# Chapter 10
# Entry Barriers to the Nanotechnology Industry in Turkey

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## ABSTRACT

*Nanotechnology is the science that focuses on the control of matter at the atomic scale. It has the potential to create many new materials and devices with wide-ranging applications, such as in medicine, electronics and energy production. There are many entry barriers which can affect nanotechnology penetration in developing and emerging nations. This chapter discusses such barriers for Turkey. Despite about 10 universities having nanotechnology programs, the number of nanotechnology firms in the country is still low. Using combinations of interviews, surveys and literature, these issues that continue to stall the commercialization of discoveries in Turkey are examined.*

## INTRODUCTION

Nanotechnology is the study of the control of matter on an atomic scale. Generally nanotechnology deals with structures of the size 100 nanometers or smaller, and involves developing materials or devices within that size. Nanotechnology is very diverse, ranging from extensions of conventional device physics, to completely new approaches based upon molecular self-assembly, to developing new materials with dimensions on the nanoscale, even to speculation on whether we can directly control matter on the atomic scale. Nanotechnology has the potential to create many new materials and devices with wide-ranging applications, such as in medicine, electronics and energy production.

It is obvious that entry barriers to the nanotechnology industry should be discussed in detail if it is the case that such entry is barred for a variety of reasons and that the public can not benefit from the nanotechnology products. Turkey is a significant example to such occurence. In particular it appears that there are ten nanotechnology research centers in ten different universities in Turkey. These centers are furnished with strong infrastructure both physically and research wise. Most of the

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researchers have their doctorate degrees from the prominent universities in the U.S. and they are working on cutting edge issues on nanotechnology. However, it appears that there are only thirteen companies in the entire country which can be classified as operating in the nanotechnology sector. Such observation is as alarming as it might be perceived as natural. For example, one could easily claim that in a developing country such as Turkey an industry which requires a long-term R&D investment might not develop as the fruits of such investment would take years to materialize. However such argument can easily be refuted as there are 41 nanotechnology firms in China and 17 in İndia and 195 for example in Germany. The country size and development levels do not seem to be the main determinants here. So what drives this lack of nanotechnology commercialization?

In Aydoğan, Chen(2008) and Aydoğan (2009), some insights were provided on the above question. Extending those insights, and in this piece we survey ten academicians from four different nanotechnology Centers in Turkey (interviews were conducted at Marmara University, İstanbul Technical University, Koç University and Sabancı University) to gather their thoughts on this pressing issue of the lack of commercialization in the nanotechnology industry in Turkey. In the below section we conduct the literature review, we summarize the ideas of the interviewees and we conclude by some policy suggestions along with some directional throughts on research.

## COMMERCIALIZATION OF NANOTECHNOLOGY: LITERATURE REVIEW

Although many countries have been developing strategies for the development of the nanotechnology industry since the beginning of the 1990's, Turkey has been lagging behind such efforts. Not until year 2000 that some steps were taken in this direction. Particularly nanotechnology has been identified as one of the critical sectors for the development of the Turkish economy. In particular a very well-equipped nanotechnology center at Bilkent, one of the most prominent universities in Turkey has been funded by the Prime Ministry State Planning Organization (Devlet Planlama Teşkilatı). Following this a number of centers among the ones we have interviewed in this study have been established. However, the commercialization process of the nanotechnology industry in Turkey has been stalled majorly. As mentioned earlier currently there are only thirteen nanotechnology companies in Turkey.

Although nanotechnology is at its nascent stages, it has become apparent that it will cause in stark changes in every area of our lives. Nanotechnology has its basis in many different sciences, and this makes the basic difference when compared with the impact of other sciences. According to Niosi and Reid (2007), the many different underlying pro-genitor technologies, of which have bases in molecular biology, electronics, materials science, physics (optics and quantum) and others, contribute to the composition of nanotechnology and hence this makes nanotechnology as inherently complex and diverse with diverse applications.

The broad spectrum of nanotechnology has lead to the development of various materials. For example, widespread commercial adoption of nanotechnology is growing rapidly; where early commercial applications are focused on the improvement of cosmetics, coatings, textiles and displays *(Bozeman, Hardin & Link, 2008)*.

Since nanotechnology is related to many different fields, it has received considerable attention among researchers from all over the world. Many countries have mobilized their universities and laboratories to conduct research and development activities in nanotechnology. However, as it is in the case of other technological developments, nations differ in their standing related to nanotechnology. Niosi and Reid (2007) suggest that due to the complexity of technologies involved in the development of nanotechnologies, training

and support for researchers are necessary, and for these high levels of training, public funding and support for infrastructure are required. Among the developing countries, the authors indicate China, India and Brazil are the three main contenders for catching up in the nano-space. For other developing countries, like Turkey, the authors propose two strategies that can be used to promote the development of emerging technologies. These strategies are early patenting in areas with the potential to attract foreign venture capital and formation of clusters and alliances.

