Editorial

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Biographical notes: Pranav N. Desai is currently the Chairperson, Center for Studies in Science Policy (CSSP), Jawaharlal Nehru University (JNU) and is engaged in teaching analysis in science and technology policy and technology futures analysis. He received his PhD in Science Policy Studies in 1985 from JNU and has conducted research in diverse areas of science policy, including emerging technologies, intellectual property rights, energy and environment-related issues. He specialises in science, technology and international affairs.

There is an increasing realisation that foresight studies need to be geared towards shaping technologies, innovations and futures, rather than merely predicting their growth and socio-economic impact. It is meaningful to conduct foresight exercises while technologies are still emerging, in order to direct them into a socially desirable path. Biotechnologies, information and communication technologies and nanotechnologies are good examples that require attention for short-term as well as a strategic or long-term foresight exercise for the next 20 years. Moreover, the emerging technologies are contributing substantially to the Gross National Product of several countries and innovations are occurring at much faster pace than ever. The rapid advancement of emerging technologies has introduced an element of uncertainty and therefore a possibility of an increased risk. This phenomenon has necessitated different foresight methodologies or different approaches in the context of the rapidly changing global socio-economic and technological scenario. These factors have not only changed the policy-making context but have also facilitated altering the focus of foresight studies from positivist and technology-focused approaches towards a wider perspective of the entire innovation system.

The past two decades of the 20th century have witnessed the emergence of new technologies, new economic environment of liberalised policies and increasing ‘globalisation’. Moreover, a trend of multiplying convergence of different technologies, such as information, biological, materials and nanotechnologies, is expected to have a revolutionary impact. Furthermore, modern science and technology have remained relatively ineffective in solving many socio-economic problems. Biotechnologies have opened new doors for treating genetically oriented diseases, increasing agricultural productivity, nutritive qualities of food crops, reduction in inputs like fertilisers, pesticides and water. Nanotechnologies also have the potential for cheaper, cleaner ways of producing and storing energy, boosting agricultural productivity, producing clean water and diagnosing diseases. Information and communication technologies have not only revolutionised industrial production and trade but have also made the organisational walls disappear and boosted international integration. This phenomenon has not only offered many promises but has also raised a number of socio-economic, ethical and political issues. Moreover, these technologies are becoming all-pervasive and this will require the coordination among all sectors of society in order to become a force for enhanced social equity and productivity.

In the preceding context, this special issue of the *Int. J. Foresight and Innovation Policy* (*IJFIP*) has discussed new approaches and perspectives to foresight methodologies. These approaches are expected to cater to the needs of the turbulent character of the emerging technology and dynamics of innovation system and their interrelationship, the policy implications for human resource in the context of continuous shift from an industrial economy to an information knowledge-based economy and a methodology to identify critical technologies for the regional innovation system.

To tackle the inherent uncertainty and systemic character of emerging technology, van Lente and van Til have developed a novel foresight methodology in their paper. The 'cluster approach' built on a systemic perspective on innovation has been combined with 'technology roadmapping', which is a business strategy instrument used for identifying and assessing alternative technology routes. This process is expected to facilitate technology selection and innovation. By combining these two approaches, the authors argue that the cluster approach will be enriched and made fit for emerging technologies. This combined roadmapping-cluster approach has been applied to a new nanocoating field in Germany and the technical and socio-economic developments related to it are analysed. The strength and weakness of these two approaches are discussed and it is argued that some of the static features of the cluster approach would be eliminated by combining it with the technology roadmapping approach. This is expected to facilitate the strategic decision-making by assessing the role of virtual innovations or the anticipated changes in technologies, markets and products. Usually, strategic roadmaps use a format of interacting layers of markets, products and technologies in order to satisfy a certain product demand of the future. Thus, the knowledge created by roadmapping process enriches the cluster approach not only for individual firms but also for research centres and policymakers.

