NANOTECHNOLOGY-AN IMPORTANT ACTOR IN KNOWLEDGE ECONOMY

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Abstract

In human history, whenever a fundamentally new type of material emerged, a new economy was born. This certainly happened during the Stone, Iron, Bronze, and Plastic Ages. Instead of pertaining to a single material, nanotechnology provides the opportunity to so fundamentally change virtually any material that a groundswell of new business will arise. Those countries and companies that do not lead in the development and application of nanotechnology are at great risk of becoming non-competitive. Recent avalanching advances in the ability to manipulate materials at the sub-microscopic scale mean that the materials of the future can have properties that were only imagined in the past.

In this paper, we try to identify nanotechnology as a new actor in knowledge economy in global arena and argue on what policy should we follow as a country to participate as a nanotechnology provider in this global knowledge economy.

Keywords: *Nanotechnology, Knowledge Economy, Technological Change*
JEL Classification: O33 - Technological Change: Choices and Consequences; Diffusion Processes

1. INTRODUCTION

1.1. Conceptual Approach

Technology is a form of human cultural activity that applies the principles of science and mechanics to the solution of problems. It includes the resources, tools, processes, personnel, and systems developed to perform tasks and create immediate particular, and personal and/or competitive advantages in a given ecological, economic and social context. (Mc Omber 1999:138)

With technology, the world has changed drastically. Most of the innovations from the technological advances have very important effects on the lives of peoples of the world, which has witnessed radical changes especially after 1960's revolutions on the microelectronics technologies. Even there are some people who argue that the history is made by technology as a result of their highly criticized techno-determinist view. (Atabek, 2006)

Etymologically technology comes from two ancient Greek words: **tekhne** and **logos**. Tekhne has something to do with producing/manufacturing.(...) Logos is the other word and it means knowledge, reasoning logic etc. However logos has something to do with the social knowledge. This knowledge of production is achieved and accumulated by social interactions. Therefore it is socialized knowledge. Finally we come to our Definition of Technology: Technology is the socialized knowledge of producing goods and services. (Atabek, 2006)

1.2. New Economy: A Postmodern View

Information Age receives us with a lot of innovations in culture as other areas. There are revolutionary changes in our economic, social and political culture. New face of commerce and its new economical concepts are important parts of these cultural transformations. (Eldeniz, Dilmen, 2005:61)

In the past, the basic outcome of industrial revolution was mass production and mass consumption. And the social life was regulated accordingly. This era could also be named as modernism. Today, we are living in the era of postmodernism.

This indicates that some things are changing. From the philosophical point of view, perceptions about the real world are changing. In stead of masses an individualistic approach is taken place. Individualism is getting more and more importance, people are talking about individualism in every instance of conversations both in scientific fields and non-scientific fields.

This transformation has created a situation where the technology, once for the masses, is now in the service of individual needs. For example, the "T model" Ford car was assembled for the masses in one color that is black, but now we have dozens of car producers, dozens of car models of each producer and we have near unlimited interior and exterior options for a car we want to buy. This is called custom-made car for your needs.

On the other hand, contrary to the sayings of producers, advertisers and techno-determinists, some argue that compared to the billions of people in the world, there are not as much choices as we think when we are buying a car. So, this seems that actually there is not a product for an individual but for individuals with common characteristics. This critic is worth to think about. We should not confuse the slogan of mass consumption with the slogan of individual freedom. Individual freedom is a good thing under the umbrella of democracy, but this should not be a tool for mass consumption greed.

Nanotechnology can be a way to escape from this situation. Because of its nature, individual needs can be satisfied with the products of nanotechnology. Individuals want non-flaming clothes, smart shirts, and small mp3 players to carry with them and cure for their deadly illness. Nanotechnology used in genetics, biology, semiconductors, displays, hard disk storage, optoelectronics/sensors and micro/nano-electromechanical systems and medicine give an opportunity to overcome such difficulties of meeting now-impossible needs.

