FTA and Innovation Systems

Per Dannemand Andersen [a], Ron Johnston [b], Ozcan Saritas [c]

[a] *Danmarks Tekniske Universitet (DTU), Produktionstorvet, Lyngby 2800 Kgs. Denmark*
[b] *Australian Centre for Innovation, University of Sydney, Australia*
[c] *Manchester Inst. of Innovation Research, University of Manchester, Oxford Road, Manchester, UK*

1. Introduction

This special issue is one of the outputs of the 5th International Conference on Future-Oriented Technology Analysis held in Brussels 27-28 November 2014. The articles in the special issue were selected from the manuscripts presented at the conference considering their relevance for Foresight and Innovation Systems. A few additional articles have been accepted through an open 'call for papers' process for this special issue.

The meaning and definition of the terms, "Future-oriented Technology Analysis (FTA)" and Foresight is debated in the literature (Sardar, 2010; Oner, 2010). To facilitate a dialogue between different epistemic communities the Joint Research Centre Institute for Prospective Technological Studies (JRC-IPTS) of the European Commission has introduced the label Future-oriented Technology Analysis (FTA) as a common umbrella term for technology foresight, technology forecasting and technology assessment. For the contributions to this special issue, we have narrowed in the meaning of FTA to cover Foresight in relation to public policy within science, technology and innovation. The term Foresight was introduced in 1984 in the book 'Foresight in Science. Picking the Winners' (Irvine and Martin, 1984). According to Martin (2012), the term foresight was used in this book as a convenient expression for a variety of techniques, mechanisms and procedures designed to identify areas of basic research with the potential to develop strategic potential. Hence, the relation to public policy was clear. As no commonly agreed terminology exists, the editors of this special issue have left it to the authors of each article to select their own. Hence, the articles use the terms Foresight, Future-Oriented Technology Analysis (FTA), and Forward-Looking Activities (FLA). Further definitions and distinctions may also be found in each article of the special issue.

In 1999, Ben Martin and Ron Johnston in this journal published the paper, 'Technology Foresight for Wiring Up the National Innovation System' (Martin and Johnston, 1999). The article emphasises the role and function that Foresight could play in enhancing the performance of innovation systems. Based on case studies of Foresight activities in three English-speaking countries, the article linked these experiences with the wide literature on technology and innovation policy. The conclusion was that technology foresight has a potentially important role to play in relation to national innovation systems, strengthening them in terms of the capacity to learn and innovate. In the period since 1984 and 1999 the practice and the theoretical understanding of foresight for innovation policy have undergone significant changes. This development have been described and discussed in several studies (Georghiou, 2001; Tegart and Johnston, 2004; Miles, 2008; Miles, 2010; Andersen and Alkærsig, 2016). This development mirrors the development in the wider field of innovation studies and innovation policy in the same period (Fagerberg and Verspagen, 2009; Martin, 2014). Martin and Johnston's article took its theoretical departure from the much larger and wider literature on technology and innovation policy. This literature has also developed significantly since 1999, and there is still a huge potential for foresight to draw from and contribute to the larger literature on innovation studies, industrial dynamics, and technology and innovation policy. The academic field of innovation studies has gradually expanded since the 1960s to include several thousand contributors from all over the world (Fagerberg and Verspagen, 2009). Although with strong roots in the 1950s, the academic field of foresight for innovation policy has mainly developed since the 1980s and includes probably only hundreds – if not less – of contributors, of which many are practitioners more than scholars[1].

A recent review of the two academic fields of innovation studies and foresight, respectively, showed that the two fields have co-evolved over the years (Andersen and Andersen, 2014). The review also argued that the field of foresight over the years has imported academic insight on innovation from the field of innovation studies, and that the field of foresight has been in a perpetual catching-up process vis-à-vis the field of innovation studies.

The conceptual interconnection between foresight and wider innovation literature has been explored by several studies (Alkemade et al., 2007; Cagnin et al., 2012). However, these studies often focus on how foresight can contribute to innovation system policies, with foresight being regarded as one among a range of other systemic policy instruments (Smits et al., 2010). As the field of foresight is in a catching-up process in relation to the field of innovation studies, it is relevant to study how the recent development in the innovation literature can contribute to the practice and to the theoretical underpinning of foresight.

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[1] A simple search in Scopus on the terms 'foresight' and 'innovation' in 'Article Title, Abstract, Keyword' resulted in 660 publications, and that only 53 authors have published more than 2 articles (26 October 2016).

