BIBLIOMETRIC AND PATENT ANALYSIS OF NANO-TECHNOLOGICAL PROCESS

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Main quantifiable indicators of scientific and technological excellence are patents and publications (Hullmann, 2006).Statistics produced by Thomson Derwent show that whilst there was a sudden rise in journal papers on nanotechnology beginning in the mid-1990s, patent applications did not start to accelerate until 1998. From that time, however, huge yearly jumps have been recorded, from around 500 in 1998 to nearly 1,300 in 2000. All of which is putting patent offices under strain. Nowhere more so than the United States Patent and Trademark Office (USPTO), which has to deal with the majority of applications (Wild, 2002).

Key words: nano-technology, science

Introduction. Patents are generally regarded as output indicator of technology development (Schmoch, 1999). They represent intellectual property rights and are thus legal documents. A patent application has to fulfill various criteria to be granted:

1) The described invention has to be new on a worldwide level.
2) The new product or process must be distinctly different compared to the state-of-the art; it must imply an inventive step.
3) The invention has to be exploitable in commercial terms. Scientific discoveries without a practical purpose are not patentable.

The third criterion implies that most patent applicants are industrial companies. This is reinforced by the fact that patent applications are expensive so that their issuance is only reasonable if a commercial exploitation is aimed at. With North American universities increasingly filing patents (mainly as a result of the Bayh-Dole Act 1980) in the last two decades, such an approach allows the identification of patenting activity of public research organizations. However, the situation in Europe is different. A recent study of the Organization for Economic Cooperation and Development ("OECD") concludes that public research organizations are presently not active patent applicants (Org. for Econ. Cooperation & Dev., 2003). Traditionally, the ownership has remained in the hands of individual employees (mainly university professors). Although several countries, among them Germany and Austria, transferred the property rights to the universities by modifying their patent law in the last couple of years, until recently universities did not frequently file patents. An inventor law, valid in the past period, which allowed university professors to exploit their intellectual property on their private account; whereas the universities did not appear as applicants in the patent documents (Heinze, 2004).

An assessment of 2003 figures from the U.S. Patent and Trademark Office (USPTO) highlighted the commanding lead held by the U.S. in nanoscale science and engineering patenting, with 42% of the overall share. Germany followed with 15.3%, and Japan was placed 3rd, with 12.6%. Fast growth was said to be occurring in South Korea, the Netherlands, Ireland and China (Huang et al, 2003). A report later that year claimed China was ranked 3rd in general nanotechnology patents behind the U.S. and Japan (Xinhua News Agency, 2003).

Furthermore, of all the U.S. patent applications in nanotechnology, about 90% of the applications came from private corporations, while universities filed roughly 7%, and about 3% were filed by government agencies and collaborative research centers. The number of issued patents involving nanotechnology has increased by more than 600% in the last five year period, from 370 in 1997 to 2,650 in 2002. While only 2% of all patents issued in 2002 involved nanotechnology, that was much higher than the 0.3% in 1997. Nanotechnology-related patent applications are evenly split between process and product inventions. Most of the inventions are refinements to known technology, but a significant number can be considered "revolutionary" or pioneering in nature (Heines, 2003).

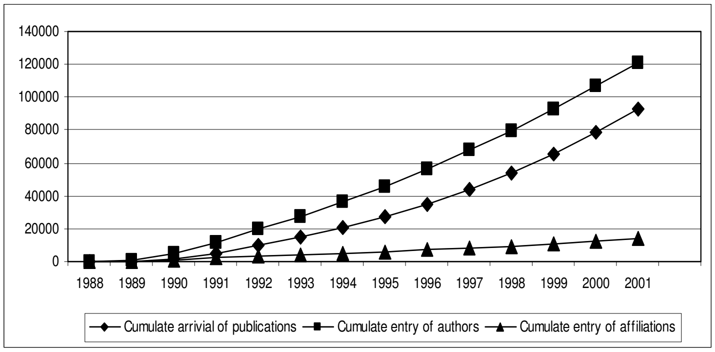
A Bibliometric Analyses of On-Going R&D Activities in Nanoscience and Technology

The scientific publications and citations represent scientific basis of nanotechnology. Scientific publications are the most appropriate indicator for measuring scientific excellence by quantifying the output (Hullmann, 2006).