2. NANOTECHNOLOGY

2.1. What is Nanotechnology?

In production, the most significant economic forces are the rising importance of information, communication, nanoscience, generic engineering, and other technological applications. In addition to the direct effects of the changes on employment, these innovations have led to increased use of services (particularly information related services), and reduced use of goods (particularly, raw materials) in the production processes of other manufacturers. (O'Dubchair, Scott, Johnson, 2001:2)

In its formal sense, the 'nano' world is where science and technology reach dimensions and tolerances in the range 100 nanometres (0.1 micrometres) to 0.1 nanometres. A nanometre is a billionth of a metre which is about 10 times the size of a hydrogen atom. So nanotechnology and nanoscience are concerned with materials science and its application at, or around, the nanometre scale. A more useful definition of nanotechnology is the application of science to developing new materials and processes by manipulating molecules and atoms. It is a collective term for a set of technologies, techniques and processes rather than a specific area of science or engineering. (Taylor, 2002:6), (Meyer, M., Persson, O., Power, Y., 2001:7)

The properties of materials can be different at the nanoscale for two main reasons. First, nanomaterials have a relatively larger surface area when compared to the same mass of material produced in a larger form. This can make materials more chemically reactive (in some cases materials that are inert in their larger form are reactive when produced in their nanoscale form), and affect their strength or electrical properties. Second, quantum effects can begin to dominate the behavior of matter at the nanoscale - particularly at the lower end - affecting the optical, electrical and magnetic behavior of materials. Materials can be produced that are nanoscale in one dimension (for example, very thin surface coatings), in two dimensions (for example, nanowires and nanotubes) or in all three dimensions (for example, nanoparticles). Potential uses of nanotechnology can be classified as follows: (The Royal Society&The Royal Academy of Engineering Report, 2004:3)

- Nanomaterials can be constructed by 'top down' techniques, producing very small structures from larger pieces of material, for example by etching to create circuits on the surface of a silicon microchip.

- Metrology, the science of measurement, underpins all other nanoscience and nanotechnologies because it allows the characterisation of materials in terms of dimensions and also in terms of attributes such as electrical properties and mass.

- Electronics, optoelectronics and ICT: The role of nanoscience and nanotechnologies in the development of information technology is anticipated in the International Technology Roadmap for Semiconductors, a worldwide consensus document that predicts the main trends in the semiconductor industry up to 2018. This roadmap defines a manufacturing standard for silicon chips in terms of the length of a particular feature in a memory cell. For 2004 the standard is 90nm, but it is predicted that by 2016 this will be just 22nm. (Gupta, Jayatissa, 2003:470)

- Bio-nanotechnology and nanomedicine: Applications of nanotechnologies in medicine are especially promising, and areas such as disease diagnosis, drug delivery targeted at specific sites in the body and molecular imaging are being intensively investigated and some products are undergoing clinical trials.

- Industrial applications: Current applications are mainly in the areas of determining the properties of materials, the production of chemicals, precision manufacturing and computing. In mobile phones for instance, materials involving nanotechnologies are being developed for use in advanced batteries, electronic packaging and in displays.

The impact of the information technology (IT) revolution on our world has far from run its course and will surely outstrip the impact of the industrial revolution. According to Moore's law the number of transistors in an integrated circuit doubles every 12 to 24 months. This has held true for about 40 years now, but the current lithographic technology has physical limits when it comes to making things smaller, and the semiconductor industry. At that point a new technology will have to take over, and nanotechnology offers a variety of potentially viable options. (Gupta, Jayatissa, 2003:470)

2.2. Nanobusiness in Knowledge Economy

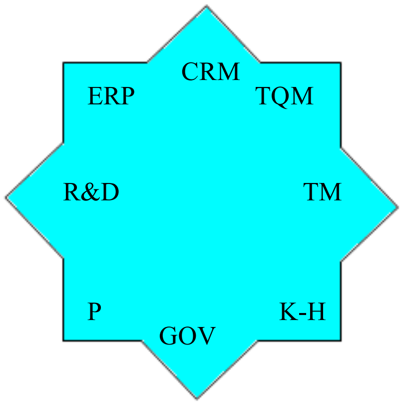
In order to accelerate the activities of research, development and commercialization, the U.S Bill Clinton government announced the first formal government programme, National Nanotechnology Initiative in 2001. European Union added nanotechnology practices into her Framework Programme as a primary field.