Jan Fagerberg, Ben Martin and colleagues have in several recent articles summarised the field of innovation studies – including innovation policy studies – and its development (Fagerberg and Verspagen, 2009; Fagerberg et al., 2012; Fagerberg, 2016; Martin, 2012; Martin, 2014). One of the most important developments described in these studies is that innovation system studies increasingly have adopted a more systemic and evolutionary understanding of innovation. Foresight for innovation policy has responded to this development by also including a more systemic and evolutionary understanding of innovation into its conceptual development and its applied practice (Alkemade et al., 2007; Abadie et al., 2010; Saritas, 2011; Cagnin et al., 2012; Andersen and Andersen, 2014; Andersen and Alkærsig, 2016). Hence, the special interest in this special issue on foresight and innovation systems.

2. Recent developments in foresight and innovation systems

In the following, we will elucidate three recent developments in foresight and innovation system studies and link each of these trends to this special issue. First, the wider field of innovation policy studies has recently noted that policy making has changed its focus on the national level to a more complicated situation with policy intervention on multiple levels: supra-national, national and regional (Martin, 2014). Also foresight has broadened its interest in policies for national innovation systems to comprise related concepts such as sectoral innovation systems (Abadie et al., 2010; Andersen et al., 2014), innovation systems around emerging developments in technology (e.g. Hekkert et al., 2007), regional innovation systems and clusters (Roveda and Vecchiato, 2008; Vecchiato and Roveda, 2014; Keller et al., 2015). The interest in foresight and regional innovation systems is not new (Cooke et al., 1997; Gavigan et al., 2001; Asheim and Gertler, 2005), but has received increasing attention in recent years, both from the wider regional innovation system community (Boschma and Frenken, 2011; Markard et al., 2009) and from policy-making. However, regional foresight exercises are often criticised for producing standard recommendations that disregard the regional context. What is required is an understanding of the regional context and inclusion of regional business communities, institutions and governmental agencies (Foray et al., 2011). Most recently smart specialisation (RIS3) has become an important policy concept under the Europe 2020 agenda (Foray et al., 2011; Foray, 2014). Foresight's role vis-à-vis regional innovation policies and the smart specialization agenda is of particular interest to less advanced and transition regions of Europe (Paliokaite et al., 2015).

Four articles in the special issues relate to this second overall development in foresight and innovation policy studies.

Weber and Schaper-Rinkel (Weber and Schaper-Rinkel, 2017) take their theoretical departure from Franco Malerba's work on sectoral innovation systems (Malerba, 2002). Empirically, they draw on insights from – and across - nine sectoral foresight reports carried out as Sectoral Innovation Watch projects within the Europe INNOVA initiative launched by the European Commission's Directorate General Enterprise and Industry. Their contribution to this special issue has two purposes. First, to outline the conceptual and methodological features of what they define as the Sectoral Innovation Foresight. Second, to illustrate the benefits of a systematic multi-sector foresight by extracting some cross-cutting insights generated across the nine analysed sectors.

Haddad and Maldonado (Haddad and Uriona Maldonado, 2017) also focus on sectoral innovation systems. They take their main theoretical departure in the framework of technological innovation systems (TIS) and that framework's functions of innovation systems (Hekkert et al., 2007; Alkemade et al., 2007), and combine this perspective with the literature on technology roadmaps (Phaal et al., 2004). The contribution presents a case study of a sectoral roadmap exercise aiming at establishing an automotive sector in the Santa Catarina State of Brazil. Among their key findings are some recommendations for the design of technology roadmap exercises. The 'functions approach' can improve the identification of key actors, technologies and institutional setup and improve the understanding of the dynamic character of the sector in question.

Featherston and O'Sullivan (Featherston and O'Sullivan, 2017) have reviewed over 240 international FTA-related policy documents for the sector of advanced materials. As such, this contribution focuses on a generic technology rather than on an industrial sector or a geographical entity. This paper explores ways that FTA might be structured for more detailed investigation of the complex innovation system journeys of new generic technologies, as they are developed, diffused, and deployed. The paper proposes three structural elements to characterise innovation systems and their dynamics: 1) 'infratechnologies' required to develop emerging technologies, 2) key phases of emergence lifecycles and 3) key stages of industrial value chains. The article argues that such an insight is useful for identifying and manage technology R&D portfolios, prioritise investments and coordinate among public innovation agencies.

Pombo-Juárez et al. (Pombo-Juárez et al., 2017) depart from Martin and Johnston's (1999) notion of foresight potential as an instrument for wiring up innovation systems and take a multi-level perspective to foresight and innovation systems. The article argues that innovation is subject to framework conditions not only within, but also across, multiple layers of innovation systems. This includes local, regional, national and international levels of such systems. A key finding in the article is that systemic interconnections and interactions within and across different innovation systems should be reflected both in the design and in implementation of foresight exercises as well in recommendations resulting from foresight exercises.

