words, the layers form a hierarchical system (cf. Saritas, 2013).

We will next describe the layers in more detail, starting with an overall view of the basic focus and questions that are relevant for the layer and how foresight contributes to answering the questions. We structure the contributions with the three facets of foresight. We start with the landscape layer, as that gives the broadest picture, and then work our way through to the individual layer.

2.2.1. Landscape layer

One of the key aspects of foresight activities has been exploring how the external environment will evolve and affect national policies or company strategies (Miles et al., 2008; Popper, Keenan, Miles, Butter, & Sainz, 2007; Boden, Cagnin, Carabias, Haegeman, & Könnölä, 2010). Many of the challenges today are global, complex and cross-sectorial. Issues such as climate change, resource scarcity, poverty, and sustainability transition across the national boundaries, involve a wide range of stakeholders, are complex and require a broad range of interlinked and interdisciplinary actions. On the landscape layer the focus is on the trends and drivers originating from the operational environment of the innovation systems, for example, major disruptions in the global economy or the implications from "Grand Challenges" (see e.g. Lund Declaration, 2009; OECD, 2012).

Foresight on the global scale is used to anticipate global developments, identify megatrends and weak signals and imagine wildcards. Examples of knowledge produced by foresight projects include, for instance, the "State of the Future" reports by the millennium project (e.g. Glenn, Gordon, & Florescu, 2014), the scenarios in the "Global Environment Outlook" (e.g. UNEP, 2012) and the listings of wild cards and weak signals by the iKnow Community (2014). The focus in the landscape layer does not need to be global, as long as it is something external to the innovation system under study. For example, developments in other sectors might have implications on the regional or local level, while still being external to the innovation system under study.

Table 2
Description of layers and the contribution of foresight.

Layer	Description	Foresight effects
Landscape	The external developments that affect the innovation systems but are hardly affected by any single measure	Anticipating global developments, trends and/or wild cards, and enhancing future-orientation of the society
Innovation system	The structure and dynamics of intertwined innovation sub-systems consisting of organisations	Increasing the capacity to reconfigure the innovation system to respond to future developments by exploring alternative futures and supporting networking between stakeholders
Organisation	The organisational culture and allocation of resources	Creating organisational future-orientation and triggering the creation of organisational responses to the anticipated changes in the operational environment
Individual	Individual capacities and capabilities	Enhancing future-oriented thinking and increasing capacities and capabilities related to anticipating possible futures

While the creation of knowledge about the alternative global developments or transitions is the main emphasis on the landscape layer, foresight is also claimed to contribute to the capabilities of a society as a whole. Foresight can be used as one instrument in creating an adaptive, learning society, and it can also enable policy learning and unlearning (Havas et al., 2010). The long-term focus and challenging of worldviews and mindsets can facilitate a cultural change and systemic thinking (Havas et al., 2010).

On the landscape level, less emphasis is put on the networking and building of lasting relations. Instead, the emphasis is more on seeing and creating the connections between different sectors or domains of interest. In addition, foresight projects with a broad scope considering multiple fields and large geographic areas can help participants to position themselves with regard to global developments.

2.2.2. Innovation systems layer

The scope of the innovation systems layer is not so much on specific global challenges, but rather on solving "system failures" (e.g. Smith, 2000; Carlsson & Jacobsson, 1997). This means that on the system layer the focus is on creating system structures favourable to, e.g. innovation, and analysing the dynamics and functioning of the system (see e.g. Hekkert et al., 2007; Alkemade et al., 2007). The aim can be, for instance, on solving system failures, market failures, system rigidities and anticipatory myopia (Salmenkaita & Salo, 2002). Approaches on this layer include, for instance, the innovation systems approaches (e.g. Hekkert et al., 2007; Lundvall, 1992; Cooke, Gomez Uranga, & Etxebarria, 1997), smart specialization strategies and different cluster strategies (e.g. Rosenfeld, 2002), innovation system foresight (e.g. Andersen & Andersen, 2014; Andersen et al., 2014) and regional foresight (e.g. Uotila et al., 2005).

On the innovation systems layer foresight is aimed at collectively creating a holistic view of the systems and alternative futures for it in order to help stakeholders identify and achieve a desired direction for joint actions. Especially the science and technology system has been the focus of many foresight projects (see e.g. Georghiou & Keenan, 2006; Grupp & Linstone, 1999; Gavigan & Scapolo, 1999; Martin & Johnston, 1999; Salo et al., 2009). In contrast to the landscape layer, more emphasis is put on identification and participation of key stakeholders. In other words, the foresight process is more about co-creation and learning than about expert opinion on the futures. The focus on the long term and exploration of alternatives is the key contribution of foresight as compared to other approaches.

On the national and regional level one of the key objectives of foresight is to inform policy in order to ensure the competitiveness and performance of the innovation system (Georghiou & Keenan, 2006; Da Costa et al., 2008; Harper, 2013; Miles, 2012; Habegger, 2010; Havas et al., 2010; Johnston, 2012; Cagnin, Amanatidou, & Keenan, 2012). Foresight is not only used to objectively inform policy, but also to support policy definition (Da Costa et al., 2008) and to influence policy (Johnston, 2012; Salo, 2001). The knowledge about the futures created by foresight is not objective. Rather, it can be seen to shape the development of the innovation systems. For instance, on the regional level, foresight is claimed to overcome the "black hole of regional strategy making" (Uotila et al., 2005) or to create strategies to escape from the negative consequences of a "risk society" (Amanatidou & Guy, 2008). Thus, foresight can create the capacity to reconfigure an innovation system: to identify missing or ignored actors, change institutions in the sense of the rules of the game (North, 1990), and to influence the nature and amount of interaction and linkages between actors.

From the viewpoint of government, foresight facilitates policy implementation (Da Costa et al., 2008; Harper, 2013; Miles, 2012; Havas et al., 2010) and helps solve market and system failure and to overcome structural rigidities and anticipatory myopia (Salmenkaita & Salo, 2002). In addition to being a policy instrument or supporting other policy instruments, foresight can also have a more subtle influence on policy through raising awareness (Johnston, 2012) and providing social fora (Georghiou & Keenan, 2006).

The contribution to skills on the innovation systems layer has not been discussed as much in foresight literature as the contribution to knowledge. For example, the emphasis on foresight processes aimed to increase the competitiveness of national innovation systems is more on the content than the process (Rijkens Klomp & Van Der Duin, 2014). However, future-orientation, alternative futures and focus on the long-term is said to enable "reflexive mutual social learning processes" (Habegger, 2010), policy learning and unlearning (Havas et al., 2010) and the "foresight literacy" of the actors (Calof et al., 2012). Participation in foresight processes can build the capability to detect signals of change and adopt new perspectives and thus enable the actors in the innovation system to enact systemic change (Cagnin et al., 2012). Participation and the learning process thus increase the "future-orientation" or the capability to anticipate future developments of the innovation system.

Foresight can enable the networking and collaboration between the stakeholders in the innovation system (Georghiou & Keenan, 2006; Havas et al., 2010; Salo, 2001; Amanatidou & Guy, 2008; Keller, Markmann, & von der Gracht, 2015) and the interaction between the stakeholders is mentioned as one of the success factors of foresight (Habegger, 2010). For research and industry the enabling of collaboration and agenda setting are among the key contributions of foresight (Keller et al., 2015). Research institutes and universities may see the foresight exercise as an opportunity to create contacts or demonstrate compliance to the government (Salo, 2001), both of which may help them in applying research in industry or obtaining more funding. For industry, collaboration is a way to combine resources and gain new knowledge.

2.2.3. Organisation layer

On the organisational layer the focus in the literature has been on the survival and capabilities of the organisation. Key questions include, for instance, how resources should be allocated between exploration and exploitation (e.g. March, 1991),

how the organisation should react to changes in the operational environment (e.g. Rohrbeck, 2011), and how the organisation can create capabilities for renewal and survival (e.g. Teece, Pisano, & Shuen, 1997; Archibugi & Lundvall, 2002)? Foresight focusing on this layer has been called corporate or strategic foresight (Rohrbeck, 2011) or organisational future-orientation (Rohrbeck & Bade, 2012). The goal is to anticipate the developments in the operational environment and to trigger responses to adapt to, and sometimes shape these changes (Rohrbeck & Gemünden, 2011). Foresight provides a long-term view on the operational environment, helps anticipate game-changing trends and disruptions, builds organisational capacity for thinking about alternative futures and aids in assessing responses to the anticipated changes.

Foresight is used to inform companies and organisations about possible developments in their operational environment (Rohrbeck & Schwarz, 2013; Keller et al., 2015; Rohrbeck & Gemünden, 2011; Heger & Rohrbeck, 2012). Through foresight it is possible to identify opportunities, threats and changes in the environment (Day & Schoemaker, 2004) and relate them when addressing the strengths and weaknesses of the organisation. On the market side, foresight can help in identifying the future markets and customers, enhance the understanding of customer needs and identify threats and opportunities related to the product portfolio (Rohrbeck & Schwarz, 2013). It contributes to ambidextrous management (Tushmann & O'Reilly, 1997); both to the exploration of opportunities and the exploitation of existing knowledge (cf. March, 1991). Foresight practices include the exploration and imagining of alternative futures and systematic scanning of weak signals and wild cards, both of which contribute to the creation of organisation preparedness (Rohrbeck & Schwarz, 2013). On the other hand, through this exploration, foresight helps exploitation of knowledge when setting priorities for investment and brings clarity in addressing the uncertainties related to R&D (Georghiou & Keenan, 2006; Rohrbeck & Schwarz, 2013).

In contrast to conventional innovation management practices, foresight increases the ability to manage both incremental as well as discontinuous change (Keller et al., 2015). While the emphasis has perhaps been on exploitation of existing knowledge, the current trend in foresight in organisations is towards challenging and shaping the future (Rohrbeck, 2011; Daheim & Uerz, 2008) and dialectical thinking embracing paradoxes and questioning mindsets (Kuosa, 2011). In particular, foresight can help to avoid lock-ins in incremental management practices (cf. Könnölä & Unruh, 2007). From an innovation management perspective, the value in dissensus and paradoxes is in expanding what is thought to be possible in the future and therefore discovering new challenges and opportunities (Könnölä et al., 2007). An "opponent role" of foresight challenges innovation projects to increase the quality of their outputs (Rohrbeck & Gemünden, 2011).