Heinze (2004) pointed out, that worldwide rise both in nanopublications and nanopatents is remarkable. Since the discovery and development of the Scanning Tunnel Microscope ("STM") in the early 1980s and later Atomic Force Microscope ("ATM"), research on nanoscale phenomena has burgeoned, particularly since the early 1990s, only when the expensive STM and ATM become available at reasonable prices. The stark increase in publications in the year 1991 has continued ever since and has led to a lagged but similar development in patenting activity. The number of SCI publications (Science Citation Index ("SCI"), the world's largest publication and citation database in the natural and medical sciences) in 2002 is six times the number it was 1992. Over the whole 20-year period, an annual growth rate of 37% in the number of publications.

The results are consistent with other bibliometric studies on nanoscience and nanotechnology published since the late 1990s. In the most recent study, however, Meyer (2001) reports far fewer worldwide nano patent applications because he used the official EPO database instead of DWPI. Derwent World Patents Index ("DWPI") is the database. Searching with DWPI titles and abstracts proves to be a major advantage for the proper identification of nanotechnology patents. The staff of Thomson Derwent prepares new titles and abstracts that describe the technological content of each patent application in more detail and depth. A search of "nano" with right-hand truncation in DWPI titles and abstracts yields about three to four times as many documents as a search in official databases of the U.S. Patent and Trademark Office or the European Patent Office (Heinze, 2004).

Figure 1. Evidence from Nanopublications. Source: Bonaccorsi and Thoma (2005).



IDENTIFYING CREATIVE RESEARCH ACCOMPLISHMENTS IN NANOT&S

Whenever a new product or process emerges, patent offices are under pressure to ensure that they understand the parameters within which development work is taking place. It is crucial to be able to differentiate between what is already established knowledge and what is new when assessing a patent application for novelty and non-obviousness. The problem is that when you are dealing with something that has not been around for very long, it is not easy to find examiners who have experience of working in the field or to track down all references to prior art. The risk is that the granting of patents can be too broad and give the successful applicant a stranglehold on huge areas within the technology, so making it far harder for other companies to operate in that field (Wild, 2002).

Nanotechnology first gained recognition after Nobel Laureate, Richard Feynman, presented his talk, "There's Plenty of Room at the Bottom" to the American Physical Society in 1959 (Coleman, 2003).

Heinze,T., at al (2006) had examined the relationships between nominated creative researchers (obtained through their expert survey and prize winner data bases) and bibliometric assessments of highly cited researchers. They found that combining two data sources – the nominations of creative research and the databases of scientific prizewinners – was complementary and offered additional validation, particularly in identifying researchers who were recognized for their creativity through multiple nominations and prizes. Authors delineated types of scientific research creativity: e.g. Invention of novel instruments that opened up new search perspectives and research domains, e.g. Scanning tunneling microscopy (STM), a powerful research instrument (Hessenbruch 2004) by physicists Gerd Binnig and Heinrich Rohrer (Binnig & Rohrer 1982). Binnig and Rohrer were awardees of the 1986 Nobel Prize in Physics “for their design of the scanning tunneling microscope”. STM opened up new research avenues in semiconductor physics, microelectronics, and surface chemistry. Most significantly, STM is recognized as an important tool in the emergence of nanotechnology (mid-1980s to present), giving rise to the promise of assembling materials, structures, and systems at atomic and molecular scales.

Donald Eigler of IBM’s Alden Research Center remembers the day in 1990 when he and Erhard K. Schweitzer, who was visiting from the Fritz-Haber Institute in Berlin, moved individual atoms for the first time. Using one of the most precise measuring and manipulating tools the world had ever seen, the researchers slowly finessed thirty-five xenon atoms to spell out the three-letter IBM logo atop a crystal of nickel. To be sure, it only worked in a vacuum chamber kept at a temperature that makes the North Pole seem tropical (Sarewitz and Woodhouse, 2003).

In 1988, Eric Drexler taught the first course on NanoTechnology. In that program, he suggested the possibility of nanosized objects that were self-replicating. The next major milestone was when Rice University Professor Richard Smalley won the 1996 Nobel Prize for discovering a new form of carbon: a molecule of sixty carbon atoms (referred to as C60).Today C60 has become one of a growing number of building blocks for a new class of nanosized materials. The advancements in NanoTechnology really began to accelerate in the late 1990s (Coleman, 2003).

NANOSCIENCE AND NANOTECHNOLOGY LINKAGES

Nanoscience and nanotechnology provide an excellent testbed case to study increasingly commonplace statements about the blurring of distinctions between science and technology and the speed at which new scientific findings are transformed into commercially important technological innovations. Current developments at the frontiers of research in these domains also provide a natural experiment to assess alternative models (e.g., linear, pipeline models; chain-link models; Pasteur's Quadrants, soccer games) of relationships between scientific and technological advances (Feller, 2001).