Cluster formation is especially important for the commercialization of nanotechnology products. Uranga, Kerexeta and Campas-Velasco (2007) state that one part of the dynamics prior to the commercialization of a science takes place at the local geographical level such as local clusters, mega-centers and regions. The importance of regions that give rise to the formation of clusters in the nanotechnology field is also addressed by other authors; Zucker, Darby, Furner, Liu, and Ma (2007), for example, conduct an empirical analysis for which authors measure the regional growth of new knowledge in nanotechnology. They do this by article and patent counts where they find that geographical regions gain cumulative advantage in the production of nanotechnology research. The authors argue that the production of nanotechnological knowledge is embedded in the wider social context of institutional organization, cross-institutional collaboration, and national structures of incentives and rewards. According to the authors, this embeddedness is both constraining and enabling. It is constraining since the range of possible actions is narrowed, and on the other hand since the flow of tacit knowledge deepens and the flow between organizations becomes more differentiated, it becomes enabling.

Until now, there had been a disconnection between the nano-technological advancement undertaken in the research centers or laboratories, and the commercialization of these products. Successful commercialization of developed products is still problematic in many countries. Since nanotechnology is still at its infancy, there exist few research on the commercialization problems. According to Bozeman, Hardin & Link *(2008)*, given the recent origins of nanotechnology research, there is heretofore no systematic research on barriers inhibiting the diffusion of nanotechnology from the laboratory to commercial application. Bozeman, Hardin & Link (2008) undertook a research project on nanotechnology firms in North Carolina region. The results of this research indicate a market failure in the capital markets because of asymmetric information on the risk and return associated with the adoption of nanotechnology and its impact on commercialization. In this piece we offer a thorough account of this disconnection from an academic angle by speaking with several university researchers.

In the commercialization of nanotechnology, knowledge plays an important role. Rothaermel and Thursby (2007) argue that an incumbent firm's ability to exploit new methods of invention in biotechnology and nanotechnology fields initially depends on its access to tacit knowledge with regard to the employment of new methods. However, over time, as firms learn and/or the knowledge becomes codified in routine procedures or commercially available equipment, inventive output, becomes more dependent on traditional R&D investments.

Shapira and Youtie (2008) indicate that path-dependent stocks of knowledge, capabilities, finance and other resources, business or policy induce capital investments in facilities, institutional strategies and linkages, and the availability of talent and human capital may influence the places where the nanotechnology research and commercialization gravitate towards; and for development in the nanotechnology sector although all the factors are relevant, a greater impact of one of them over the others will have regional implications. According to the results of their analysis, due to the concentration of research either in universities or government laboratories, nanotechnology

emerges in nontraditional places of technological development. This finding indicates the prominent role of universities in nanotechnology research.

University spin-offs and new start-ups also contribute to the diffusion of nanotechnology. Uranga, Kerexeta and Campas-Velasco (2007) believe that the origin of start-ups in the fields of biosciences and nanotechnologies has to be linked to research in laboratories and universities. These companies' main function is to commercially exploit research results. In other words, these firms work in the field of exploiting intellectual property rights.

Libaers, Meyer, and Geuna (2006) find that although university spin-off companies in the field of nanotechnology in UK have an important role, they do not necessarily play a dominant role in the development of nanotechnology. According to the results of the research, while university spin-off companies are important drivers of technological change in the subfields of nanomaterials, nanodevices, nanobiodevices and nanoinstruments; they do not play a part in the formal commercialization of nanoservices or nanofabrication facilities. The overwhelming majority of nanopatents are owned by multinational corporations (MNC) and indirectly through academic technology transfer offices by university spin-off companies. Therefore, the increase in the commercialization of nanotechnology is not just related to university spin-offs but also MNCs.

## Turkish Context: Nanotechnology Sector and Problems with its Commercialization

There appears to be several issues that are related to the inability of the nanotechology sector to blossom in Turkey. For example the key researchers at Marmara University in Istanbul although strongly think that the Nanotechnology Center at Marmara has a practical focus that targets commercialization they also add the following issues for the lack of the number companies in this area. First of all these scholars think that the potential number of researchers who would engage in such ventures is limited. This is because there is not enough demand for scientists with Ph.D. degrees to work in such companies. Most R&D start-ups companies appear to be owned by individuals that are not as highly educated and hence lack vision. On the other hand, the researchers claim that financing a nano-tech venture is basicly formidable in Turkey as there is no developed venture capital market and the banks would not invest in technology related ventures that require such large funds. Also TÜBİTAK (The Scientific and Technological Research Council of Turkey) although is able to fund selected research projects the amount of the extended funds would certainly be not enough to develop products in the nanotechnology sector as the budget of this agency is way too narrow to this end. Researchers suggest an inventive solution to the lack of interest in such funding and the underdeveloped capital markets. They claim that a ministry of technology would be able to set the vision, handle the groundwork and hence solve the funding problem.

Apart from the financing problem researchers also mention that there are no incubation centers of nanotechnology in universities partly because nanotechnology products require much longer periods of research time. Another issue related to the commercialization of nanotechnology products is a possible lack of demand to Turkish produced nanotechnology products due to the lack of trust in their reliability. A related issue which the researchers raise is the weak patent and copyright laws in Turkey which curb the researchers' incentives to engage in researching and developing nanotechnology products. Researchers also mention that there is a lack of trust between the industry and the university as private sector professionals in Turkey do not have enough confidence in the ability of the university professors in handling the practial matters of the market. Finally, researchers at Marmara argue that the whole country is not as developed as the main cities like Ankara,

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