Investment in nanotechnology is increasing rapidly. It is a subject that attracts large and small countries. More than 30 countries have nanotechnology activities and plans. As well as the major players, there are growing programmes in Singapore, Russia, China and the Ukraine. In Mexico there are 20 research groups working independently. Korea, already a world player in electronics, has an ambitious 10-year programme to attain a world-class position in nanotechnology.

Knowledge Economy has a very important concept as its core. This core is called Intellectual Property. Intellectual Property has eight subparts of data pieces. Namely, they are: (Küçük, 2005:112). These new attributes produce a new type of market and a new society highly dominated by electronic powerful networks.

1. Customer Relations Management
2. Enterprise Resource Planning
3. Total Quality Management
4. Research & Development
5. Trademark
6. Patent
7. Know-How
8. Governance

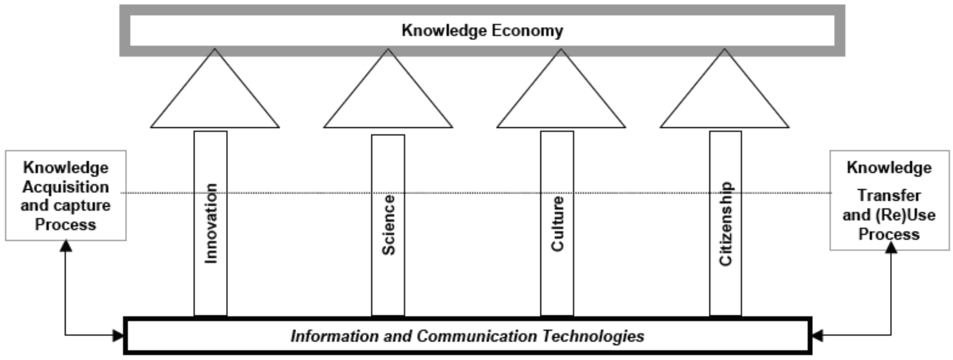
Figure-1: Octagonal Star of Intellectual Property



KE (Knowledge Economy) is associated with the impact of the technological innovation which reflects in reduced prices, bigger levels of efficiency through the combined use of telecommunications, computers, mobile devices and the Internet. Associated to those developments, new products and services emerge, strong innovations in the financial markets grow up, new methods of payment appear, organizational cost reductions are achieved, and new improvements in the quality of products and efficiency of processes are obtained. (Lopes, Martins, Nunes 2005:131)

KE has a base of Information and Communication Technologies. This type of economy must stand on four pillars: Innovation, Science, Culture, and Citizenship. From the sociological point of view, "Citizenship" is important. Some indicators suggest that besides expressing the level of integration of the citizens and countries in the KE, they equally express the quality of that integration. The use of the Internet, the development of e-commerce in purchases and sales, the e-governance and the existence of specialized personnel in ICT in the companies, are the pointers that characterize this pillar. The citizenship always has expression in the degree of participation of the citizens in the society, while the culture is linked with the existence of the person as human being, always the main factor of its development (Lopes, Martins, Nunes 2005:132)

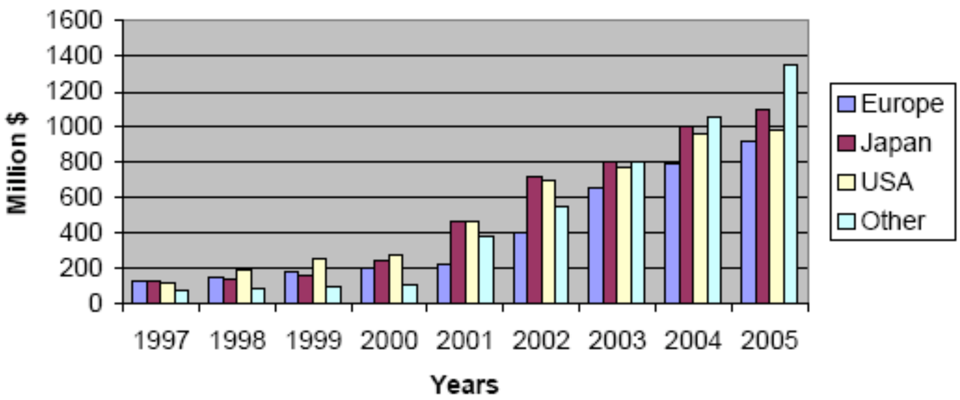
Figure-2: Knowledge Economy pillars.