Foresight has also been described as an organisational capability (cf. Rohrbeck, 2011; Slaughter, 1997). From this perspective, the objective of foresight is to create "foresight literacy" and "foresightful leaders" (Calof et al., 2012), organisational future-orientation (Rohrbeck & Bade, 2012) and foresight culture (Rohrbeck, 2011). This represents the capability to adopt alternative perspectives, learn from them and adjust a company regarding anticipated alternative futures. This learning is essential for enabling a "learning economy" which is capable of renewal (Archibugi & Lundvall, 2002).

On the organisational layer, foresight contributes both to external and internal networking. The external networking was described on the innovation systems layer, but on the organisational layer the perspective is on how it benefits an organisation. An organisation can aim to shape the future by collaborating with other companies and influencing policy-makers (Rohrbeck & Schwarz, 2013). For example, technology roadmapping has been used to coordinate developments in industry (Phaal, Farrukh, & Probert, 2004). On the internal side, foresight can foster conversations about overall strategy (Rohrbeck & Schwarz, 2013) and thus both build a shared vision for an organisation and increase understanding of different perspectives within an organisation.

2.2.4. Individual layer

Effects of foresight are often not thought about on the level of individuals participating in the process. However, individuals are the key to creating a change within an organisation and subsequently on the innovation system. This can be a consequence of changing mindsets and worldviews through learning. The differences between the competences and perspectives of the stakeholders are a main source of learning as well as knowledge creation (Salo, 2001). A participative foresight process may thus create new insights and perspectives for participants.

Foresight can enable learning by bringing new knowledge, facilitating the sharing of different perspectives and providing learning opportunities (Rohrbeck, 2011). Through foresight, it is possible to influence the way of thinking, the mindset, mental models or perspectives of an individual by facilitating the exploration of the future and the present and focusing on the mismatch between them (Calof et al., 2012). Foresight process supports the broadening of a context to display a bigger picture of the issue under study (Halonen et al., 2010). Both reflecting on the past and thinking about alternative futures together can trigger social and expansive learning: questioning and renewing the implicit assumptions about the current worldview or perspective (Engeström, 2001; Halonen et al., 2012; Schauppenlehner-Kloyber & Penker, 2015 Schauppenlehner-Kloyber & Penker, 2015). However, learning is not a self-evident effect of the foresight process, at least not any radical change in mindsets. Schartinger, Wilhelmer, Holste, and Kubeczko (2012) found that participants in a foresight process had gained new perspectives and understanding of the system as a whole, but did not change their lines of thinking. Such transformative learning requires commitment and support also beyond the foresight project (Keller et al., 2015).

On the individual layer, a foresight process can contribute to at least two kinds of capabilities: the capability for strategic or future-oriented thinking and the capability for conducting foresight exercises (learning-by-doing). Foresight is a learning process for participants as well as foresight practitioners (Georghiou & Keenan, 2006). Since the context influences the foresight process, each new foresight project offers the chance to further develop foresight practice. Having appropriate methodologies and skills to conduct the foresight exercise is one source of foresight effect (Calof et al., 2012).

On the individual level the participatory nature of foresight enhances the chances of meeting new people, creating new connections and strengthening old ones. Foresight workshops can be regarded as the generation of temporary connections that aid in the implementation of process results (Dufva & Ahlqvist, 2015; Kerr, Farrukh, Phaal, & Probert, 2013). For an individual this may be helpful also for personal gains, such as career development. Networking also creates social capital for the individual as well as the organisation (Mauerhofer, 2013).

2.3. Using the layers to position the foresight exercise

The layers described in this section help structure the contribution of foresight. However, there are no self-evident boundaries between the layers; hence the multi-layered structure is applied at best as a heuristic instrument. More important than defining which foresight contribution or benefit belongs to which layer, is to use the layers to position the foresight exercise and its contributions. By positioning we mean identifying the layers in which the main emphasis is and interrelating that with the adjacent layers:

- Landscape layer: exploring the landscape and its global future developments,
- Innovation systems layer: positioning the system, and its sub-systems, vis a vis future developments,
- Organisation layer: positioning organisations in the system vis a vis future developments,
- Individual layer: positioning individuals in the organisations vis a vis future developments.

We argue that this positioning leads to improved understanding of the system at hand which helps the actors define their role, strategy and needed actions. In the next section we illustrate the positioning and use of the layers with a case example.

3. Empirical case example: Water in Antofagasta 2040

In this section, we describe how the concept of multi-layered foresight benefited the design and management of the foresight project "Water in Antofagasta 2040" conducted by the authors during the spring 2013 in Antofagasta, Chile. The knowledge base of the case study consists of our experience as project coordinators, notes taken during the project, initial results from the foresight workshops and feedback gathered from key participants in a half-a-day evaluation workshop held after the end of the project. The evaluation workshop applied the multi-layered foresight supporting the structured analysis.

The foresight project was an integral part of a broader joint project between the VTT Technical Research Centre of Finland and the Mining Technological and Scientific Research Centre CICITEM in Chile, which had an overall objective to enhance innovation-driven sustainable economic development of the Antofagasta region. The foresight project was carried out jointly by researchers from VTT and CICITEM to enable capacity building. The main goals were to

- Create a vision and common understanding on issues related to water in Antofagasta in 2040.
- Bring together key players related to water: water research, water availability, water use.
- Enhance collaboration between the industry, government and research organisations.
- Foster forward-looking and future-oriented culture in planning.

In addition to planning meetings between CICITEM and VTT experts, the activities of the foresight project included the scenario and roadmapping work that consisted of a conference with around 50 participants, two stakeholder workshops with around 20 participants, a stakeholder survey that gathered 42 responses from the conference participants, five interviews with mining companies and a reflection discussion with the CICITEM experts. The conference and workshop

Table 3
Contributions of foresight in the "Water in Antofagasta 2040" foresight project.

	Knowledge	Capabilities	Relations
Landscape	Increased understanding of the global developments and networks and the position of Antofagasta as part of the global system	Skills and tools to scan and project global developments and networks	Identification of and engagement with international stakeholders
Innovation system	Identification of key barriers and drivers in the system and its sub-systems related to water issues, actions to overcome the barriers and a vision of a desired future	Increased familiarity with foresight and its benefits	Gathering stakeholders from different sectors together for the first time
Organisation	Roadmap for research related to water and mining: new possibilities, new actions, structuring of existing actions and understanding of different perspectives	Increased foresight culture and capability to conduct foresight	Improved contacts and status for CICITEM
Individual	Improved understanding of the regional context and views related to water, and foresight and futures thinking	Increased skills to conduct foresight exercises by training and engagement of CICITEM in the design and management of the exercise	Individual networking

participants included representatives from local universities, regional government, NGOs and industry, excluding the mining companies. However, the views of the mining companies were included through the interviews.

The project paid particular attention to the system and organisational level, but the landscape and individual layers were also addressed during its design and management. While the final impacts of the project can be better observed with more time, it is possible to study the participant feedback given during the reflection workshop and provide further suggestions as to what the evaluation might include in the different layers. In Table 3 we apply the multi-layered foresight concept to describe the key findings of the analysis.

3.1. Landscape layer

Although the overall focus of the project was on enhancing the innovation capacity of the Antofagasta region, it was important to understand the developments on the global level: how the region is connected to the rest of Chile and the world, how global developments influence the region and how that might change. This was reflected on the design phase when thinking about the topics for the foresight project. As mining is the most important industry in the region, a lot of the topics involved mining. However, we wanted to broaden the focus and to think about other aspects of the region that would be relevant for its global competitiveness. This led the discussion to water scarcity as the region is extremely arid, being home to a part of the Atacama Desert. The water topic also connected well to the mining industry, as it is one of the users of water.

Global competitiveness was also explicitly addressed during the foresight project, for instance as part of the theme for one roadmap exercise conducted in the second workshop. The aim was to help the participants see the region as part of a larger, global system and come up with the pathways to increase the capacities of the region and to find its niche in the global market. Positioning Antofagasta as part of the global system was also connected to a shift in the focus from present problems to future opportunities. The evaluation of the project on the landscape level could focus on how these opportunities were followed.

3.2. Innovation systems layer

The foresight project was one part of a larger process which aimed to enhance the innovation capacity of the region. Other activities included an analysis of the innovation system structure and proposal for improving the structure. The role of the foresight project was to support the joint strategy formulation and the creation of a shared vision for the region through focus on the long-term and by organising participatory workshops including different stakeholder groups.

In the design phase the different perceptions to the proposed foresight project topics were explored through stakeholder analysis together with VTT and CICITEM researchers. Anticipating the different expectations of stakeholders helped choose a topic that would be interesting and beneficial for all the stakeholder groups, which in turn would aid in committing the stakeholders to the foresight process. However, this did not mean that the topic was chosen based on where the opinions of the stakeholders were expected to be most converging. Quite on the contrary, the water topic was chosen, because there were inherent conflicts related to the water use between the stakeholders. The foresight process was thus framed as an attempt to think for solutions to these conflicts through the exploration of alternative futures. As one CICITEM researcher expressed it: “things are born from discussions”.

During the foresight project, the different stakeholders were involved through two workshops and a survey. However, due to past experiences and a lack of cross-sectoral collaboration, only a few representatives of the mining industry participated in the workshops. In order to bring in their diverse views and also communicate the viewpoints of other stakeholders, interviews were conducted with the mining industry representatives. While this was better than excluding them from the process, it obviously did not facilitate a thorough interaction between the mining industry and other stakeholders.

The tasks in the workshop and questions in the survey focused on exploring the key barriers and drivers of the system now and in the future and, more importantly, possible actions to overcome the barriers. In the second workshop, four roadmaps were created with different themes, all presenting pathways towards a desired future. These pathways were constructed with the innovation system actors in mind: it was explicitly asked who would be responsible for the actions described. Possible things to consider in the evaluation of the system layer contributions would be how the pathways were followed and how the networks between the stakeholders evolved.

