Innovations in emerging versus mature technology fields: The differing roles of private and public sector organizations

Poh Kam Wong (pohkam@nus.edu.sg)
Professor, NUS Business School
and Director, NUS Entrepreneurship Centre

Yuen-Ping HO
NUS Entrepreneurship Centre

National University of Singapore
E3A Level 6, 10 Kent Ridge Crescent, Singapore 119260

Theme: Organization of Science and Innovation

Research Topic

The Triple Helix concept (Etzkowitz et al., 2000 & 2003) posits the dynamics of an innovation system to be governed by the interactions between government, universities and private industry. In recent years, there has been more attention paid to the role of the non-industrial sectors as sources of technological invention. In this paper, we examine the roles of the three Triple Helix actors in two technology fields differentiated by maturity levels. Our analysis is based on the premise that the nature of the technology, in particular the maturity of the technology, influences the organizational patterns in innovation.

We posit that emerging technology fields are likely to be more "science-based", with universities and/or public research institutions (PRIs) not only contributing an above average share of patent outputs (compared to the mean of all patent classes), but also garnering a disproportionate share of the more highly cited patents. This has been established in the case of biotechnology, where several studies have highlighted the disproportionately larger role played by public science in the earlier years of the field's development (Zucker and Darby, 1997; Zucker et al, 1998, Adelman and DeAngelis, 2007). In studies on the emerging field of nanotechnology, Wong et al. (2007) and Igami and Okazaki (2007) likewise found that universities play a significant and growing role in nanotechnology patenting, mirroring early trends observed in biotechnology. Mature technological fields, on the other hand, are expected to yield inventions that are applications-based and less reliant on basic science, with correspondingly smaller role played by universities and PRIs in the patent landscape.

In addition to the relative role of public and private sector organizations, we also investigate whether the degree of organizational concentration in the invention and ownership of innovations may be correlated with the level of maturity of the technology fields. Specifically, we explore whether an emerging technology field is likely to exhibit a more dispersed pattern of inventorship and ownership compared with a more mature technology fields, where large established firms are expected to dominate innovation activities.

Data and Methodology

Our analysis draws on two patent databases that we have constructed for two different technology fields at different stages of technological maturity: (i) Nanotechnology and (ii) Water Treatment technology. *Nanotechnology* represents a new, emerging technology that is expected to bring about radical changes leading to the formation of new enterprises and creation of a new industry, similar to the biotechnology revolution of the 1990s (Zucker and Darby, 1998). *Water Treatment technology* is an example of a mature technology area, with roots tracing back to the 17th century. This technology is at the core of the well-established water processing industry in which technological innovations continue to play a critical role, as private sector firms increasingly compete on technological advantages (Lin and Chan, 2008).

Using taxonomic methodologies previously developed in the literature (Wong et. al. 2007, Lin & Chan 2008), we sieved patents granted by the USPTO between 1976 and 2006 into the two technological fields. The nanotechnology database comprised over 8,000 patents while the water treatment technology database contained close to 7,000 patents. For each patent in the respective technology class, we extracted and classified relevant information such as the organizational characteristics of the assignee, the location of the inventors, and its pattern of backward and forward citation links. We also identify patents that are "science-based" by examining whether they made backward citations to scientific publications.

Preliminary Findings

Our analysis thus far confirms significant differences between the two technological fields in terms of the role of public vs. private sector organizations. However, we also found systematic variations across different groups of economies. In the emerging field of Nanotechnology, university ownership of patents is particularly high (over 10%) and continuing to grow in the developed Anglo-Saxon nations of USA, UK, Canada and Australia. In contrast, in Germany, France and Japan, universities own few nanotechnology patents but relatively high shares are owned by PRIs. In the newly-industrialized economies (NIEs) of Korea and Taiwan, our data indicate that nanotechnology development has been initially driven by government sponsored research in PRIs, but the contribution of universities is growing faster in recent years. Citations analysis reveal that university patents are on average more highly cited than patents by PRIs or private firms, although there are some variations across the different groups of economies.

In the case of Water Treatment technology, the role of the public sector is far less significant, with only around 2% of patents owned by universities and 3% owned by PRIs. The large majority of water treatment patents are from private industry, with little or no university and PRI involvement in many economies. An exception is the USA, where the contribution of universities has gradually increased; from 2.3% in the 1980s to 5.8% in the 2000s; however, PRI share has fallen from 4.2% to 2.7%. In contrast to nanotechnology, university patenting in Water Treatment technology are not as influential and are less frequently cited than private sector patents.

The full paper will present more detailed analysis, including analysis of possible differences in inventorship and assignee concentration pattern, as well as the pattern of collaboration (as measured by co-inventorship) and knowledge flows (as measured by citation links) among the university, PRI and private enterprise sectors. The full paper will also discuss the implications for national S&T policy, in particular the need for public S&T policy to take into account the maturity of technological fields in designing Triple Helix innovation support programs.

Key Words: Innovation pattern, emerging vs. mature technological fields, nanotechnology, water treatment technology