Mehta, M. D. (2002). denotes that developments in nanoscience and nanotechnology will provide social scientists with a unique opportunity to examine how different models of innovation may explain how the knowledge-based economy is being shaped by radically new approaches to science. Nanoscience and developments in nanotechnology are expensive and require cooperation between universities, governments and industry. Not too long ago, the ***linear model*** of innovation dominated. Traditionally, knowledge transfer within innovation processes is considered a one-way flow of scientific or technological knowledge from academic research (university) to industrial development. Several other actors play important roles in innovation processes, such as government (Leydesdorff & Etzkowitz, 1996), investors (Coehoorn, 1995), and end users (Bobrowski, 2000; Bunders, Broerse, & Zweekhorst, 1999; von Hippel, (1988); Kline and Rosenberg, (1986)), criticized the linear model and launched the so-called ***chain-linked model*** of innovation processes. In this model, the "central chain of innovation" begins with design and moves toward development and production to marketing. Each step is linked together via feedback loops and all are side-linked to research. It is assumed that scientific research is not a source of inventive ideas but is used to solve problems along the chain of innovation.

Stokes (1997) introduced an alternative innovation model in his book ***Pasteur's Quadrant***. This model rejects the traditional distinction made between basic and applied research. Stokes outlines how basic science could be oriented toward improving simultaneously an understanding of fundamental principles and stimulating improvements in technology by formalizing the links between science and technology. Another innovation model is the ***"triple helix"*** of Leydesdorff (2000) and Leydesdorff and Etzkowitz (1996). This model focuses on the overlay of communications and interactions between the three institutional spheres (three helices) of industry, university and government. Each sphere produces its own knowledge, engages in marketplace activity and attempts to control external influences. Through information exchange and shared expertise, internal transformations in each of the helices facilitate the generation of new ideas and stimulate innovation.

The last type of innovation model the author of this article would like to mention is called ***"national systems of innovation"*** (Niosi, 2000) and has been defined by Lundvall (1992) as "the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge either located within or rooted inside the borders of a nation state". Such a system creates, stores and transfers information, knowledge, skills and artifacts related to technologies and innovations. Although scholars and policymakers apply different definitions and perspectives to this concept, in general the basic premise is that understanding the linkages between actors involved in innovation is central to improving technology performance (Organization for Economic Cooperation and Development, 1996).

Understanding the roles and relations between academia, government, and industry could be the basis for assessing and anticipating the likely trajectories of technology-induced social change and help answer the following question: *What model or models of innovation best explain the changes being ushered in by the revolution in nanotechnology?*

Darby, M. R. and Newlon, D. H., (2003) stated several research and evaluation methodologies which are encouraged economists to address several main research questions, in support of the National Nanotechnology Initiative. ***One question is,*** what policies increase or determine the transfer of nanoscale science and engineering knowledge from academe to industry? Issues to be examined include licensing intellectual property to inventor-affiliated companies under the Bayh-Dole Act[1] and concerns about conflict of interest or commitment. The issues could be framed in terms of the optimal assignment of property rights for university research, developing ideas of Aghion and Tirole (1994) and Jensen and Thursby (2001).

Other issue is, should there be a research exemption for patents? At present, there is much debate about the conditions under which scientists should have a free license to employ patented inventions in non-profit research for example, in their instrumentation and other research tools. Traditionally. technological inventions can be patented, whereas scientific discoveries cannot. Yet, the line between nanotechnology and nanoscience is unclear, and the economic benefits of progress be diminished if intellectual properly rights prevent rather that stimulate innovation. The fear lies where potentially devastating effects of being excluded from a market because of a rival's over-broad patent means extra expense for companies who could do without it. It is not cheap to challenge an examiner's decision within the USPTO, let alone through the courts, whilst delays in obtaining protection could make the difference between securing funding and going out of business. When Todd Dickinson former Commissioner of the USPTO was made aware of difficulties in handling business method patent applications, he undertook a period of extensive consultation with industry. As a result new examination guidelines were drawn up. Companies and investors, who are pouring billions of dollars into the nascent nanotechnology industry, are expectant of a similar approach (Wild, 2002).

BAYH-DOLE'S ACT IMPLIED DUTY TO COMMERCIALIZE

The Bayh-Dole Act can be seen to impose a duty on the part of all researchers who contract with the government, referred to as grantees or contractors, to pursue the commercialization of government-funded scientific inventions. Recognizing an implied duty to commercialize under Bayh-Dole begins with the Act's enumerated objectives, contained in Section 200. Directly implicating utilization of the patent system for the

[1] The Bayh-Dole Act is one of the most important 20th century pieces of legislation in the field of intellectual property in the US, along with the creation in 1982 of the Court of Appeals for the Federal Circuit. Perhaps the most important contribution of Bayh-Dole is that it reversed the presumption of title. Bayh-Dole permits a university, small business, or non-profit institution to elect to retain title first.

purpose of effectuating its goals, Congress identifies seven objectives which form the basis of its policy promoting commercialization, three of which are of particular importance in outlining a duty to commercialize. The first of these relevant objectives, “to promote the utilization of inventions arising from federally-supported research or development,” indicates the intent of Congress to ensure that promising research results are put to productive use.