3.3. Organisation layer

The foresight project had an implicit goal of enhancing the foresight capabilities of CICITEM. To this end CICITEM researchers were closely integrated into the design and implementation of the foresight project. In the design phase this resulted in new ideas on the role of CICITEM. The design phase, as well as the actual foresight project broadened the views of the CICITEM researchers and gave new ideas on linking their capacities to developments in the innovation system or landscape. As an example, the roadmaps done in the second workshop were reflected against the competences of CICITEM: what would it mean for CICITEM to pursue the developments described in the roadmap. In other words the results were used to discuss the position of the organisation related to the overall developments in the innovation system and its landscape.

As the organisation was fairly small and young in our case, the foresight project influenced the social dynamics within the organisation. Not every researcher at CICITEM saw the benefit of the project and some were reluctant to participate. Thus, at the latter parts of the project we noticed that there was a risk of creating an "in" group of persons more heavily involved in the process. In situations like this "bridge builders" are needed to make connections between the "foresighters" and the "reluctants" (c.f. Hines, 2003). How to create these bridge builders in the organisation depends on the context. In our case, we discussed this risk with the CICITEM researchers more involved with the foresight project, in order to have them act as "bridge builders" and reach out to the "reluctants". The discussion revealed complex tensions stemming from the history and structure of the organisation. To some extent, the foresight project was seen as a tool for alleviating these tensions by bringing people from different parts of the organisation together to discuss a common future. On the other hand, it also illustrated the influence of existing tensions and boundaries within the organisation, as some researchers did not participate in the project even though requested to. This unbalanced representation of the different parts of the organisation meant that some topic areas probably received less attention and, more importantly, the implementation of the results probably became harder due to lack of buy-in from those who did not participate. This is a good example of how a foresight process is connected to organisational dynamics, even though the focus might be on enhancing an innovation system; in other words, how the layers of foresight are interconnected.

In the reflection workshop at the end of the project we received very positive feedback from the CICITEM researchers. They assessed that CICITEM had gained the capacity to conduct foresight exercises and they had a new foresight project already in the planning phase. The planning of further foresight projects could be taken as an indication of a change in the mindsets of the CICITEM researchers and hint at a change in the organisational culture toward more future-orientation. The evaluation could thus focus on how these projects have succeeded.

3.4. Individual layer

While the focus was on enhancing the capacities of the innovation system and the organisation, the ultimate limiting factors are the capacities and capabilities of the individual. On the individual layer the case is thus analysed as a learning process for the participants. The pre-foresight training and the project are aimed at enhancing foresight skills especially via "learning by doing". This includes the specific methods, but also experience in scoping, designing, implementing and documenting the foresight process. The process thus not only enhanced the foresight skills of the participants, but also improved practices not directly part of foresight, but related to it (such as facilitation, documentation, connecting to the policy process). A CICITEM researcher commented during the final reflection, that he learned how to "bring ideas that were high up in the sky down to earth" and make them actionable. In addition to specific skills and methods, it would seem that the process enhanced the capability for future-oriented thinking by challenging existing worldviews and mindsets and understanding others' viewpoints and perceptions. During the process, the participants were asked to think about the issue of water in Antofagasta from different viewpoints. The initial ideas were mainly linked to mining, which is understandable because Antofagasta was seen to be a region dominated by the mining industry. However, when pushed to think in the long-term and to think about the characteristics of the region more broadly, new ideas started to emerge, such as "water scarcity as an asset". The participants discovered new possibilities, for example using the desert and the sun as the basis for new industries. We interpret this as an indication that the viewpoint changed from a mining dominated future towards a future where the region utilises also its other, more sustainable natural characteristics. The participants were asked to actively share their own viewpoints and build on the viewpoints of others, for example in creating a common roadmap. As the initial expectations of some of the researchers had been that foresight is just a set of methods and tools, experiencing this kind of perspective changing was an important insight for them.

4. Discussion

The layers emphasise different foresight contributions. On the landscape and system layers there is a bigger emphasis on the knowledge produced, whereas the individual, and to some extent the organisational layer, put more emphasis on the capabilities gained during the process. This is because the focus of knowledge is usually on the developments in the operational environment and the users of that knowledge are individual members of an organisation. Therefore the content and effects of the foresight exercise gain more attention on the innovation system and landscape layers, whereas the learning, i.e. gaining of capabilities during the process, is seen as important especially on the organisational and individual layers (see also Rijkens Klomp & Van Der Duin, 2014).

Foresight, however, contributes to knowledge also on the individual layer and to capabilities on the landscape layer. On the landscape layer foresight can enhance the capability of society as a whole to better adapt to changes (Havas et al., 2010). In the case example the participants of the workshop considered the region as part of a global system: how the global developments could influence the region and how the region could aim for excellence in a specific area (such as new mining practices related to water) on the global level. On the individual layer, the knowledge produced is tied to the learning process and may include the translation of alternative futures affecting existing worldviews, reflection on the perspectives of other participants and the interpretation of trends and weak signals to day-to-day life. The layers thus provide alternative views to the knowledge, capabilities and relations created in a foresight project.

These alternative views can be seen in the plurality of foresight "flavours" that are available. For example, corporate foresight focuses on the organisation layer, while national foresight programs and future-oriented technology analysis tend to put more emphasis on the innovation system layer. On the other hand, the landscape layer and the individual layer have perhaps gained less attention in foresight. This means that foresight could benefit from considering more the individual capabilities and the interactions between individuals as well as framing the innovation system as part of a larger landscape. In the case example we tried to pay attention to all the layers by reflecting the regional situation against the global landscape, thinking of changes needed in the collaboration between the stakeholders, discussing the results with CICITEM and interpreting what actions would be needed from CICITEM as an organisation and what capabilities enable the actions on the individual level.

5. Conclusion

In this paper, we have elaborated upon the concept of multi-layered foresight, which is aimed to structure the benefits, effects and contributions of foresight and support the design, management and evaluation of foresight projects. The need for a framework to clarify the contribution of foresight emerged during the discussions in the case example, as we needed to both build the foresight capability of an organisation and create new future pathways for the region. Because the theoretical basis of foresight is diverse (Piirainen & Gonzalez, 2015; Mermet, Fuller, & van der Helm, 2009; Barré & Keenan, 2008; Hideg, 2007), it was important to link the framework to different traditions and theories in Section 2. The concept of multi-layered foresight may help clarify and structure what is being created in foresight and what levels of analysis are implicit in different foresight approaches. We invite also other scholars to develop the concept further and test it in different contexts to improve its applicability.

With our empirically based concept of multi-layered foresight the goal is not to introduce yet another type of foresight, but rather to help position different foresight approaches in relation to each other and clarify their contributions. The layers help to achieve this in two ways:

- By positioning the foresight exercise in relation to the broader context and more specific parts of the system. For example when foresight is aimed mainly at renewing the innovation system, this type of exercise needs to consider developments in the landscape layer, such as global megatrends and geopolitics. Likewise, organisations that are part of the innovation system could devise their own strategy by deliberating on the identified alternative future developments of the innovation system.
- By positioning the contributions of foresight in the context where the foresight exercise is conducted. For example, how could the outcomes of a foresight process aimed at enhancing the innovation system be of use to the organisations in the innovation system or for the individuals in the organisations?

While the concept of multiple layers is not new (see e.g. Geels, 2002), it has not been systematically applied to structuring foresight contributions and approaches. The layers we suggest have been considered in foresight mostly separately, as was demonstrated in Section 2. The concept of multi-layered foresight brings the different layers together and also highlights the individual layer, which is often neglected. The explicit structuring of the contributions of foresight to three facets and four layers helps in the positioning of different foresight approaches. There are thus three main contributions of this article to the research on foresight: combining different layers, highlighting the individual learning and capabilities, and positioning different foresight approaches and practices.

For practitioners designing and conducting foresight our results provide both a checklist and examples on the effect and influence of foresight, and a rough framework of which layers to consider. We argue that by taking into account all of the layers practitioners can better design foresight exercises that (1) are relevant and interesting to the individuals involved, (2) contribute to the capabilities of the organisation, (3) shape the system to enable the desired future and (4) capture the most recent advances and create new knowledge on the topic. For funders or customers of foresight our results systematically show that there is more to foresight than just the process and immediate outcomes. For example, a successful foresight process might change the capacity of an organisation or a community to anticipate the future and through that even create a regional transformation. However, further research developing and applying multi-layered structures to analyse foresight exercises is needed to capture the full potential of foresight activities.

Acknowledgements

Financial support from the VTT Graduate School is acknowledged (Mikko Dufva). The contribution of Totti Könnölä was made possible thanks to the financial support of Insight Foresight Institute.

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Article IV

Dufva, M., Ilmola, L. & Ahlqvist, T. 2015. Emergence of shared perceptions of futures in a foresight system. Submitted manuscript, 32 pages.

Emergence of shared perceptions of futures in a foresight system

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Abstract

Foresight is an approach for anticipating future developments in a given topic area. Foresight both explores alternative futures and facilitates discussion on the preferable futures, often aiming to generate shared future perceptions. Shared perceptions emerge from the interactions between agents. However, the dynamics through which this shared perception arises has gained little attention in foresight literature. In this report we study the emergence of shared perceptions in what we call a foresight system. We define the notion of a foresight system based on literature on foresight, complex adaptive systems and social constructionism. In this study the foresight system is studied as a subsystem embedded in a wider innovation system. For scrutinizing the construction of shared perceptions, we conducted an empirical analysis of the written documents generated during the production of the Finnish Government's report on the future. Through qualitative analysis guided by text-mining we tracked the conceptual changes documented in the different phases of this process. The concept of growth was the key analytical target. The results show that the foresight system does not function as foresight literature commonly anticipates; instead of producing radically new concepts, the foresight project changed the contents of the concepts. In the analysed material, the concept of growth firstly changed from economic growth to sustainable growth, and, secondly, economic growth was reframed as sustainable growth by decoupling it from material growth. The results imply that intensive interaction during the foresight process has a power to change the contents of the concepts used. The systems view contributes to the theory and practice of foresight by providing a frame for understanding the interactions between agents involved in a foresight system.

