Buying the nano-market

Nanotechnologies are expected to deliver big future benefits. Market research and reports have produced a slew of economic predictions. But how do these reports stack up against each other on the present and future economic values of nanotechnology?

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The ongoing public debate on nanotechnology development has thrown up a series of key issues, like the prospective risks, difficulties in legislating, and the anticipated high economic benefits. This article attempts to probe the figures about the predicted nanotechnology benefits. Nanotechnology is used here in the sense given to it by the internationally recognized review of the Royal Society and the Royal Academy of Engineers[1], which describes nanotechnologies as "the design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale". As nanotechnology embraces a wide range of technologies and tools, therefore, it is more appropriate to refer to "nanotechnologies". One thing that all nanotechnologies share is the tiny dimensions they operate at, a scale at which materials may behave very differently from in a more macro form. Nanomaterials can be stronger or lighter or conduct heat or electricity in a different way, and even be differently coloured. Nanotechnologies are widely seen as having a huge potential in areas like IT, energy storage and healthcare.

The Nano race

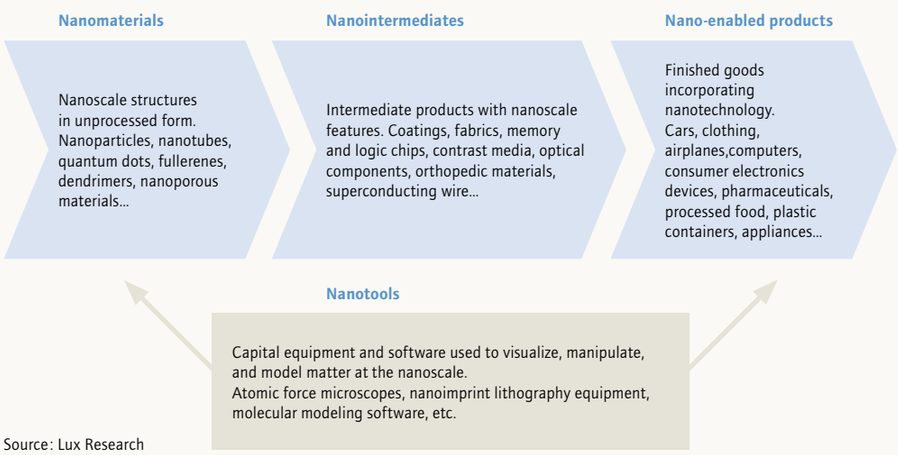
In 2000, an announcement by the US National Nanotechnology Initiative triggered a nanotechnology race, prompted by its vista of boundless opportunities in almost every area of technology. In 2008, the picture is different; the focus has shifted away from technology opportunities and onto market opportunities. At the same time, over the last five years, concerns have surfaced about the environmental, health and safety impacts of nanoparticles. The big problem is that very little is known about their toxicity. Meanwhile, the markets have been flooded with products using applied nanoparticles in things like sun lotions or clothing that come into contact with the human body.

The uncertainties surrounding nanotech development are addressed not only by governmental policy makers and scientists but also marketers, public relations professionals and journalists. Many among them use communication strategies that exploit the ambiguities of nanotech to translate the technologies into a moneymaking industry[2].

1. Royal Society and Royal Academy of Engineering 2004, *Nanoscience and Nanotechnologies: Opportunities and Uncertainties*, London, <www.nanotec.org.uk/finalReport.htm>.

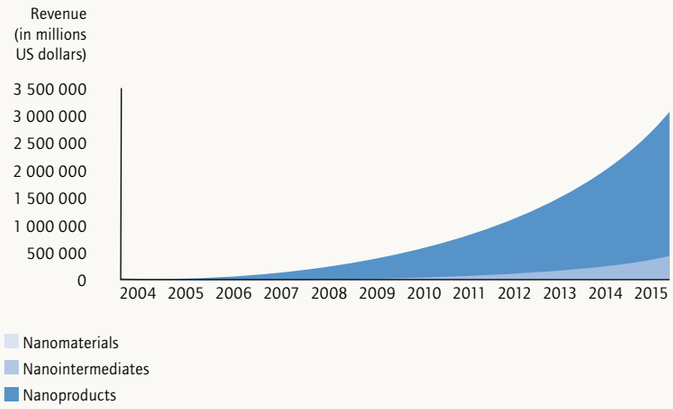
2. Ebeling, M 2008, "Mediating Uncertainty: Communicating the Financial Risks of Nanotechnologies", *Science Communication*, vol. 29, p. 335-361.

Figure 1 **The Nanotechnology Value Chain**



Source: Lux Research

Figure 2 **Value of Nanotech in 2015 according to Lux Research Inc.**



Source:
Lux Research, 2008

This article studies the market for nanotechnologies in general and does not differentiate between the diverse industries or areas of work covered by the broad term “nanotechnology” or “nanotechnologies”. One reason for this is to reduce the level of complexity, since there may be large value variations between nanotechnology sectors and marked differences between the factors influencing these values. Another important reason is that the economy itself does not always distinguish between these different sectors. To the contrary, we shall see that the umbrella term "nanotechnology" captures broad societal attention, which in turn elicits funding from government agencies, non-governmental organisations, private investors and industry. But it must be borne in mind that the story presented here is unique for each sector and should be carefully assessed for each sector individually before jumping to conclusions.

A number of international nanotechnology market research studies and reports deal with the anticipated benefits of nanotechnology development. Some put figures on the future value of nanotechnologies, while others value the benefits of this new technology by playing up the investment put into research. These figures and visions do not always stack up and also arguably reflect different influences.