The second objective, “to protect the public against nonuse or unreasonable use of inventions,” supports the first objective and further demonstrates Congress’s intent to ensure that publicly-funded inventions reach the public. Furthermore, it reflects the government’s right to enforce the commercialization provisions of Bayh-Dole. The third key objective, “to promote collaboration between commercial concerns and nonprofit organizations, including universities,” explicitly partners academia and industry, providing a pathway for academic interests to comply with the Act’s duty and ultimately effectuate the Act’s goals. (Henderson et al 2002).

Categorization of Nanotechnology Activity at Multinational Levels

Denominating national engagement in NanoT&S development by means of assessment of country participation in innovation, Barker et al. suggest that “most government

Category	Requirements To Fulfil The Category
National Activities or Funding	Either: 1. A national strategy for nanotechnology; 2. Nationally co-ordinated nanotechnology activities; 3. Government funding for nanotechnology research
Individual or Group Research Project	At least one individual or group currently conducting work identified as ‘nanotechnology research’
Country Interest	An expression of interest from country governments, representatives or delegates

investments are aimed at improving national corporate competitiveness in nanotechnology”. Roco believes some governments are focussing efforts towards nanotechnology because they have recognised lost opportunities at the dawn of earlier technologies such as the Human Genome Project, ICT and biotechnology.

Table 1. Denomination by categorization of country activity in NanoT&S.

Whilst global government spending on nanotechnology is relatively evenly split between North America (inclusive of Canada) ($1.6 billion), Asia ($1.6 billion) and Europe ($1.3 billion) (President’s Council of Advisors on S&T, 2005).

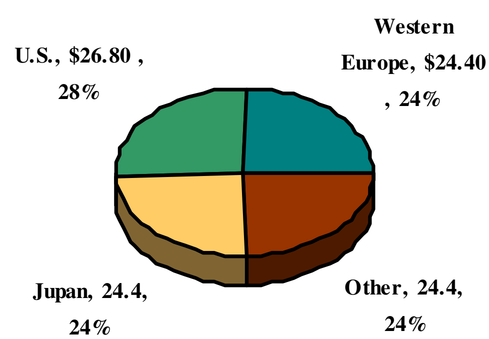
Categorization of general level on NT activity of the country is performed according to the degree of government support for NT, as well as on level of industry involvement and the amount of internet accessible NT research from academic institutions and research groups (Court et al 2004).

The Lux Research data included U.S. State funding in the total for North America and incorporated figures from associated and acceding EU countries in the European estimate. The remaining governments, not covered above, contributed $133 million. Funding among nations varies greatly. For example, whilst both the U.S. and Thailand have national nanotechnology programs, established in 2000 and 2003, respectively, Thailand's program receives approximately $2 million per year (Changsorn, 2004) compared with 2005 annual funding for the U.S. National Nanotechnology Initiative (NNI), set at $982 million (Office of S&T Policy, Executive Office of the President, 2005). At 25th of November 2006 Arab News reports, that the King of Saudi Arabia is putting the equivalent of about US$9.6 million into nanotechnology at Saudi universities.

U.S. CURRENTLY LEADS THE WORLD IN GOVERNMENT R&D INVESTMENT, WITH A LITTLE OVER 25% OF THE TOTAL[2.] National Nanotechnology Initiative supported by U.S. government holds Worldwide Leadership in Nanotechnology Research. At the White House, at the 3rd of December, 2003, the President George W. Bush signed into law the "21st Century Nanotechnology Research and Development Act". This legislation puts into law programs and activities supported by the National Nanotechnology Initiative (NNI), one of the President's highest multi-agency R&D priorities. The Act aims to cement U.S. economic and technical leadership by assuring stable, long-term support for nanotechnology research.

The U.S. is the world leader in generating knowledge and performing creative interdisciplinary research.

Figure 2. Share of Global Investment in NTS



Funding for the National Nanotechnology R&D Program is one of the Administration's top multi-agency priorities.

