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# Technology foresight in transition

ABSTRACT

Technology Foresight (TF) became an increasingly popular approach for science, technology and innovation (STI) policymakers from the mid-1990s on. Achieving prominence in Japan and Western Europe, it attracted the attention of researchers and policy analysts in many parts of the world in subsequent decades. TF is often seen as a set of tools for informing decisions about STI priorities within established innovation systems. These priorities have necessarily changed as scientific knowledge, technological opportunities, and social demands have evolved. But so too have the ways in which innovation processes operate, and understandings of the roles that STI policies can play. Accordingly TF has also been applied to inform efforts to restructure innovation systems - and, indeed, it was often seen as also providing tools to assist in such efforts. The need for such restructuring has been particularly acute in countries undergoing massive transitions. These include transitions from centrally planned to market economies, from non-industrial to newly industrialized countries, and from being imitation-oriented to becoming innovation pioneers. Correspondingly, considerable effort has been put into TF in many such countries. But much of this TF effort has been largely invisible, or at best poorly documented. TF may itself require redesign, taking different forms in various contexts, and as experience with the tools has accumulated. This might involve different patterns of emphasis of, and ways of articulating: the methods that are employed; the stakeholders engaged; the linkages with STI policymaking; and so on. Informed by the contents of this Special Issue, this essay considers the issues arising from this diffusion and evolution of practice, outlining the main capabilities required to mount successful TF exercises in different contexts.

## 1. Introduction

For most of human history, the disruptive changes encountered by even the most complex societies mainly involved tribal and military conflicts, political upheavals and the effects of geological or meteorological shocks. There were few grounds on which to anticipate substantially new economic activities and ways of life, let alone to imagine that these might be underpinned by new scientific knowledge.[1] However, since the scientific and especially the industrial revolution, long-term planning and policymaking have necessarily had to take into account the probability of future technological change.

Disruptive technologies and new forms of work and consumption became increasingly evident with the emergence of the factory system, steam power, and later on electrification and new agricultural, communication and medical technologies drawing on deeper understandings of biology, chemistry, and physics. Creative individuals - often scientists or well-informed science fiction writers like Verne and Wells, and later on Stapledon and many others - produced compelling appraisals of transformative change in the later nineteenth and early twentieth centuries. Demographic and economic forecasting became established practical tools where statistical data and methods could be brought to bear, and there were occasional warnings of resource depletion, such as Jevon's *The Coal Question* in 1865. Systematic approaches to technological forecasting only emerged in the years around the Second World War, as technological progress came to be seen as more of a process of accumulation of knowledge, contributed to by many players, than the product of unpredictable insights from isolated geniuses. (The work of William F. Ogburn and colleagues is important both for this appraisal of the innovation process and for the development of tools for assessing trends and impacts of change.[2]) The development of tools and

[1] Perhaps the agricultural revolution was seen by those caught up in it as involving new knowledge - the story of the forbidden fruit in Eden can be interpreted in this light. We know little of this, since record keeping was largely associated with the tributary systems that arose in agricultural societies. We doubt, though, that this was interpreted as representing a trajectory of progressive change.

[2] See appraisal of Ogburn by Duncan (1968), Godin (2010), Kotsemir et al. (2013), Meissner et al. (2016).

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techniques for technology forecasting was subsequently honed in the context of military and large-scale technoscience projects such as the US space programme. Many of the techniques of technology forecasting (Delphi, scenario analysis, trend analysis, etc.) were adopted to greater or lesser extent as the field of "futures studies" crystallized from the 1960s on.[3]

In the 1970s, Japan institutionalized a system of analysis of opportunities facing national Science, Technology and Innovation (STI). This was initially known as Technology Forecast. Technology frontiers - and ways of reaching them - were of great interest to a country that was, in this decade, moving on from being an imitator of Western innovations. It was becoming a leader in its own right, especially in electronics and related industries. Among other means, the Japanese used tools such as Delphi to aid long-term STI policy-making and generate collective awareness of STI possibilities, and thus to help Japanese industry undertake this transition towards innovative leadership. This experience was to prove influential when Western countries concluded that they had difficulties of their own in STI - many economies were already seen as falling behind the USA, and now Japan and other new contenders were seen as challenges. Similar ambitious TF programmes were developed in Canada and several European countries, in the 1980s and especially the 1990s. The term Technology Foresight was used to describe the large exercises that were being undertaken. (This terminology was then used by the Japanese to label their own exercises.)[4]

