

Concerns of new technology based industries—the case of nanotechnology[☆]

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Abstract

Among the emerging technologies of this century, nanotechnology has been generating extensive interest, and its impact on society is expected to be widespread and all pervasive. Critical research in this field is being carried out all over the world, leading to a growing industry and entrepreneurial activity. Innovation aspects of such new technology based companies have important implications for the economic growth of nations. A framework for understanding these aspects that would be revealing and instructive in dealing with such new technology based innovation and technological change is attempted in this paper.

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1. Introduction

Small opportunities are often the beginning of great enterprises. Demosthenes (384–322 BC).

Innovation, and its dynamic relation to economic growth, has generated considerable interest over the years (Bhat, 1997). An economy can achieve and maintain a high growth rate only through innovative capabilities of companies and organizations, resulting in the incessant generation of new technologies and new products. Having realized this, Schumpeter (1962) questioned whether the interaction between technology and management that makes innovation happen can be made a routine process that can then be managed more efficiently. He also propounded that major technological change brings about a process of ‘creative destruction’ that would dislodge incumbent companies and favor entrants, as wealth is created and redistributed through the constant change and disruption of existing companies, markets and structures. An emerging industry, such as

nanotechnology, offers scope for looking at these and related issues very closely.

Nanotechnology has become one of the most important of sectors, drawing intense interest. It is widely touched that it is going to change every aspect of our lives and lead to the generation of new capabilities, new products and new markets. It is thus described as an enabling technology that will pave the way for novelty in every stream of technology. Another important aspect associated with nanotechnology is its multidisciplinary nature, which makes it very difficult to pin down and prophesy the future impact in any specific sector appropriately. Its impact on society is expected to be widespread and all pervasive. Critical research in this field is being carried out all over the world. Interest in nanotechnology has grown substantially over the years and funding statistics has grown very impressively, particularly in the last couple of years, leading to a growing industry and entrepreneurial activity. Understanding the growth aspects associated with nanotechnology based companies would be revealing and instructive in dealing with such new technology based innovation and technological change.

2. Review of change concepts

A number of strategy concepts and frameworks have been evolving over the years to understand the process of

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technological change, some of which are normative and others descriptive. Historically, the concepts were used as logic to explain a casual relationship in a variance theory. Change was then viewed as a discrete shift from one stage to another. That change, with its increasing pace and complexity, is an ongoing dynamic journey has been established (Van de Ven et al., 1999; Tushman and Romanelli, 1985). Utterback (1994) defined a model with three phases to explain the dynamic processes that take place both within an industry and within the companies that are part of an industry, over time: *fluid transitional and specific*. These phases are associated with both the rate of innovation as well as the underlying dimensions of product, process, competition and organization. One can additionally define a *breakaway phase*, when a new technology or next generation technology gets introduced that starts replacing the old technology. A new market also gets created as the new technology starts getting accepted and the old market gets affected. Studies on different industries further indicate that if the new technology is radical enough, then the incumbents' existing capabilities will all the more ensure the shift to the new technology in the breakaway phase, as it will be more difficult to adapt to the requirements of the new technology (Hendersen and Clark, 1990). There is ample evidence of these phenomena in the Indian industry scenario. How is the situation in the case of a 'multiply-enabling' technology like nanotechnology, and what are the implications for industry?

3. Nanotechnology, the term: multidisciplinary nature

Before going to the industry structure of nanotechnology, it is necessary to first understand what nanotechnology means, more than being a range of highly promising disciplines in science and technology. A nanometer is one thousandth of a micron or one millionth of a millimeter or 10^{-9} of a meter. The term nanotechnology itself has been variously defined by different nations. Without going into restrictive definitions, one can accept that nanotechnology is being used to represent a far broader arena (Gary, 2001), the deciding factor being that *novel and differentiating properties and functions are developed at a critical length scale of matter typically under 100 nm (NIST, 1999)*. The emphasis is on *materials and systems whose structures and components exhibit novel and significantly improved physical, chemical, and biological properties—and that enable the exploitation of novel phenomena and processes—due to their nanoscale size (NSTC/NSET, 2002)*.

Another important dimension is that the domain of nanotechnology is not restricted to only the realm of materials and applications but extends even to life sciences. It is now plausible to replicate living organisms to perform engineered tasks. Besides, a number of technological strides are being made in information technology, biotechnology, semiconductors, and other

technologies; they all have an impact on and are in turn being impacted by developments in nanotechnology. The industries that are likely to be immediately impacted are purported to be: aerospace, automotive, biotechnology, ceramics, chemicals, computing, defense, electronics, metals, materials, paper, plastics, renewable/sustainable energy, textiles and telecommunications.

4. The industry

The nanotechnology industry has been given a lot of attention by governments, industries and nations. New nanomaterials to address specific needs of different industries are being created rapidly, and these new materials promise a cornucopia of new products with superior performance characteristics that are likely to dramatically transform the markets in a number of key industries. The point to note is that such products are not in the realm of science alone anymore, as real products incorporating new nanomaterials are being introduced into the market. Yet, while nanomaterials may create a wealth of new business opportunities with the potential to radically and abruptly impact a company's market position, they may also pose tremendous business risks. Companies in the US, Japan, Europe and several other nations are attempting to successfully position themselves to be nanotechnology leaders. India is yet to initiate significant efforts in this area.

Overall, apart from the general hype that is associated with this technology that has been responsible for the increased interest and activity, there is a general consensus in most literature that nanotechnology will be a very big and dominant industry not far in the future.

A rough estimate of the number of companies focusing on nanotechnology related work worldwide currently is around 550, including large companies that have opened up units devoted to this field, as well as start-ups and smaller companies.

5. The study

Companies located in the US that are actively into nanotechnology have been taken into account in this study. Data relating to the companies for the purpose of drawing implications have been accessed from public data sources, business information databases, technical databases, company sites, articles, papers and publications, and through interviews.

Most of the companies selected are start-ups. Almost all of them have strong linkages with scientists who are either currently attached to universities or research centers and are researching nanomaterials or were actively involved in nanotechnology research before joining the companies. Most of the companies have availed of funding from various government agencies. As in the case of most evolving

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