Nanotechnology Innovation Systems:
A Regional Comparison

Nazrul Islam, Cardiff University, UK

ABSTRACT

The general aim of this chapter is to provide a systematic comparison of nanotechnology innovation systems (NanoSI) at the national level in Europe and Japan. In particular, the characteristics of the national NanoSI that relate to the evolving structure and dynamics of the systems, demand and push factors for driving nanotechnology innovation are investigated, as well as other framework conditions shaped by government policies. In this chapter, a deductive research approach has been adopted rather than an inductive one, a research hypothesis has been put forward and supported by qualitative data analysis. Having carried out a detailed analysis on the primary data, relevant attributes of nanotechnology innovation infrastructure have been identified and similarities and disparities between European and Japanese NanoSI have been explored. The author addresses strengths and weaknesses, major drivers and barriers to a detailed understanding and smooth functioning of NanoSI.

INTRODUCTION

The 'nanotechnology' concept first captured the world's attention when the Nobel Prize winner Richard Feynman advocated the possibility of widespread nanotechnology research by delivering his famous speech, "There's Plenty of Room at the Bottom" just half a century ago. The emerging nanotechnology field comprises one of the fastest-growing research and development (R&D) areas in the world (National Science and Technology Council, 2006). Developed countries, as well as many developing countries, have prioritized nanotechnology as a core scientific and technological research agenda since the early 2000s. R&D activities in nanotechnology have been strengthened worldwide recently to provide a foundation for technological advancement, since governments of many countries have invested aggressively in the relevant research through academic funds and subsidies for private companies (Roco, 2005). Nanotechnology is attracting ever larger private and public investments in many parts of the world, for example, the Unites States, Japan, and the European Union have about the same annual government investment for nanotechnology R&D – approximately $1 billion US. Corporations are thus directing their R&D activities towards the exploration of nanotechnology opportunities for sustainable

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economic development and for the comfort and safety of the people.

Like biotechnology, nanotechnology exists strategically on the borders between disciplines, including physics, chemistry, materials science, biology, medicine, engineering, and information and communication technology. Nanotechnology conforms to a pattern of science-based innovation, which represents a multi-disciplinary field of research and development, since it requires multi-disciplined networked research (Meyer and Persson, 1998; Roco and Bainbridge, 2002; Islam and Miyazaki, 2009), education and the improvement of human skills performance. It also requires input from, amongst others, chemists, physicists, materials scientists through to biologists, engineers and pharmacologists. Therefore, it has been of importance to explore how nanotechnology has evolved through different scientific disciplines and technology domains. The main objective of this chapter is to explore the attributes that are likely to enable an overall understanding of nanotechnology innovation infrastructures in the case of Europe and Japan. The chapter's aim includes identifying critical factors and identifying effective nanotechnology innovation systems (NanoSI) that increases the awareness of nanotechnology from an innovation system perspective. This chapter also seeks to understand the basic strategies of nanotechnology research management and technology development, and attempts to exhibit a forward-looking approach in characterizing nanotechnology innovation trajectories between the regions.

Advancing the understanding of innovation systems requires a methodology, which makes it possible to investigate these systems in depth as well as to make comparisons across borders. This study adopts a qualitative research methodology which includes primary data analysis. A series of face-to-face interviews were carried out with representatives (e.g. scientists, practitioners, researchers) from the universities, public research institutes, government organizations and funding agencies in Europe (e.g. UK, Germany, France, Italy, and Switzerland) and in Japan (e.g. Tokyo, Tsukuba, Osaka, Hiroshima, Kyushu, and Tohoku). A core team of scientists and researchers from ten European institutes and eight Japanese institutes conceptualized and conducted the interview survey and analyzed the results. These qualitative data have provided a key understanding of R&D management, the roles of government bodies and the activities of funding organizations that have helped to shape nanotechnology innovation infrastructures.

Foresight studies predict that nanotechnology will be all around us in 10-15 years and it looks like developing in a series of overlapping S curves of technology maturity. As an emerging field, nanotechnology is too diverse to be treated as one industry or to be thought of as one technology. It is necessary to consider various kinds of technology (e.g. materials, sensors, pharmaceuticals) and the different parts of the industry (e.g. information & communication, biotech, design and construction, manufacturing) individually for an effective innovation process of nanotechnology to take place. Davies and Gann (2003) suggested that nanotechnology is currently in the stage of the innovation cycle just prior to the beginning of commercialization where the technology breaks out of its original locus of R&D and is adopted by industrial sectors. At this stage, innovations have to be linked to achieve full potential benefits. Nevertheless, several questions arise, for example, which technology sectors will be the potential early carrier industries and who will begin to articulate their demands for nanotechnology? And how will the interaction between academia and industry develop? Hypotheses on the key innovation dynamics of nanotechnology have been few up to now and the two mentioned here vary in their argument: Darby and Zucker (2003) proposed that the main engine of nanotechnology development will be start-ups founded by scientists, with alliances between start-ups and large incumbents, close ties between academia, start-ups, and available venture capital as the critical factors. Mangematin *et al* (2006) on the other hand, proposed that large firms and start-ups from the previous generation of general-purpose technologies (e.g. biotechnology) are playing a key role in the development of nanotechnology. The technology does not