The National Nanotechnology R&D Program involves 10 federal agencies and continues to be a high priority of both the Administration and the Science Committee. Between FY 2001 and FY 2005, spending on federal nanotechnology R&D more than doubled, rising from $464 million in FY01 to $982 million in FY05. The FY06 budget requests an estimated $1.05 billion for the program in FY06, an decrease of $27 million, or 2.5 percent, over the estimated FY05 level. Requested funding for the five agencies authorized in the 21st Century Nanotechnology Research and Development Act (P.L. 108-153) is $665 million, and remains significantly below the $890 million authorized for these agencies for FY06 in the Act.

Nanotechnology promises to be both evolutionary and revolutionary-improving and creating entirely new products and processes in areas from electronics to health care.

[2] Source: Jim Murday. NanoBusibess Aliance Analysis, in "Nanotechnology and Energy. Be a Scientist –Save the World!" by Adams, W., Jaffe, A., Smalley, R. (2005). In memoriam of R. Smalley.

Nanotechnology can help provide clean energy. Nanotechnology is expected to have a broad and fundamental impact on many sectors of the economy, leading to new products, new businesses, new jobs, and even new industries (Rejeski, 2006).

Lux Research, Inc., expects sales of products that incorporate emerging nanotechnology to rise from less than 0.1% of global manufacturing output today to 15% in 2014, for a total of $2.6 trillion annually - a value that approaches the size of the information technology and telecom industries combined and is 10 times larger than biotechnology revenues.

THE SIXTH FRAMEWORK PROGRAMME OF THE EUROPEAN COMMISSION

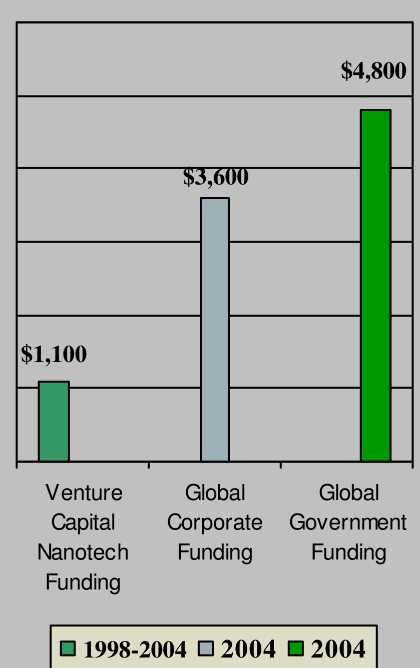
Figure 4. Sector specific distribution of application field of companies' products.

Nanotechnology initially was the priority of material sciences and began it's start-up mainly in materials production industry. Nanotechnology is providing a critical bridge between the physical sciences and engineering, on the one hand, and modern molecular biology on the other. Materials scientists are learning the principles of the nanoscale world by studying the behavior of biomolecules and biomolecular assemblies. In return, engineers are creating a host of nanoscale tools that are required to develop the systems biology models of malignancy needed to better diagnose, treat, and ultimately prevent cancer (NIH Publication, 2004).

The Sixth Framework Programme of European Community predominantly covers activities in the field of NT research, technological development and demonstration (RTD) for the period 2002 to 2006. The data collected are gathered in a knowledge database, which gives the possibility to obtain specific technology roadmaps depending from the branches and the industrial applications. The results have been published in different reports, one of them is "European survey on success factors, barriers and needs for the industrial uptake of nanomaterials in SMEs" (Small and Medium Sized Enterprises survey). SMEs account for around two-thirds of employment in Europe, it is evident that more effort is needed to encourage the creation of new and innovative enterprises (Commission of the European Communities, 2004).

In order to remain competitive on these markets, companies have to integrate these new results in their commercial vision for future products. Within the survey the situation for companies working in the branches medical & health, energy, automotive and aeronautics has been examined in detail. 39% of the enterprises (not mainly pharmaceutical) specified that "Medical & Health" applications parallel among their basic productions.

FIGURE 3. MORE GOOD NEWS: U.S. CORPORATE INVESTMENT IS SIGNIFICANT ($ Billions)

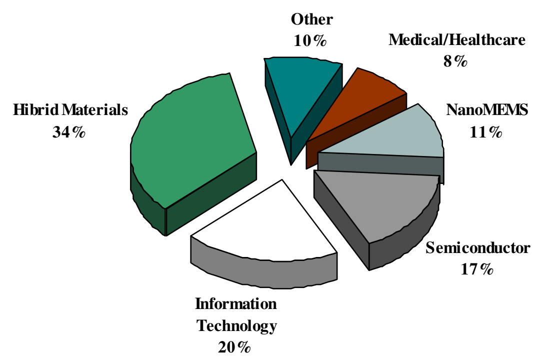


HEALTH-RELATED NANOTECHNOLOGY PATENT ACTIVITY AND RELEVANCE OF INDUSTRIAL IMPLICATION. The U.S. National Institutes of Health counts nanomedicine as one of its top five priorities, the National Cancer Institute committed $144 million to nanotechnology research in October 2004. Yet major pharmaceutical companies are committing almost no money or people to nanotechnology research – exposing them to strategic risks (Lux Research, 2005).