Source: Lopes, Martins, Nunes: 2005:133.

The 2006 NNI (National Nanotechnology Initiative) budget request for nanotechnology R&D accross the Federal Government is $1.05 billion. Estimated spending in 2005 is nearly $1.1 billion, an increase of 9% over 2004 expenditures. The increase in spending for nanotechnology over the last five years (from an estimated $464 million in 2001) reflects the importance attributed to nanotechnology by the U.S.A. For example, funding for various PCAs (program component area) is as follows: For nanomaterials, the amount is $228 million, for nanoscale devices and systems, the amount is $244 million, for nanomanufacturing the amount is $47 million and finally, for social dimensions, the amount is $82 million. These numbers mentioned here are only for the U.S. economy. On the other hand, countries like Singapore, Russia, China, Korea and Taiwan are also spending huge amount of money. (Marburger, 2005:i),

Figure-3: Global funding of nanotechnology.



Source: Ottilia Saxl: 2005: 18.

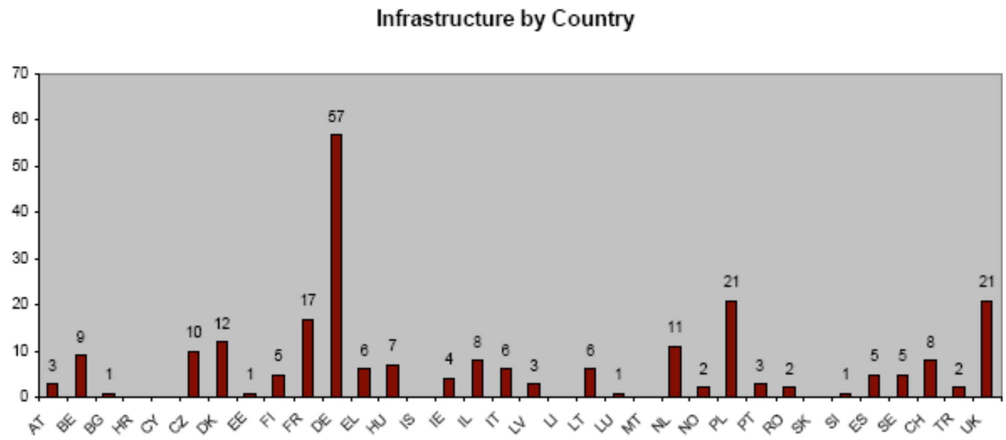
The markets for nano materials, tools and equipment for nanoelectronics totaled US$1,827 million in 2005 and are forecasted to reach $4,219 million by the year 2010. Revolutionary nano materials, tools and equipment accounted for 10 percent of the market or $189 million in 2005 and are expected to reach $866 million in 2010 led by growth in carbon nanotubes (CNT), nano imprint and extreme ultra-violet lithography. (NanoBusiness Alliance, 2005)

The global market for nanoparticles is expected to approach $1 billion by 2005. Fixcluding historic applications of carbon black and fumed silica in tyre reinforcement and adhesives, the market in 2001 was estimated at around $550 million. By the end of 2004 it is expected that it will have reached $900 million, poised to pass the psychologically important $1 billion threshold in 2006. (www.metal-powder.net, 2003:2)

2.3. Nanotechnology in Turkey from the European Perspective

Nanotechnology infrastructure in the EU and associated states (by country) is shown in Figure 4. A total of 236 centers with extensive fabrication and/or analytical facilities were identified. Turkey has only 2 centers dealing with nanotechnology. (Ottilia Saxl, 2005:18-19)

Figure-4: Nanosciences and Nanotechnologies (N&N) Infrastructure in Europe.



Source: Ottilia Saxl: 2005: 18.