Keywords: foresight system; foresight process; shared perceptions; sensemaking; complex adaptive systems

1. Introduction

Foresight is an approach for anticipating future developments in a given topic area. It has been defined as an ability, a set of methods and a systematic and participatory process of exploring alternative futures and coming up with actions to be implemented in the present (Miles et al., 2008; Rohrbeck, 2011; Slaughter, 1997). Through foresight one can explore the alternative future developments of the operational environment, and facilitate discussion on what is thought to be the preferable development direction and future state of the system. Outcomes of the foresight process describe different perceptions of what the future might be, what is probable and what is preferable (Fuller and Loogma, 2009; Barré and Keenan, 2008). In this paper we focus on how these perceptions about the futures are developed.

The question about how perceptions about the futures emerge has not gained much attention in foresight or futures literature. Traditional foresight literature has focused more on the methodological aspects or philosophical underpinnings of futures knowledge (Schwartz, 1991; Slaughter, 2001; Dufva and Ahlqvist, 2014). In this study we argue that foresight process, and related dynamics, could be perceived as a system. Recent literature has set a request for more profound theoretical grounding for foresight as a discipline. (Barré and Keenan, 2008; Hideg, 2007). This study aims to do its best in order to address this request and to contribute to the theoretical development of foresight by introducing one aspect of the systems analysis to the body of knowledge. We claim that the systems view facilitates a more transparent and in-depth understanding of foresight processes (see also Amanatidou and Guy, 2008; Andersen and Andersen, 2014).

There are three strands of previous foresight research that are relevant for understanding how shared perceptions emerge. We call these the process view, the impacts view and the systems view. The process view focuses on the idealized phases of a foresight exercise and the methods that are useful in these phases (see e.g. Heger and Rohrbeck, 2012; Rohrbeck, 2011; Smith and Saritas, 2011; Popper, 2008b; Voros, 2003; Horton, 1999;). However, instead of describing a linear, neat foresight process, we study a real-world foresight exercise, including all of its “actual messiness”. This empirical work offers an opportunity to compare the idealized and real-life case descriptions, and thus benefit the methodological development of foresight. We present some initial insights on this comparison in the conclusions.

The impacts view focuses on the analysis of the real-world foresight exercises, which has been a core rationale, for example, in foresight evaluation (see e.g. Georghiou and Keenan, 2006; Martin and Johnston, 1999; Salo et al., 2009; Rijkens Klomp and Van Der Duin, 2014; Havas et al., 2010). In the evaluation studies, the focus has been on the assessment of the quality of the process and its outcomes as well as analysis of the results, if the stated goals have been met. In contrast to these studies, this research is not about evaluating the quality or the outcomes of the foresight exercise, but rather about exploring the actual process evolution, that is, analysing what happened in a foresight process, how it happened, and why it happened. The outcome of our analysis is not normative, although the frameworks we use might be useful also for the evaluation of foresight processes.

The systems view seeks to combine systems thinking and foresight (see e.g. Saritas, 2013; Andersen et al., 2014; Amanatidou and Guy, 2008; Alkemade et al., 2007; Andersen and Andersen, 2014). The aim of this strand is to improve foresight processes by approaching foresight from a systems perspective; mainly by considering it as a system and analysing the interconnections and feedbacks of the case studied. In order to deepen this systems perspective, we will study the agents[1] in the foresight process, and their network and interactions. In this study, the "foresight system" is perceived as a subsystem in the wider innovation and policy development system. Our research question is thus:

How do shared perceptions about futures emerge in a foresight system?

Our study is unique by its nature due three reasons: it applies comprehensive systems thinking (in section 2 we will define what we mean by a foresight system), we had access to all the documentation of the strategic foresight process of the government (section 3 presents the case study) and we applied an automatic analysis method that minimizes the researcher impact on the analysis of the qualitative data (methodology used is described in section 3). Section 4 describes the results; changes in the perceptions and links them to the interactions between agents in the foresight system. Section 5 discusses the results, benefits and pitfalls of a systemic view of foresight. Section 6 concludes with the main implications for research and practice of foresight and recommendations for further research.

[1] By agent we mean an individual, a group, an organisation or other entity that acts, in other words, that has an agency. See Anderson, 1999; Lane and Maxfield, 2005.

2. Foresight system and concept network

The generation of shared perception of the future takes place in a social system (Luhmann 1995). Thus, the theoretical basis for our research is in the theory of complex adaptive systems (e.g. Kaufmann, 1995; Anderson, 1999; Stacey, 1996) and sensemaking via the social construction of reality (Berger and Luckmann 1967; Luhmann 1995; Weick,1995). The main purpose of a social system is to distinguish itself from other systems and from its environment (Berger and Luckmann, 1967). For this purpose the social system is building, maintaining and defending its identity (Luhmann, 1995). In order to exist, the social system develops a shared perception of identity, internal rules of operation and the idea about the nature of its environment (Anderson, 1999). The foresight system supports all of these features, and thus it is part of identity building. The social process is intersubjective and based on communications (Stacey 1995), and thus the interaction between agents is a core element of the foresight system and process. Taking these characteristics into account, we consider the foresight system as a complex adaptive social system that is embedded in the innovation system[2] (see Figure 1).

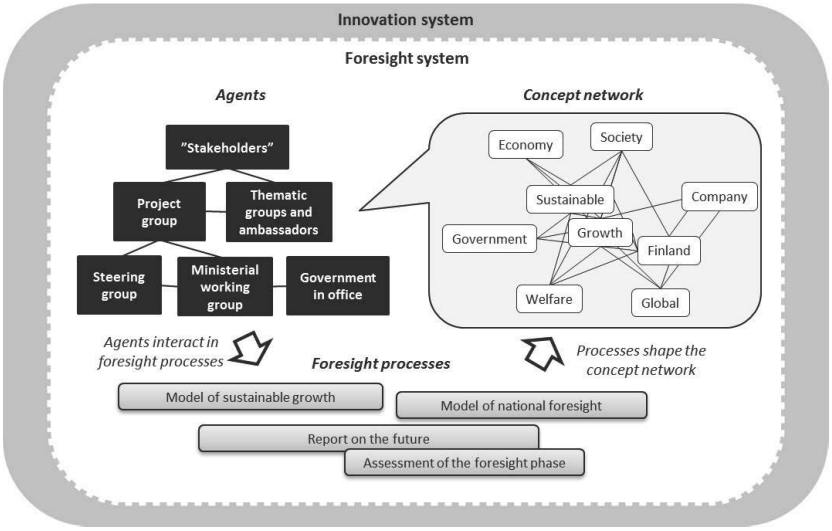

Figure 1. Innovation system, foresight system, foresight processes and the concept network in the case study.

[2] An innovation system is a societal system consisting of actors and institutions that contribute, directly or indirectly, to the emergence or production of innovation (Hekkert et al., 2007, p. 414)

The concept of 'system' has been defined as a functionally indivisible set of interconnected, interdependent agents, which together generate emergent, aggregate behaviour not attributable to any single element (Ackoff, 1974). A social system as a complex adaptive system has the following features in addition (Kaufmann, 1995; Anderson, 1999; Stacey, 1995; Pascale et al., 1999):

- It consists of agents with different perceptions acting in parallel
- It is self-organizing: order and patterns emerge without central control
- It is a dissipative structure: it requires energy from the outside in order to self-organize
- It can exist in a state of "bounded instability", meaning the exact behaviour of agents cannot be predicted, but it will be within limits. Of course, it can also be unstable and in a chaotic state.
- It evolves: agents, their perceptions, their interactions and the structure of the system change over time.

By applying these definitions, we can clarify what we mean by a foresight system. We define it as a transient ensemble of agents, set up to catalyse future-oriented insights, decisions and actions in a certain context. It consists of a set of interacting agents, such as the government, funders, universities and other stakeholder groups, each with their own perceptions about futures. We define the aim of the interactions to be:

1. to make sense of and share the social system's perceptions of possible futures,
2. to support existing identity and thus filter information that has meaning in the identity building process,
3. to process new information in order to challenge existing ideas about the current reality and drivers of futures, and exploring new ones, and
4. to reflect these ideas to the present in order to come up with actions to both adapt to and influence the futures.

The term "foresight system" has been used before by Amanatidou and Guy (2008) in building a framework for assessing the impacts of foresight. Compared to their work, we put more emphasis

on the relations and interactions of agents and less on the impact assessment. Another previous approach to combine systems concepts and foresight is the work by Saritas in defining a "Systemic Foresight Methodology" (Saritas, 2013). However, in contrast to our research, Saritas does not consider foresight itself as a system, but rather as a systemic inquiry about human systems. More recently Andersen et al. (2014) have proposed an approach called "Innovation System Foresight", which builds on the systemic view of innovation and sees foresight as embedded in the innovation system. They also make a distinction between the process of foresight, which is presented as a linear sequence of activities, and Innovation System Foresight, which takes into account also the demand and use of the results in the context of an innovation system (Andersen and Andersen, 2014).

We apply the Innovation System Foresight framework, but we make a distinction between the foresight system and the foresight process. The foresight system operates through different foresight processes. We define a foresight process as a temporary and dynamic activity of analysis of the drivers of change in order to produce better insight into alternative futures (cf. Bishop et al., 2007; Godet, 2000; Schwartz, 1991). There can be several foresight processes going on simultaneously in the foresight system. The boundaries of the system are thus not defined by a single foresight process, but rather by the agents and their perceptions involved in foresight. Much of the literature on foresight has thus far focused on a single process, often slicing the foresight process into different linear phases and offering advice on which methods to use during which phase (Bishop et al., 2007, Popper, 2008b; Smith and Saritas, 2011; Andersen and Andersen, 2014). This view fails to consider the continuous interaction between different parallel foresight processes in the system. By considering the foresight process and foresight system as different concepts, we hope to shed more light onto the interactions of a foresight process with its environment.