Between 1996 and 2001 among all of NT patents medical applications were filed most often, both in United States and Europe according to comparison of nanopublications and nanopatents, seems that specialization in pharmaceutics tends to be reflected in a relatively high share of patents for medical purposes (Heinze, 2004).

As of mid-2006, 130 nanotech-based drugs and delivery systems and 125 devices or diagnostic tests are in preclinical, clinical or commercial development. The combined market for nanoenabled medicine (drug delivery, therapeutics and diagnostics) will jump from just over $1 billion in 2005 to almost $10 billion in 2010 and the US National Science Foundation predicts that nanotechnology will produce half of the pharmaceutical industry product line by 2015. Nanomedicine will help big pharma extend its exclusive monopoly patents on existing drug compounds and on older, under-performing drugs. Analysts suggest that nanotech-enabled medicine will increase profitability and discourage competition. (The ETC Group, 2006)

Figure 5. NanoT&S Industry Focus



Despite the promise of nanotechnology, experts of Lux Research, Inc., mention, that the big pharmaceutical companies are 'flat-footed' in their nanotech initiatives, while medical device firms are more advanced in their race to develop nanotechnologies, with major players such as Baxter International Inc., Medtronic Inc., and Guidant Corporation all pursuing nanobiotech R&D," says Lynn Yoffee, associate publisher of NanoBiotech News, which produced the 2005 Nanomedicine, Device & Diagnostic Report.

These suggestions are statistically inevitably evidenced by the confirmation, that medical and healthcare sectors takes only 8% in whole nanotechnology industry (Fig. 5.). (Coleman, 2003). This is tentative for belief, that transfer from S&T sector to industry is somehow delayed. When matching performed for revealing confluence of publications and patents, in order to reflect flow rate of science to technology, Meyer observed, that knowledge transfer from science to technology is most prominent within the academic sector, rather than from academe to industry (Meyer, 2001). It's noteworthy to mention the case study (Borreguaro et al, 1994) from marketing manual, which is depicted, that one of the Hispanic homeland medium-sized textile enterprise "Industrias Beltran" was considered as market leader with ownership of only 7% share of total textile market in the country. The total market share of materials' production and informational technologies are much more prevailing, compared with medical & healthcare industrial market in general. So merely 8% involvement for NT investment in medical & healthcare sector could be accepted as substantial impact for advance in innovative technology implication.

“Nanotech presents many opportunities to pharmaceutical giants, ranging from better delivery of existing drugs to entirely new therapies based on nanomaterials,” said Lux Research Vice President of Research Matthew M. Nordan. “But big pharma is not investing in nanotech today. If this trend continues, nanotech will play out in pharmaceuticals just as biotechnology did, with major pharmaceutical companies leaving money on the table and allowing new competitors to take root.” Lux Research bases its conclusions on in-depth interviews conducted with individuals accountable for nanotechnology at 33 global corporations with annual revenues exceeding $5 billion. The interview data reveals that:

- No life sciences interviewee rates NT as a high corporate priority, as opposed to 78% of interviewees in electronics and materials;
- Only one out of six life sciences respondents claims to have an explicit strategy for nanotechnology, compared with two-thirds of those in other electronics and materials;
- Big pharma companies on average commit 16 people and less than half of one percent of R&D spending to nanotechnology research, whereas like-sized electronics and materials firms commit more than 100 people and more than 8% of R&D.

Lux Research’s analysis finds that large drug manufacturers pay little attention to nanotechnology for three reasons: organization, history, and hubris. *First,* big pharma companies typically entrust accountability for nanotechnology to an executive responsible for drug discovery, pharma’s biggest cost driver – but nanotech’s big near-term impact is in drug delivery.

Second, big pharma companies learned during the biotech revolution that they could avoid their own investment and instead in-license drugs from start-ups at a late stage – but greater pressure on big pharma’s drug pipelines today gives nanotech start-ups a negotiating advantage. *Finally*, many big pharma executives claim they’ve been “doing nanotech” for years by developing small-molecule drugs or engineering proteins – however, few can claim the materials science expertise that truly novel nanotech innovations depend on. Pharmaceutical companies’ laissez-faire attitude towards nanotech will have consequences. “Big pharma will have to contend with a new wave of superbranded generics that will erode market share. This trend began with the approval of American Pharmaceutical Partners’ nano-enabled ABRAXANE cancer therapy this January, 2005” said Nordan. “On the other hand, opportunity exists for a forward-thinking drug manufacturer to go on the offensive and acquire competitive capabilities by picking up a nanoscale reformulation specialist, as mid-cap pharma manufacturer Elan and medical devices leader Baxter already have.”