Piirainen, Tanner and Alkærsig (Piirainen et al., 2017) take a smart specialisation approach to an emerging sector: the offshore wind servicing sector. The article explores the typology of structural change pattern of a region, which is a core feature in the smart specialisation framework (Foray, 2014). Among the article's key contributions to the practice and scholarly field of foresight is that the suggested typology of smart specialisation dynamics provides an analytic framework for regional development, and that this framework enables a comprehensive anticipation of the industrial dynamics in the sector. Furthermore, such a typology can be used to identify plausible development paths based on actual regional capabilities.

Ho and O'Sullivan (Ho and O'Sullivan, 2017) in this issue discuss the topic of standardisation for innovation activities. A roadmapping procedure is introduced to enable standardisation for making the innovation process more efficient. The discussion is carried out around the Information and Communication Technologies (ICTs) domain, and smart systems in particular, where a number of hi-tech devices and applications need to interact with each other to achieve interoperability. Future-oriented technology analysis (FTA) is considered to play a role for the anticipation and management of standards. The paper proposes a systematic and structured process for managing roadmapping, as a commonly used technique in FTA studies, to support effective standardisation processes in a highly complex and heterogeneous area of smart systems. Proposals are made on how roadmaps can be better structured and managed for effectively addressing standardisation issues.

Second, there is an increased request for impact assessment of foresight as a tool in innovation policies and its impact in general (Georghiou and Keenan, 2006; Havas et al., 2010; Harper, 2013). Also the wider innovation policy literature has stressed the need for evidence-based policy making (Martin, 2014). Three articles in this special issue relate to this development in foresight and innovation policy studies.

One focus of innovation policy is collaboration, which is seen as a key to unlocking productivity improvements, both as an integral process of the knowledge economy and to produce economy of scale and learning-based cost reductions. But translation of this objective into regular accepted practice faces many challenges. Forward looking activities (FLAs previously labelled foresight) have been proposed as a process that could assist in addressing these challenges.

Haegeman, Spiesburger and Könnölä (Haegeman et al., 2017) examine this issue in the context of transnational research programming. They demonstrate the value of an evaluation scheme which assesses relevance, efficiency, effectiveness and utility/appropriateness/ sustainability to a program to develop shared research programs between the EU and Russia.

Havas and Weber (Havas and Weber, 2017) start from the perspective that FLAs have been available to science, technology and innovation policies for several decades, but that knowledge of impact is markedly limited. They seek to address this deficit by analysing the fit between different types of FLAs and 'innovation policy governance sub-systems' which contribute to identifying and prioritising policy needs and problems; the better the fit, the greater the likely impact. Based on detailed case studies of FLAs in Germany, Greece and Hungary, they conclude there is a need for a far closer tailoring of FLA design to the characteristics of the relevant component of the innovation system.

Couto e Silva, Silberglitt, Machado, Maia and Cagnin (do Couto e Silva et al., 2017) describe a new approach to directing foresight towards weaknesses in the national innovation system. They combined foresight, national innovation indices (based on the Global Innovation Index data) and decision analysis to identify the best combination of investments to improve a national innovation system, using Brazil as an example. Applications include informing policy-makers of possible gaps in innovation strategies and shaping foresight studies to contribute more directly to improving a country's innovation performance.

Third, the availability of 'big data' has created new methodological opportunities in innovation studies. A recent special issue of Research Policy discussed the potential of this new frontier in innovation studies (Feldman et al., 2015). Scholars of innovation studies have for long use quantitative and statistical data such as patent databases and bibliometrics as well as statistical data from national authorities and from OECD and EuroStat. New technological possibilities such as machine learning and large data capacity open up possibilities for large-scale data linkages, text mining, and data of behaviour at the level of the individual. Such new possibilities have for quite some time also been examined in the field of foresight. A recent book has identified some of the promising opportunities of such large data analyses (Daim et al., 2016). Two articles in this special issue relate to the use of quantitative approaches in foresight and innovation policy studies. One article by, Piirainen, Tanner and Alkærsig, is already mentioned above.

The other article, by **Kayser** (Kayser, 2017) in this issue argues that when analysing innovation systems it is important to consider additional considerations reaching beyond the scientific discourse. Further outreach to the public discourse is proposed as a key indicator for diffusion of innovations. A text mining framework is used to analyse scientific discourse through scientific publications, and public discourse through news articles. The results of analyses are then compared through a process model, which is described in detail. The methodology is demonstrated through three case studies on cloud computing, artificial photosynthesis and vegan diet. The comparison of information sources from science and media provide valuable insights about the level and extent of innovation diffusion and matches and mis-matches on how certain innovations are perceived by scientists and the society.

Acknowledgement

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