The shared perception about futures is socially constructed. New constructions of futures emerge from the interactions between agents (Breger and Luckman 1967, Fuller and Loogma, 2009; Luhmann 1995). The shared perception is thus an emergent property of the system. It represents the dominant view about futures. However, the shared perception is not the same as a consensus about futures. It is not necessarily equally shared by all those involved in the foresight process.

In order to study the dynamics of the process we operationalize the shared perception as a set of concepts. Agents have different ideas and perceptions about futures, which they communicate via interactions with other agents. The concepts used by agents reflect their perceptions. The

concepts and their connections form a concept network, which can be used as a representation of the shared perception. The concept network describes which concepts are used in the foresight system, and how they are connected. By studying the concept network at different phases of the foresight process, the changes in the shared perception (Ilmola and Kuusi, 2013) can be analysed.

3. Case description and methodology

3.1. Finnish Government's report on the future

As a case study we analysed the process of creating the Finnish Government's report on the future titled "Well-being Through Sustainable Growth" published in October 2013 (Prime Minister's Office, 2013). The Finnish Government prepares a report on the future of Finland and its environment for the Parliament once during each parliamentary term. The topics vary from report to report, but their task is to ensure continuity across parliamentary terms by highlighting issues that require future attention and are not the responsibility of any single ministry. The report on the future is deeply connected to Finnish policy making, as it is used as one of the inputs to the next government program as well as the strategies of the ministries.

The report published in 2013 looks at the future of Finland to year 2030 with a focus on sustainable growth and wellbeing. Its aim was to generate new and "fresh" ideas about the future directions and desired future of Finland in 2030. The preparation of the 2013 government report on the future put more emphasis on participation compared to the previous reports on the future. For the first time the preparation was divided into a separate participatory foresight phase that applied many channels for participation, such as surveys, workshops, invited expert groups and an online platform for dissemination and debate. The participatory nature of the preparation process provided us with an excellent opportunity to analyse the influence of agent interactions on the emergence of shared perception.

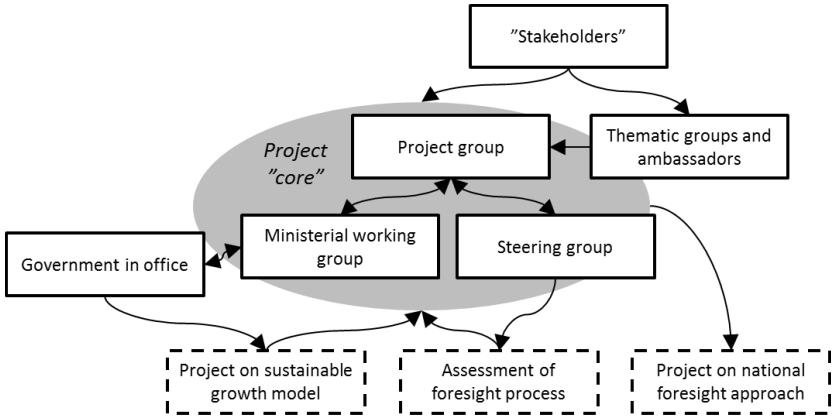

Figure 2. Main agents in the foresight system of the case study.

Different phases of the foresight process involved many stakeholders. To enable agent-specific analysis of development of shared perceptions about futures, the following agents were analysed: the project group, ministerial working group, steering group, thematic expert groups and stakeholders (figure 2). The project group consisted of 2 representatives from each of the four main organizations in the project: the Prime Minister's Office, the Finnish Innovation Fund Sitra, the Academy of Finland, and the Funding Agency for Technology and Innovation Tekes.

There were also three parallel processes tightly connected to the government report on the future: a report on a sustainable growth model ordered by the Prime Minister's office from a group of experts (Castells and Himanen, 2013), an assessment of the foresight process (Ramboll, 2013) and a project on developing a national foresight approach (Prime Minister's Office 2014). The report on the sustainable growth model was used as one of the inputs in the report on the future. The assessment of the foresight phase analysed the experiences and initial results from the making of the report on the future, but its results were also used as inputs to the final report on the future. The development of the national foresight approach project arose during the making of the report on the future, and used its results as a starting point. While we highlight some of the effects these parallel processes had on the making of the report on the future, a thorough analysis of the interactions between the processes is outside the scope of this paper.

In order to study the interactive nature of the foresight system we focused our analysis on three project phases: an online survey at the beginning of the project, the refining of the themes in formal meetings of the steering group and the ministerial working group, and the work of invited

thematic expert groups. The online survey was used to capture a wide audience and help in defining the scope of the project.

The survey results were used in drafting initial themes on which to focus, that were refined in the formal meetings. The refined themes were then used to guide the work of thematic expert groups. The outcome of the thematic expert groups was published as an interactive online report (Prime Minister's Office et al., 2013). The online report was the basis for the final report on the future.

The survey, formal meetings and thematic expert groups represent three common ways of participation in a foresight process. Online surveys are a way to gather input from a broad range of stakeholders (Popper, 2008a). Expert groups do not enable as extensive participation, but still gather participants with diverse backgrounds and thus provide the process with wide perspectives (Ilmola and Kuusi, 2013). In expert groups it is possible to discuss a topic in more detail than is possible in a wide online survey (Popper, 2008a). The formal meetings represent the other end of the spectrum with a stricter agenda and focus on sharing existing information and aligning the process with the interests of the key agents rather than exploration of the topic and creating new information.

3.2. Description of data and analysis method

The analysis is based on written documents of different lengths produced during the process (see Table 1). They were analysed qualitatively by comparing how different key concepts were framed in different phases of the process. In order to minimize researcher bias in interpreting the data (Ilmola 2014), we used automatic text mining to guide the analysis. The documents were fed into text-mining software that analysed the co-occurrence of words in paragraphs as well as how close to each other they appeared in the paragraph. This gave a rough picture of what were the most often used words and what words were used together. Common words were removed from the analysis and different versions of the words were treated as the same word. The software listed the number of occurrences for each word and created a "concept map", which showed the main connections between a chosen word and the words that were most often connected to it. An example of a concept map is given in figure 3.

Table 1. Material used in the analysis

Phase	Data	Paragraphs
Initial state	Government program 2011	1 200
Preparation	Preparatory memos by project group	30
Survey	Survey answers	19 000
Initial themes	Theme descriptions suggested by project group	280
Refining themes	Comments by ministerial and steering groups	30
Final themes	Final theme descriptions given to thematic groups	200
Thematic groups – initial	Preparatory questionnaire	790
Thematic groups – final	Foresight report	500
Final state	Government report on the future	350

The research question of this study was "How do shared perceptions about futures emerge in a foresight system?" In order to operationalize this question we divided it into two more specific questions; "What was the change in the concepts used?" and "How did this change happen?" First we describe the method used for addressing the first sub-question.

3.2.1 What was the change in the concepts used?

In this study the concept map is a representation of the concept network. By comparing the concept maps from different parts of the process, and by analyzing the similarities and differences of the concept maps, we could identify what were the changes in the concept network. We identified also the changes in the meaning of the individual concepts by reviewing the contexts in which the concept was used. This was done by analyzing all the phrases the concept occurred in. The outcome of this analysis describes how different concepts changed during the process.

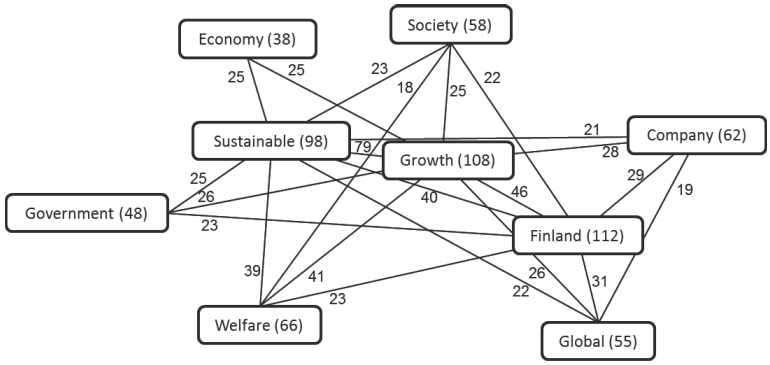

Figure 3. Concept map from the government report. The number in the concept box refers to the number of paragraphs in which a concept was mentioned. Numbers within links reveal the connection counts between concepts.

3.2.2. How did the change of concepts happen?

The analysis of the concept maps focuses on the changes in the concepts and concept networks. For understanding how the change happened, a further analysis of the foresight system agents and their interaction is needed. In order to analyze the functioning of the foresight system we use innovation systems literature. An innovation system is characterized both by its structure and by its functions (Alkemade et al., 2007; Andersen and Andersen, 2014). In this study we adopted the functions as described by Hekkert et al. (2007). These functions are entrepreneurial activities, knowledge development, knowledge diffusion, guidance of the search, market formation, resource mobilization and the creation of legitimacy. Since these functions describe the processes that need to be in place in a well performing innovation system, they provide a heuristic for analyzing the functioning of the foresight system as well. However, the innovation system functions have to be adapted to the specific characteristics of a foresight system (see table 2).