Even with big pharma companies largely sitting on the sidelines, start-up companies are surviving and even thriving and new start-ups emerging nearly every month (Powers, 2006). Welland challenges the contemporary belief that drug research has to be capital intensive, claiming that pocket-sized, drug factories “could theoretically end the control of large companies over manufacturing” (Mantell, 2003).

PATENT PROTECTION BECOMES INCREASINGLY CRITICAL FOR INVESTMENT. Successful researchers are frequently turning into entrepreneurs by launching start-up companies. Out of the hundreds of such companies founded in recent years, one-half are located in the USA compared with one-quarter in the EU (De Francesco, 2003).

"For start-ups especially patents are absolutely critical," says Leon Radomsky, a patent attorney with US law firm Foley & Lardner. "Their assets are based on their intellectual property and this is what they are selling to the venture capitalists (VCs) and to the larger companies when they are planning their exit routes." He says that for investors, who were hit badly by the dotcom meltdown, patents covering technologies with applications in potentially huge markets are just the kind of tangible asset they are looking for. And companies clearly realize this. According to the 2001 Business of Nanotechnology Survey, the smaller nanotech businesses are attracting record levels of venture capital interest with 53 funds in the US now actively investing in the sector. For 2002, the total amount invested by venture and private equity is forecast to come in at $1 billion, with a growth rate of 20% per year for both 2003 and 2004 as technologies and products begin to have an impact in various market places. Between them, the three strands of the nanotech revolution are expected to spend $2 billion to $3 billion on research and development over the next 12 months. And as more and more money is poured into R&D activities, so the importance of patents is on the increase.

Banks and venture capitalists are very selective when offering risk capital, in particular, for areas that are perceived by them to have a high technical risk, uncertain time-to-market, or could have negative ethical, health or environmental consequences. Patents are normally needed to prove ownership of the knowledge and new entrepreneurs need not only to be at the forefront of nanotechnology but to combine this with management and business strategy acumen. New entrepreneurs often complain that they are offered credit (instead of risk capital) and that they receive no support in management - this increases their exposure and perception of risk. Despite technological success, start-ups may fail due to lack of financial breakeven – the so-called "death valley". This problem can be acute for nanotechnology, where the R&D process necessitates a long-term commitment. In this context, the European Investment Bank (EIB) can play an important role in providing loans and strengthening the capital base for nanotechnology enterprises (Commission of the European Communities, 2004).

FOCUSED RECOMMENDATIONS FOR NT COMMERCIALIZATION. National Science Foundation (NSF) predicts that the world market for goods and services using nanotechnologies will grow to $1 trillion by 2015. Lux Research calculates that in 2004 there was $13 billion worth of products in the global marketplace incorporating nanotechnology (Lux Research, 2004). Worldwide about $9 billion annually is being spent by governments and the private sector on nanotechnology research and development. Any government program, policy, or strategy must work for our small businesses; they are the heart of the nanotech revolution and will remain so into the foreseeable future. According to the 2003 Small Tech Census™ research, nearly 72% of 300,000 manufacturing entities in the United States have less than 20 employees and 92% of manufacturing companies have less than 100 employees. Additionally, the Small Business Administration estimates that there were approximately 22.9 million small businesses in the U.S. in 2002 and that small businesses provide approximately 75% of the net new jobs added to the economy, represent 99.7% of all employers, and represent 97% of all U.S. exporters (Small Business Administration 2006).

Nanotechnology is no longer just a large government science research project. In the long run, key social and economic benefits will only occur if we succeed in bringing innovations to market. To do that, we need to place new people, resources, and ideas behind an expanded national nanotechnology initiative.

NANO T&S PATENT OWNERSHIP BY MEDICAL & HEALTHCARE SECTOR. With respect to medical-healthcare sectoral ownership, 77% of patents are held privately, 16%

by universities, 5% by government and 2% by independent, not-for-profit organizations. The U.S. remains the leader in terms of the shear number (75%) of nano-based medical products in development, and of the 25% of drug and device candidates being developed outside of the U.S., Canada, Australia and Israel are working on 43% of the total 63 drugs and devices in the works around the world.