The analysis in the preceding paper has revealed the significance of various attributes of the innovation system as a whole, rather than technology characteristics alone for the foresight studies. Alkemade, Kleinschmidt and Hekkert further magnify the same in their paper. It is argued that the success of sustainable innovations depend in a large part on their environment, the innovation system and the insight into the structure and dynamics of the innovation system is of crucial importance in foresight studies and policy analysis. The analytical framework outlined in this paper allows us to study the relations between the components, the structure and the functionality of the innovation system resulting in increased insight in (future) system behaviour and performance. Furthermore, mapping the (actor-independent) functions of the innovation system allows us to compare different cases, enabling timely and adequate policy measures through improved foresight. Their framework has been applied to the California Wind Energy Innovation System (CAWEIS) and has demonstrated that the emerging innovation systems are characterised by complexity and path dependency. The study has defined seven functions of the innovation system and the functional analysis of the same in one period provides insight in the behaviour of the future period as well. Moreover, the present approach makes it possible to systematically compare empirical data about different emerging technologies, which will help recognise the patterns of success and failure, providing increased foresight and allowing timely interventions.

This study has also provided two important lessons for policy making. Firstly, it was found that short-term policy and short-term management practices are the blocking mechanisms for new technology-specific innovation systems such as the CAWEIS. It is because new technologies are often not competitive on the short run and need a long-term vision to develop. This is even more important since system failures that occur in previous periods still influence the current performance. In the present case premature convergence towards a particular design, namely, large-scale wind turbines, decreased the system variety and led to incompetent technology. In addition, radical institutional changes are harmful to the emerging technological system, because their system structure is only weakly developed and can easily disintegrate. The present study has demonstrated that the liberalisation of the electricity market and the energy crisis of 2000/2001 almost destroyed the wind energy innovation system, affecting both the system structure and the functionality.

Many foresight studies have overlooked the changing character of human resource due to the very nature of technology. Human resource, a crucial component of technological change, becomes all the more relevant in the context of information society technologies and globalisation. Mahroum, Dachs and Weber have approached this issue in the IST sector from a broader perspective, by not limiting themselves to a labour economics perspective of supply and demand trends of workforce. It does so by addressing the future of human resources for IST from three different angles: the future composition of IST workforce, the future geography of HRIST supply and demand and the future orientation of IST markets. The paper argues that the pending demographic change, the internationalisation of education, labour and markets and the continuous shift from an industrial economy to an information knowledge-based economy will transform the dynamics of workforce supply and demand as we know it today. Foresighting the future of IST workforce will require the ability to identify and to understand these new dynamics.

Recently, the concept of regional innovation system has started gaining currency due to increasing globalisation, fierce competition and the emergence of successful clusters of firms around the world. It is argued by many that firm specific competencies and learning process can lead to regional competitive advantage if they are based on localised capabilities such as specialised resources, skills, institutions and share of common social and cultural values. However, due attention is not being paid to the nature and relevance of technologies that play significant role in enhancing regional capabilities by many. The paper by Moreira, Carneiro and Tavares has described the methodology used to identify critical technologies for the regional economy of the North of Portugal under the project 'NORTINOV 2015'. The Commission for Coordination and Regional Development of the North of Portugal (CCDR-N) promoted *NORTINOV 2015*, a project created to define a regional innovation strategy for the North of Portugal based on the automotive, information technology, communication and electronics clusters. Accordingly, it developed a technology forecast for the year 2015 in order to help the North of Portugal cope with intensifying global competition and rapid technological change.

Technologies are classified into three groups by some as the emerging, key and base technologies. Though the contribution of the emerging technologies could be marginal to a given business area, their potential development could prove quite crucial for the firm's future. Key technologies are indispensable for a firm's competitive edge and the base technologies are the standard technologies used widely. However, depending on the nature of an industrial sector, the same technology can be a base technology in one business, a key technology in another business, and an emerging technology in a third business. After having made this distinction, critical technology has been defined on the basis of their extent of influence on the output and development of the system.

The methodology used involve three main steps: technology identification and study, in which a list of emerging technologies was implemented; refinement of emerging technologies in which 90 technologies were identified; and finally, classification and hierarchisation of technologies, in which 30 technologies were identified as critical for crafting of the regional innovation strategy. This process is expected to enhance the effectiveness of the regional innovation system.