A number of factors contributed to the subsequent global spread of TF. International organizations - notably the EU, APEC (particularly influential in South East Asia) and UNIDO (especially in Latin America and Eastern Europe) organized training programmes, held conferences, and produced guides to best practice. The EU effectively required new members in Central and Eastern Europe to use Foresight in developing their own STI policies. Some countries' efforts were half-hearted, or examples of "me too" following of fashion. But policymakers in many countries did recognize that their existing STI policies faced acute problems. Among these were:

- difficulties in assimilating new generations of technology (let alone contributing to them);
- problems in reconciling pressures on public finances with the calls to finance new initiatives in STI (and even to retain longstanding commitments);
- a sense that existing structures for governance of STI were cumbersome and ineffectual (this was especially the case for countries leaving the Soviet bloc);
- social unease about some aspects of science and some applications of technology (notably biosciences and nuclear technology), together with demands for accountability where public expenditure was required;
- new challenges related to energy and food security, climate change, and the like.

While some of the experiences with TF, as it spread from Western Europe to other regions, are well-known, many others are poorly documented. The issues that had to be confronted in implementing the approach have only been discussed to a limited extent, and among specialist groups of practitioners.[5] The essays in this issue of TFSC are intended to help bridge this gap; we are fortunate to have detailed knowledge of a good range of case from informed observers and practitioners. These essays can hardly represent the last word in analysis of the diffusion and evolution of TF, since many other experiences remain relatively underexposed.

The various guides and training programmes to TF that were produced around the turn of the century frequently made the case against "one size fits all" methodology in TF. Whereas some influential consultancies had effectively promoted their "one, true" approach around the world, many TF pioneers insisted that while some general principles were standard, it was essential to design TF exercises in the light of local circumstances. The objectives and scope of the TF, the resources (of expertise and political support as well as funding) that could be drawn on, the participants to engage, and so on, were liable to vary considerably from context to context. While it is fairly straightforward to identify the decisions that need to be taken, the ways in which these are handled will be very contingent on circumstances.

Despite the variety of exercises - differing in focus, scale, and other attributes, common features of most TF exercises can be summarized as follows:

- The TF is designed to have an influence on **policy**, not as an ivory-tower exercise.
  - Thus it is important to have access to influential decision-makers, and ideally they will be engaged as sponsors of the work.
- The influence may be narrowly conceived, for example in terms of identifying priority areas for financing of R & D or training.
  - But TF will also often play a role in addressing weaknesses in the innovation system by helping to align different stakeholders around shared appraisals of future prospects.
- The **products** of an exercise will typically include codified reports, presentations, Internet resources, and the like.
  - Wider outcomes will also involve "process benefits" linking together stakeholders and, not least, enabling key actors to understand why particular policies are being pursued and what their roles could be.
- The TF is liable to be **participatory**, to network together many sources of knowledge in different locations and institutions.
  - The complexity of modern societies and the technologies they employ is such that it is difficult for any individual agency to acquire all knowledge required to take informed decisions in the STI arena. Thus it is necessary to engage stakeholders who have knowledge of, for example, key issues in science, in commercialization and application of inventions, in markets, intellectual property, and trade.
  - Such wide engagement can be important for establishing the legitimacy of decisions informed by the TF.
- Bringing together these different actors and their knowledge may be undertaken through tools such as Delphi, or via more face-to-face methods like conferences and workshops.
  - Sharing and fusion of the different types of knowledge may require more than traditional presentations of different fields of work, and methods such as scenario analysis, "soft systems" and roadmapping can play a role here.
  - The networks and mutual learning established in such work may play important roles in shaping actors' strategies and decisions beyond the immediate focus of a TF.

[3] For accounts of futures studies around the world, before the current wave of TF, see Fowles (1978).

[4] For a fuller treatment of this history, see Georghiou et al. (2008), Miles (2010).

[5] Georghiou et al. (2008) do consider TF activities in various regions - but the level of detail on Central and Eastern Europe, Latin America, and Newly Industrializing Asia, is far from complete.