U.S. government added financial muscle to nanobiotech development in 2005, with major capital infusions through the National Cancer Institute's Alliance for Nanotechnology in Cancer and the National Institutes of Health's Program of Excellence in Nanotechnology.

Sector	Share (%)
Private Company	54
Individual	23
University	16
Government	5
Independent, Not-For-Profit	2

Table 2. Distribution of health-related nanotechnology patent activity by sectors for 2004. Source: Maclurcan, D.,C. (2005).

Nanomedicine started out with a bang in 2005, with the U.S. Food and Drug Administration's (FDA) approval of ABRAXANE in January, considered a seminal event by industry experts. And experts predict 2006 will be another good year for nanomedicine. In fact, this year may bring several new nano-based drug approvals and the continued rapid evolution of tools and enabling technologies that are propelling the development of drugs, delivery vehicles, diagnostics, and medical devices. According to data compiled by NarwBiotech News in the 2006 Nanomedicine, Device & Diagnostic Report, more than 130 nano-based drugs and delivery systems and 125 devices or diagnostic tests have entered preclinical, clinical, or commercial development - up from 61 drugs and 91 devices and diagnostics the previous year, meaning the clinical pipeline has grown 68% since last year at this time (Powers, 2006).

ნანოტექნოლოგიური პროცესების ბიბლიომეტრიის და პატენტების ანალიზი.

თ. ჩაჩიბაია, ე.რაუპი,
(საქართველოს უნუვერსიტეტი, სოციალური ეკოლოგიის და საზოგადოებრივი ჯანდაცვის ფაკულტეტი, თბილისი, საქართველო, მინეაპოლისი, აშშ)

რეზიუმე:

ნანოტექნოლოგიის სფეროს აღმავლობის მაჩვენებელია პუბლიკაციებისა და პატენტების ზრდა ამ სფეროში. პატენტების რაოდენობრივი მონაცემების შესწავლა და ბიბლიომეტრიული ანალიზი წარმოადგენს ყველაზე უტყუარ საძიებო საშუალებას ნანოტექნოლოგიური მიღწევების შესაფასებლად. „

კვლევების სამეცნიერო ღირებულების განმსაზღვრელია იმ წამყვანი მეცნიერების როლი ნანოტექნოლოგიის განვითარებაში, რომლებიც ფლობენ ჯილდოებსა და პრიზებს, ასევე გრანტებს ამ სფეროში წარჩინებული მიღწევებისთვის.

სწრაფი და დროული ურთიერთქმედება და თანამშრომლობა კვლევით საუნივერსიტეტო მეცნიერულ ცენტრებს, ინდუსტრიულ სექტორსა და სამთავრობო სტრუქტურებს შორის მნიშვნელოვანი ხელისშემწყობი ფაქტორია ნანო ტექნოლოგიისა და მეცნიერების სწრაფი განვითარებისათვის.

ქვეყანაში ნანოტექნოლოგიის ძლიერი განვითარების ერთ-ერთი ძირითადი მაჩვენებელი და ხელშემწყობი ფაქტორია სახელმწიფოს მხრიდან ინვესტირების მოცულობა.

აშშ ლიდერობს ნანოტექნოლოგიის დარგში სამეცნიერო ინფორმაციის გენერირებაში, ასევე, მრავალრიცხოვანი ინტერდისციპლინური კვლევების განხორციელებაში.

ამერიკასა და ევროპაში ნანოპატენტებისა და ნანოპუბლიკაციების შედარებითი ანალოზის მიხედვით საკმაოდ მაღალია ფარმაციის წილი, მიუხედავად ამისა, სამედიცინო და ჯანდაცვის სექტორს მთელი ნანოტექნოლოგიური ინდუსტრიის მხოლოდ 8% უკავია.

სამედიცინო და ჯანდაცვის სექტორში პატენტების 77% კერძო მფლობელობაშია, 16% - უნივერსიტეტების აკადემიური სექტორის, 5% - სახელმწიფოს, ხოლო 2% დამოუკიდებელი არაკომერციული ორგანიზაციების.

ფარმაცევტიულ ინდუსტრიაში წინსვა ნანოტექნოლოგიური ინოვაციების გამოყენებით უფრო მოსალოდნელია კერძო მცირე და საშუალო ზომის საწარმოების მიერ უფრო მეტად, ვიდრე სახელმწიფო სექტორის მხრიდან.

საჭიროა საზოგადოების ინტერესის აღძვრა სწრაფად მზარდი ნანოტექნოლოგიური სფეროს მიმართ, რათა დროულად მოხდეს ფოკუსირება ნანოკომერციალიზაციის მიზნით.

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