Table 2. Innovation system functions and foresight system functions

Original definition by Hekkert (2007)	Our adapted definition[3]
Entrepreneurial experimentation: In an innovation system the role of the entrepreneur is to take existing knowledge, apply it in practice and experiment with new solutions, thus creating new knowledge.	Exploration of alternative futures and involvement of new agents
Knowledge development: research and development and other activities resulting in learning by search or learning by doing.	Shared sensemaking and synthesis of knowledge
Knowledge diffusion: sharing of information between actors in the innovation system.	Knowledge diffusion
Guidance of search: the selection mechanism in innovation systems, defining the focus for the search of technological options.	Defining the scope
Market creation: the creation of protected space for a new technology in order for it to increase its chances of competing against existing technologies. This can be done by favouring a specific technology or creating a niche market for it.	Demand articulation
Resource mobilisation: In innovation systems different functions, especially knowledge development, require both financial and human capital as an input.	Resource mobilization
Creation of legitimacy: activities by interest and lobby groups to promote a specific technology.	Creation of legitimacy

[3] See a detailed description in section 3.2.2

Based on the original function definitions, we defined the foresight system functions as follows:

1. Exploration of alternative futures and involvement of new agents, which focuses on how agents in the foresight system use existing knowledge as a basis to explore alternative futures and on the inclusion of new agents to the system.
2. Shared sensemaking and synthesis of knowledge, which focuses on how agents interpret futures knowledge according to their perceptions, and cluster fragments of knowledge to form a coherent narratives and images of the futures.
3. Knowledge diffusion, which focuses on the networking and exchange of information among different agents. We especially looked at the intensity of the information exchange (how frequently the agents exchange information), the diversity of information (how much do the ideas presented vary), and the direction of the information flow (for example is it from many to one, one to many, or interactive)
4. Defining the scope, which bounds the foresight process to consider only certain topics and ignore others (cf. Popper, 2008b; Keenan and Miles, 2008). While this is necessary for practical reasons, considering how, when and by whom the scope is defined is important in ensuring the transparency of the foresight process.
5. Demand articulation, which focuses on how the need for the foresight process is framed and a "protected space" is created to explore alternative futures. This can mean for example analyzing how the foresight process is connected to a policy or strategy process.
6. Resource mobilization, which focuses on how both financial and human capital is used in the system. From a complex adaptive systems perspective, mobilizing resources is one way of bringing the system or maintaining it in a state of bounded instability, since it increases the energy of the system.
7. Creation of legitimacy, which focuses on the promotion and lobbying for a specific perception about futures.

The functions were used as a structure for analyzing the changes in the concept network. We focused on same three main phases of the process as in the concept network analysis: the preparation and survey, the feedback meetings and the work done in the thematic expert groups. We analysed the changes identified in the concept network using each of the functions in turn.

We also used material describing the process to gain a better understanding of the context in which the changes took place, for example the agendas for the feedback meetings or thematic group work. The functions offer different views and highlight different aspects of the system. In the next section, we will describe first the changes in the key concepts and then use the functions to analyse how these changes took place.

4. Results

4.1. Comparison of initial and final concept networks

The change in the overall perceptions before and after the process, was analyzed by comparing the concept maps from of the government program from 2011 and the government report on the future. While these documents represent how the government views the concept network, they also describe the dominant or official discourse for talking about the future, since the government is one of the main agents in the system. The differences between the government program and the government report on the future are mainly on the emphasis (figure 4). Some of the differences can be attributed to the purpose of the document, such as with the concepts of sustainability, growth and wellbeing, because those were the topics of the report on the future. In addition, there seems to be less emphasis in structures in the report on the future, but the report focuses on "enabling" positive development, which is not captured by the text mining.

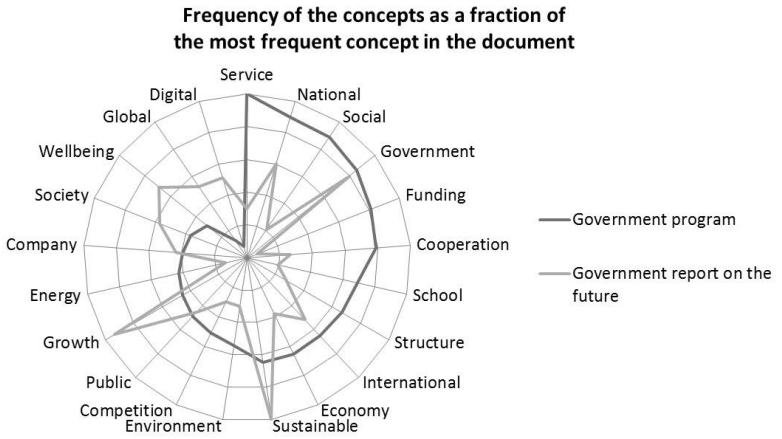

Figure 4. Frequency of the 15 most common concepts in both documents as a fraction of the most frequent concepts.

When the differences due to the nature of the report are taken into account, the government report on the future seems to put more emphasis on the concept of society, while many of the concepts mentioned in the government program seem to receive less attention in the government report on the future, such as social, school and energy. However, the changes are more on the emphasis and few new concepts are introduced. One notable exception is the concept of “digital” that is hardly mentioned in the government program, but is one of the key concepts in the report on the future. While “digital” is mentioned in the government program, it is mostly in the context of digital technology, while in the government report on the future it is about “digital economy”, which is a concept that was introduced somewhere during the process.

4.2. Changes in the concept of growth

The comparison of the initial and final concept networks showed that there were changes in the emphasis as well as an introduction of a new concept. In order to describe these changes in more detail we analyzed how the concept of growth was framed in different parts of the process. The concept of growth was chosen as it is a central theme in the government report on the future. The analysis was based on the comparison of concept maps. A detailed description of the changes is given in Appendix A.

The main changes can be summarized as four phases (see figure 5). At the beginning of the process the concept of growth was understood mostly as economic growth that is restricted by concerns on environmental and social sustainability. However, the survey results challenged the underlying assumptions of economic growth and the emphasis on the concepts connected to the concept of growth shifted to responsible economy and sustainability. The ministerial working group and the steering group connected the concept of growth more to their aims, and thus the emphasis shifted even more towards sustainable growth and its enablers, although the concept of sustainable growth remained vague. The expert groups focused on the exploration and definition of the concepts and this phase reframed the concept of growth; now the economic growth was decoupled from material growth. The concept of digital economy is connected to this reframing.

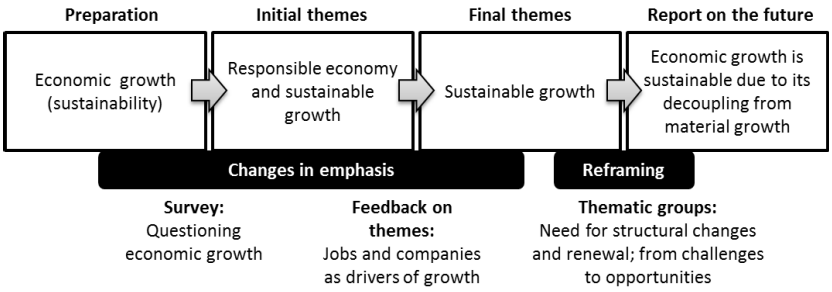

Figure 5. Summary of the changes in the concept of growth.

4.3. System functions and how change happened

Table 3 presents a summary of how the change happened using the system functions as a structure. In the survey, there was wide participation and thus a diversity of perceptions, but a main theme of challenging the paradigm of economic growth emerged from the answers. The survey offered a channel to voice concerns about the future and the results were used, at least to some extent, in defining the scope of the process. While the diversity of participants was very high, the flow of information was asymmetric and there was little interaction between agents. This is reflected in the shared sensemaking, which was done by the project group, resulting in a rewording of the scope rather than abandoning economic growth as a central concept.

In the feedback meetings of the ministerial working group and the steering group, there was practically no exploration of the topic, since the agenda was to reflect the suggestion for themes against the existing shared perception of the group. While the feedback meetings were much more interactive than the survey, they were among a group with a relatively common perception about the futures. The feedback meetings had an important role in connecting the process more closely to the demands of the government by refining the scope to be more acceptable for the government.

In the thematic group work the scope of the foresight exercise was set and it defined the space and boundaries of exploration. There was a lot of interaction between a selected, but diverse group of stakeholders. The information flow was mostly symmetric, although the chairpersons of the groups were more aware of the work done in other groups than the other participants. The groups both explored and defined what different concepts, such as sustainable growth, mean. As a result of the exploration and shared sensemaking, some of the concepts were reframed in order to guide the path towards a desirable future.

Table 3. Analysis of the process phases based on the system functions.

Change in the concept of growth	Preparation and survey: Economic to responsible	Feedback meetings: Responsible to sustainable	Thematic group work: Economic is sustainable due to decoupling
Exploration	New agents question economic growth	No exploration due to meeting agenda	Different meanings of sustainable explored
Shared sensemaking	Rewording to fit answers to original aim	Alignment with existing perceptions	Reframing of concepts to produce coherent, desirable future
Diffusion	Asymmetric, low intensity, high diversity	Symmetric, high intensity, low diversity	Symmetric (partly), high intensity, high diversity
Scoping	Results used in scoping the process	Refining the scope to meet government aims	Emphasis on specifying and framing rather than scoping
Demand	Offering a space to voice opinions	Process connected more closely to government needs	Creating a space for foresight
Resources	Large flow of information into the system moves it away from stability	No new resources	Intense interaction between different agents moves the system away from stability
Creation of legitimacy	Inclusion of a large set of stakeholders	Aligning with government aims	Reframing challenges as opportunities to increase acceptability

5. Discussion

The research question of this study is: how shared perceptions emerge in a foresight system? The results suggest that the final perceptions about futures are gradually shaped from existing perceptions. In our case example, the foresight process changed the emphasis of existing concepts but did not report radically new ideas. This is contrary to the stated aim of generating new and “fresh” ideas about the future. However, even if the role of foresight was different than expected it cannot be considered as a failure. The main role of the foresight in this case was to challenge and shape existing perceptions in order to be better prepared for the futures.

There was one notable concept that emerged from the process, that of a digital economy. It was based on the reframing of growth in the thematic group work and further refined after the publication of the foresight report. This new concept can be seen as an example of a reframing where a constraint is perceived as an opportunity. There were also other similar examples, such as the “government as an enabler”, which represents a shift from a control role to guidance role of the government.

In the survey there was a lot of new information from a diverse set of stakeholders. This brought the process away from the “stabile state” by questioning the original aim and concepts that were used. However, due to a low intensity of interaction, the process did not perhaps reach the “edge of chaos”, where new ideas would have been created. The feedback meeting had a stabilizing role, but the thematic group work again disturbed the system, this time by creating a lot of interaction between different agents. This resulted not only in shifts in emphasis, but in reframing of some of the concepts.