On 12 May 2004 the Commission adopted the Communication Towards a European Strategy for Nanotechnology in which a safe, integrated and responsible strategy was proposed. This aims to reinforce the Union's leading position in N&N R&D and innovation while addressing any environmental, health, safety and societal concerns upfront. In this context, several needs were highlighted: (Potocnik, 2005:2-3),

- Increase investment and coordination of R&D to reinforce scientific excellence, interdisciplinary and competition in N&N together with industrial exploitation;

- Develop world-class competitive R&D infrastructure ('poles of excellence') that take into account the needs of both industry and R&D organizations;

- Promote the interdisciplinary education and training of R&D personnel together with a stronger entrepreneurial mindset;

- Provide favorable conditions for industrial innovation to ensure that R&D is translated into affordable and safe wealth-generating products and processes;

- Respect ethical principles; integrate societal considerations into the R&D process at an early stage and encourage a dialogue with citizens;

- Address public health, occupational health and safety, environmental and consumer risks of N&N-based products at the earliest possible stage;

- Complement the above actions with appropriate cooperation and initiatives at the international level.

The participation of candidate countries in European projects is still improvable. If the origin of the Expression of Interest for priority 3 (Nanotechnologies and nanosciences, knowledge-based multifunctional materials and new production processes and devices) submitted to the EC in 2002 is taken as measure, only Poland with 9% is represented strongly, followed by Turkey with 4% and the Czech Republic with 2%. (Malsch, 2003:6)

On the contrary, In the report "Nanotechnology in the Candidate Countries Who's Who and Research Priorities" published in 2003 by nanoforum.org, it is reported that in Turkey nanotechnology is not explicitly mentioned in the Science and Technology Policy. (Malsch, 2003: 208)

3. CONCLUSION

The evolution of nanotechnology advances into new economies is still at the early phase, but there is already noteworthy success, like the commercialization of remarkable biomedical test kits, multiwalled nanotubes as conducting additives for plastics, and nanofiber coated textiles for ordinary clothing. Overcoming the barriers between early technological breakthroughs and products is always challenging, and targeted governmental funding can make the difference between a shelved technology and a commercial success. (Feng, 2004: 26)

A key issue arising from our discussions with the various stakeholders was how society can control the development and deployment of nanotechnologies to maximize desirable outcomes and keep undesirable outcomes to an acceptable minimum – in other words, How nanotechnologies should be regulated? (The Royal Society&The Royal Academy of Engineering Report, 2004:6)

A key issue now, is how to rein in the insatiable, and misplaced, drive for industrial growth that has been part of our daily life ever since mankind harnessed steam; and to try and undo some of the damages already inflicted by modern cities and civilizations. (Nanotechnology – a Key Technology for the Future of Europe, 2005:29)

If it is difficult to predict the future direction of nanoscience and nanotechnologies and the timescale over which particular developments will occur, it is even harder to predict what will trigger social and ethical concerns. In the short to medium term concerns are expected to focus on two basic questions: 'Who controls uses of nanotechnologies?' and 'Who benefits from uses of nanotechnologies?' These questions are not unique to nanotechnologies but past experience with other technologies demonstrates that they will need to be addressed. (The Royal Society&The Royal Academy of Engineering Report, 2004:5)

Some thinkers say that it is a common misconception that technology is neutral. On the contrary, a technology reflects the values and goals of the society within which it emerges and, in turn, may alter the values and aspirations of that society. In a somewhat ("critical") climate of public opinion, more sensitive areas of technology might be seen as a social contract. A technology would be welcomed if the values and goals of the inventor are close to those of wider society, and if the invention correctly anticipates what society wishes, as with the acceptance of the mobile phone. (Nanotechnology – a Key Technology for the Future of Europe, 2005:31)

For this reason, considering the current situation of globalization ruling forces of the universe are in charge for nanobusiness in knowledge economy. Every nation in this case has to find her way along the long path of knowledge economy. Some sort of polarization is unavoidable. Some will follow the leader positioned nation, the U.S.A. Others, like European countries are trying to unite their forces to create a synergy by not heavily depending on capitalistic market driven thinking, on the contrary, trying to establish regulations and amendments on the front hand. This is a more socially delicate approach. There are other countries, the countries of third world of the past, like China, India, Russia and Korea etc. These countries have the opportunity to close the power gap between them and now-big nations. This opportunity is given by the innovations in nanotechnology.

In this respect, Turkey has to involve in nanotechnology by increasing collaborative works with European Union and the other hand, domestically, universities should consider the issue in multidimensional approach. This means that, this issue is not just a technical issue. It has sociological, political, economic, and ethical aspects that need to be considered simultaneously. Therefore, universities should establish academic units dealing with the nanotechnology in multidimensional way.

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