The results indicate that intense interaction between diverse agents supports the reframing of concepts better than surveys or small focused feedback meetings. This is supported by the complex adaptive systems theory, which claims that in order for the system to produce something new, it needs to be in a self-organizing state. In order to get there, the system needs import of energy; new agents, new challenges or more interaction between the agents (Anderson, 1999). Expert group work had all of these three aspects, but the results indicate that the most important aspect was the intense interaction and the space for exploring the themes.

The systems view also brings the influence of other processes into focus. While the context dependence of foresight has been noted before (Amanatidou and Guy, 2008; Andersen and Andersen, 2014; Cariola and Rolfo, 2004), there is little studies of foresight processes that take other parallel processes into account. The systems view to foresight thus not only considers a single foresight study as a system, but also sees the practice of foresight itself as part of a wider system. This means that foresight does not consist of separate foresight processes, but it should be perceived as continuous interaction between agents involved in anticipating the future. For example, the project on sustainable growth model was one of the inputs to the final report on the future, and could be seen to support the reframing of growth as sustainable. In further research the connections between different foresight processes could be analysed in more detail.

The results also shed light on the nature of participation in a foresight process. While participation is claimed to be one of the key characteristics of foresight (van der Helm, 2007; Miles et al., 2008; Cagnin and Keenan, 2008; Glenn and Gordon, 2003), it has also been criticized as being too expert-oriented and ignoring many stakeholder groups (Kettunen, 2014; Bauer and Pregernik, 2013; Loveridge and Street, 2005). The process for creating the report on the future had an explicit emphasis on participation. The process included charting the views of stakeholders beyond the “usual suspects” of experts mainly via the online survey and, to some extent, also via meetings and hearings. However, it seems that despite this explicit aim, the views of the

stakeholders, at least those articulated in the survey, in the end did not have much influence on the outcomes of the process.

Based on the analysis of the conceptual changes, we propose three types of participation in order to explicate why the stated and actual participation differed. In the first type the entire process is framed based on the data received and interpreted by the stakeholders. In other words, the framing is constructed though open and transparent participation. In the process, the framing emerges from the interaction between the stakeholders, i.e. the agents in the system. In the second type the framing is based on expert participation. Experts discuss and define the framing based on their perceptions of what is important for the process. In the third type the framing is decided by the owners or the initiators of the process. The role of participation is to give feedback inside the predefined framing, i.e. what stakeholders think are important things within the framing, and to inform the stakeholders of the interests of the owner of the process. However, the framing as such is not open for discussion and thus remains relatively unchanged, despite the discussion or feedback.

Using these three participation types, it would seem that although the process was explicitly stated to be of the first type, that of empowered participation, it was implicitly more of the third type, that of locked framing. Thus, the power structure among the actors of the process was presented to be somewhat balanced and non-biased, but actually the power structure was quite asymmetric and biased towards the initiator of the process, that is, the state government. All three ideal types were present to differing degrees throughout the process. The survey is a clear example of the first type, aiming to get the views of the stakeholders with a relatively open scope. However, an initial, more restrictive framing was in the background and was surfaced in the interpretation of the survey results and in the feedback meetings. The thematic expert groups are a good example of the second ideal type of expert participation, but it too was shadowed by the implicit framing that could not be challenged.

5.1. Limitations

We studied how the perceptions of the project group were transformed in three different parts of the process: the survey and its analysis, the feedback meetings of the ministerial and steering groups and the work done by the thematic groups. These phases were a main source of new knowledge in each of the phases, thus it is reasonable to assume that they had a substantial

influence. As there were a lot of other activities during the process, the changes in perceptions cannot be attributed solely on the phases analyzed.

The key limitation for the generalizability of the results is that they are based on a single case study. Furthermore, we analysed the process only until the finished report, and did not include how it was used to guide decision making or what kind of impact it had. However, the case study presents a typical example of a foresight exercise with surveys, expert groups and a small project team with a steering group. Therefore we think it is a good example of government-led foresight process and the suggested results provide a good basis for further research, but it is only a beginning and the conclusions should be tested in a more comprehensive setting. Further research is needed in refining the concept of foresight system and the functions. The functions provided a heuristic that proved to be useful for analyzing how the changes in perceptions happened, but more work is needed in clarifying them and making sure that they cover all relevant aspects of foresight.

6. Conclusion

Future developments are contingent upon the actions of the agents in the present, which are shaped by their perceptions of the present reality and the preferred future. In other words, the shared perceptions of futures have the power to influence how the future evolves. Therefore it is important to understand how the agents decide what is preferred and how the shared perceptions of futures emerge in the process. In this article we have used the systems perspective to study the changes in perceptions and how this change happened in a foresight process that will have a major impact on policy making in Finland.

An implicit assumption in much of the foresight literature is that it creates new perceptions about futures. The results suggest a different view. Shared perceptions are gradually formed based on existing perceptions by changing the emphasis and to some extent reframing the concepts used to talk about futures. The analysis of the case study indicates that foresight does not replace existing perceptions, but rather complements them by suggesting slight variations and sometimes new interpretations. New interpretations and reframing seem to be supported by intensive interaction between agents with diverse backgrounds, as in expert groups with broad representation.

While foresight is often expert-oriented, we suggest two complementary types of participation that help to understand the extent of the shaping of the shared perceptions. In the first type stakeholders are empowered to change the framing and scope of the process. The other ideal type is that of a given framing. The framing and scope are reflected in the shaping of the shared perceptions. For example, in the case study the framing was implicitly locked and thus there was only a slight change of meaning of the concepts used when talking about the future.

The systems view to foresight suggested in this article has three benefits compared to a traditional process-focused view. First, the systems approach provides us a way to study the dynamics of sensemaking and the way the shared perceptions are formed. By understanding who the agents are and how they interact in a foresight system, it is easier to understand what the needs, ambitions and aims are for the foresight process. It also brings to the fore the power relations between the agents and highlights who is involved and who is ignored.

Second, instead of focusing on one process, the foresight system aids in seeing a foresight process as part of continuum of processes. This helps in understanding the context (what processes is this foresight process based on and what is going on in parallel) as well as anticipating the use of the results (how will this process lead to further foresight processes). Third, through the first two benefits, the systems view provides a structure for coping with complexity. It helps in identifying the agents and analysing their interactions as well as seeing the process as part of a larger whole. Rather than trying to reduce or simplify foresight to a linear process, the systems view applies complexity as an inherent characteristic of foresight.

This paper contributes to the on-going discussion on combining systems thinking and foresight. We build on the notions of Systemic Foresight Methodology (Saritas, 2013) and Innovation System Foresight (Andersen and Andersen, 2014). The concept of a foresight system helps in understanding the context of foresight in which shared perceptions emerge. It also brings more structure to the analysis of the influence of parallel processes. Furthermore, we adapted the innovation systems functions as a frame of analysis of the interactions between agents. The functions help in understanding why and how the changes happened during the different phases of the foresight process. The results are useful for creating a better understanding of the dynamics of the foresight system.

For practitioners, the foresight system and the system functions provide a perspective that will help in designing and managing a foresight project. Instead of focusing only on the process, the

methods or even the substance, the emphasis should be on facilitating the interactions between the agents. This includes considerations about the diversity of agents, the intensity of their interaction, and the context of the foresight process.

Acknowledgements

Financial support from the Young Scientist Summer Program (YSSP) at the International Institute for Applied Systems Analysis (IIASA) and from the VTT Graduate School is acknowledged (Mikko Dufva).

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Appendix A.

Detailed description of the changes in the concept of growth

Preparation of the initial themes and the survey

The comparison of the concept maps of the preparatory memo and the initial theme suggestion shows that the concept of growth remained fairly unchanged (figures A1 and A2). There are two different concepts: instead of economy and social aspects, growth is now connected more with responsibility and competence. A closer look at the documents shows that in the preparatory memos there is an emphasis on trying to ensure social justice while aiming to continue productivity and economic growth. In the initial theme suggestion this has changed to a responsible economy and sustainable growth. In addition, instead of talking about creating growth, there is an emphasis on creating the requirements of growth. One requirement is ICT competence.

Even though the other concepts connected to growth seemed to stay the same, there were some differences in their framing. In the preparatory memo wellbeing was discussed in connection with the welfare society, while in the initial theme suggestion wellbeing is mentioned alongside growth, but their connection is not defined. Another concept that was slightly different is that of international: in the preparatory memo the aim was to get international recognition for the Finnish model of sustainable growth, while in the theme suggestion the emphasis was on companies operating in international markets and thus creating growth.

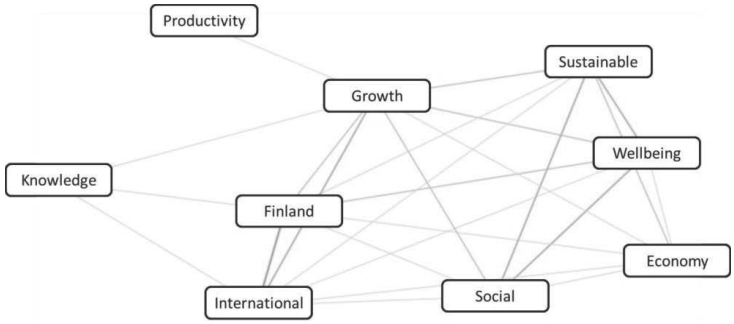

Figure A1. The concept of growth in the preparatory memos.

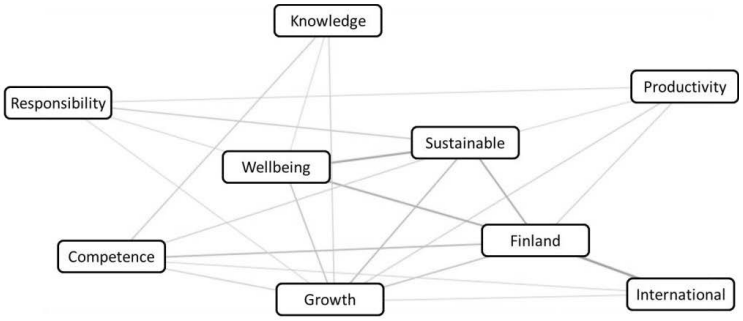

Figure A2. The concept of growth in the theme descriptions suggested by the project group.

The survey results explain the change from economic growth to a responsible economy and sustainable growth. Of all the survey answers, about 3% (650) explicitly mentioned growth. Out of these around 40% questioned the idea of continuing growth, either because of the limits, e.g. finite resources, or because the environment or welfare were seen as more important than economic growth. Despite that growth was largely questioned, about a third of the answers discussed the requirements of growth, including finding the balance between economic growth, welfare and the environment. About 10% of the answers mentioned the importance of companies, especially small- and medium-sized companies and small start-ups, as a driver for growth.

Even though 40% of the answers mentioning growth questioned its desirability, growth was kept as a main theme in the project. The main change was how growth was framed: the theme suggestion talks about responsible economy and sustainable growth instead of productivity growth. Furthermore instead of directly saying how to create growth, the emphasis is on creating an environment in which growth may flourish.

Feedback on the themes by the steering and ministerial working group

The theme suggestions were discussed in the steering group and ministerial working group and refined based on the feedback to the final theme descriptions by the project group. The concept map of growth of the final theme descriptions (figure A3) is similar to the concept maps based on the preparatory memo and the theme suggestion. The main difference is that instead of the concepts of responsibility, competence or information, growth is now more connected with “global”, jobs and companies. The disappearance of the concept of competences is due to

rewording: the theme description talks about state-of-the-art know-how and skills as the requirements of growth. Responsible economy is however not mentioned.

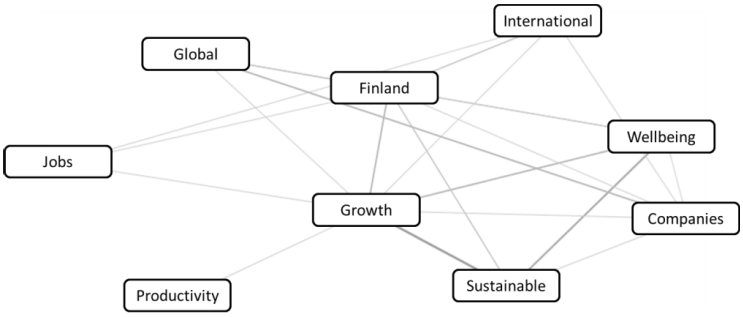

Figure A3. The concept of growth in the final theme descriptions.

The concepts of global, jobs and companies are all connected to the requirements for growth. Companies, including small and medium enterprises, are seen as parts of global value networks and creators of jobs and through this as drivers of growth. The listed requirements for growth include also a functioning and cohesive society and the renewal of industry structure. ICT is mentioned as the driver of productivity growth.

Most of these changes can be seen to come directly from the feedback given by the steering and ministerial working groups. Furthermore, they can be seen also in the government program. For example the government program emphasizes the importance of companies and jobs as drivers of growth. Global, on the other hand, is mostly connected to climate policy in the government program. There is, however, talk about companies operating in international markets. The feedback to put more emphasis on global developments came from the steering group, so it might reflect their perceptions more than that of the ministerial working group. The importance of ICT for productivity is not mentioned in the documentation of the feedback. It might be that it was mentioned in the discussion but not documented, or it might be an independent addition by the project group.

Work of the thematic groups

The final phase that we analyse covers both the thematic group work as well as the various hearings held after the thematic group work. However, we will only focus on analysing the work done by the thematic group, because that is well documented and is a good example of expert

panels, an often used participation method. We will first look at the changes from the theme descriptions to the final report and then analyse the thematic group work in more detail.

The concept map for growth based on the government report on the future is rather similar to that of the theme descriptions (figure A4). The main changes are that there is more emphasis on the connection between growth and economy, government and society. Even though jobs, productivity and international are not presented in the graph, they are discussed in the report in connection to enabling growth. The change is thus more in the emphasis.

Unlike in the earlier documents, the report on the future explicitly states that economic growth is the only way to create wellbeing. However, growth is decoupled from material growth by focusing on immaterial growth. Economic growth is thus reframed to be compatible with sustainable growth. The role of the government is specified to be the enabler of this growth, while the communities, NGOs and especially companies are the drivers and creators of growth. The requirements of growth are the main focus of the report, among them the cohesion of the society as well as the renewal of its structures.

The concepts that are mentioned in all of the concept maps are given more detailed description. Sustainable growth can partly mean “green growth”, that is growth of the industries focusing on environmental technologies and resource efficiency. Finland is seen not only as a place, but also as an actor, and the object of action. The connection of wellbeing and growth is articulated: growth is seen as a prerequisite of wellbeing and wellbeing as a requirement for growth.

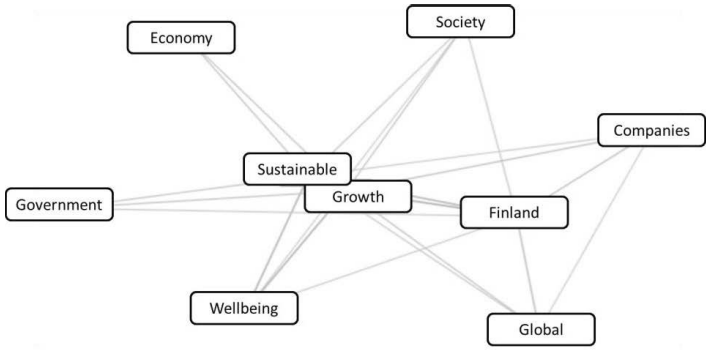

Figure A4. The concept of growth in the government report on the future.

In order to understand these changes better, we look at the start and end of the work of the thematic groups and see which concepts were reframed already during their work and which changes probably happened during the hearings and writing of the report on the future. In the initial questionnaire the members of the thematic groups emphasized the challenges of economic growth such as increasing inequality, limits to growth, and the need for sustainable growth. Economic growth was seen as a requirement for ensuring wellbeing, but the members were sceptical about being able to maintain growth and thus the quality of life. The main drivers of growth were thought to be growth companies operating in global markets, new innovations and technology, and the structural change of the industry. Growth industries mentioned included tourism, “cleantech” and technology around scarcity, renewable energy, mining, and marine transport. A concept map of the answers to the initial questionnaire is shown in Figure A5.

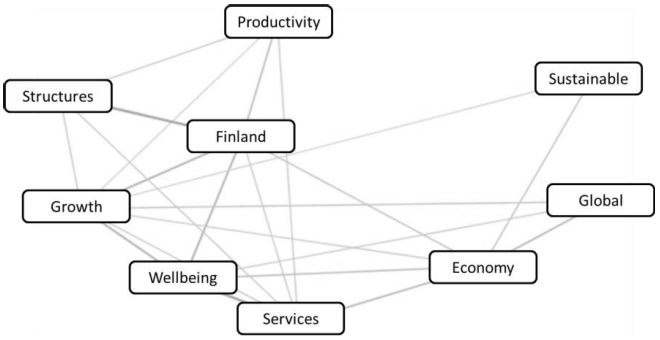

Figure A5. Concept map of ”Growth” based on the results of the initial questionnaire.

The concept map for the foresight report (figure A6) is similar to the one based on the results of the initial questionnaire, the main changes being less emphasis on economic growth and more on robust structures of the society and the skills and competences of people. Many of the challenges mentioned in the theme descriptions and in the responses to the initial questionnaire were translated as opportunities. For example, instead of inequality, the report talks about active citizens who are encouraged and enabled to shape society and ensure the growth that is necessary to bring wellbeing to everyone. In addition, instead of focusing on the limits to growth, the report focuses on improvements in resource efficiency as a way to increase the competitiveness of the Finnish economy also globally. Both of these require building a strong competence base and renewing existing structures.

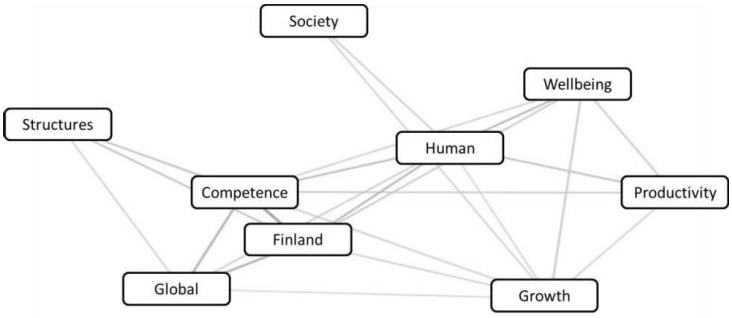

Figure A6. Concept map of "Growth" based on the Foresight report.

Based on this analysis of the thematic group work, the reframing seems to have happened mostly in the discussions of the thematic group. However, there are some influences from outside of the process that are worth mentioning. In parallel to the making of the report on the future there was a project on the sustainable growth model, which focused on reframing the economic growth (Castells and Himanen, 2013). In this model there is a link from sustainable wellbeing through sustainable economy back to sustainable growth, a link that appears also on the report on the future. Thus in the report growth is an enabler of wellbeing and wellbeing is a prerequisite of growth.

Foresight is often described as a process for anticipating future developments, scoping alternative futures and creating present actions based on futures knowledge. The foresight process is viewed as a strategic exercise disconnected from the everyday operations of organisations. Futures knowledge is then seen as the outcomes of the process, such as scenarios, roadmaps and visions. In this dissertation I apply a systems view to foresight and futures knowledge creation. I argue that futures knowledge is created gradually through the interaction between humans and can be seen as the shaping of a network of concepts. In addition to framing futures knowledge as a network of concepts, I propose a typology for futures knowledge, define the elements of a foresight system, and describe a multi-layered foresight framework. The main practical implication of the systems view to foresight is the shift from seeing foresight projects as separate to perceiving them as part of an interconnected whole.

Aalto-DD 222/2015
VTT SCIENCE 121

ISBN 978-952-60-6607-3 (printed)
ISBN 978-952-60-6608-0 (pdf)
ISSN-L 1799-4934
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)

978-951-38-8383-6 (printed)
978-951-38-8382-9 (pdf)
2242-119X
2242-119X (printed)
2242-1203 (pdf)

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