The "value" of nanotechnologies

The nanotechnology market as a unified market was first quantified in 2001 by the National Science Foundation, the US agency that supports fundamental research in all the non-medical fields of science. It estimated the market value of nanotechnologies as amounting to 1 trillion dollars by 2015[3], but the figure has steadily risen over the years. There are currently several estimates of the value of nanotechnologies, most produced by market research companies. Lux Research Inc. has collated the indicators most commonly used in analyses. The European Union, United Nations and countries like the Netherlands refer to their figures, making the Lux Research predictions among the most useful exemplars of the economic value of nanotechnologies.

According to Lux Research, the market value of nanotechnology in 2008 was about $238 billion. They expect that nanotech will reach $3.1 trillion worth of products across the value chain in 2015 (see Figure 2). Nano-enabled products will account for the lion’s share of that figure with $2.7 trillion, followed by nanointermediates with $432 billion, while nanomaterials will account for a comparatively small $3.0 billion in sales.

It is clear from this that the financial value generated by nanomaterials is minimal compared to that of nano-enabled products. It shows that the high value estimated to be generated by nanotechnology comes mainly from finished goods incorporating nanotechnology, like cars, clothing, plastic containers, aircraft, etc.

The economic benefits of nanotechnologies can also be assessed by the size of investment required to reach end product development. Underlying the growth trend, it is important to note that corporate investment growth (+23%) outpaced government funding (+8%) from 2006 to 2007 (see Figure 3).

The structure of funding and investment trend in nanotechnology development may point to several things. Investment growth reflects the growing importance placed on this new technology in general. The rapid increase in corporate investment means that the government investment steer is not the strongest influence in nanotechnology development, meaning that governments are not the one decisive source of nanotechnology development. Another less business-oriented, more neutral market research report comes from Cientifica[4], which has different data and predictions about the structure of international nanotechnology investments. Cientifica’s figures show corporate investment in nanotech research and development as outweighing government funding far more than Lux Research (see Figures 3 and 4).

International investment differentials are another important consideration. The United States have a slight lead, closely followed by Asia, with Europe slightly further behind. Although the ”rest of the world” is showing strong investment growth, +30% from 2006 to 2007. However, they still represent only 4.2% of total word wide funding. Other nanotech market analyses are available. As far as the distribution of world funding between different countries goes, Cientifica has different figures. Their analysis for 2009 shows the EU investing 27%, Russia 23%, the USA just 19%, Japan 12%, China 11%, Korea 4% and the rest of the world 4% of total global nanotech investments[5].

Lux Research distinguishes three major areas of nanotechnology investment: manufacturing and materials, electronics and IT, healthcare and life sciences. The manufacturing and materials sector predominates, accounting for more than 60% of revenues; but electronics have grown at the fastest rate. As far as the economic expectations of nanotechnology development in the years ahead are concerned, Lux Research[6] predicts that growth in all sectors will be roughly evenly matched as nanotech expands into more product categories (see Figure 5).

Along with the two main market analyses mentioned above are several others which look at the precise amounts invested in or earned from nanotechnology development,

3. Berger M 2007, “Debunking the trillion dollar nanotechnology market size hype”, *Nanowerk*, <www.nanowerk.com/spotlight/spotid=1792.php>.

4. Cientifica Ltd 2008, *Nanotechnology Opportunity Report-3rd edition, Executive Summary*, <www.cientifica.eu>.

5. Cientifica Ltd 2009, *Nanotechnology takes a deep breath... and prepares to save the world*, 20/05, <http://cientifica.eu>.

6. Lux Research Inc. 2008, *Nanomaterials State of the Market Q3 2008: Stealth Success, Broad Impact.*

Figure 3 **Nanotech funding by source** (in billions US dollars)

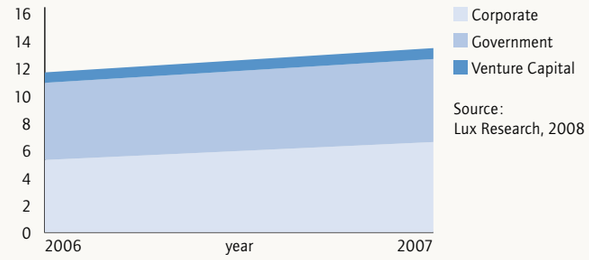


Figure 4 **Global Nanotech Spending** (in millions US dollars)

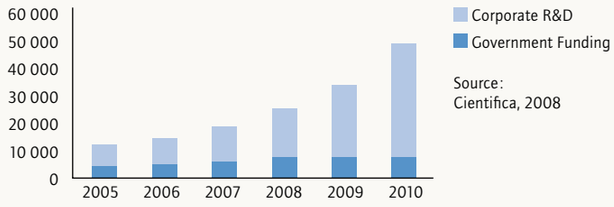
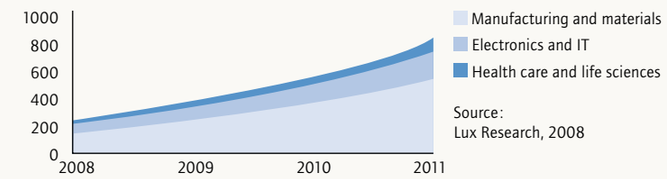


Figure 5 **Expected nanotechnology related revenues word wide 2008 -2011** (in billions US dollars)



but it can be assumed that their figures differ for current and future investments. This suggests that these figures do not necessary reflect actual investments or revenues, and so are not absolutely reliable indicators.

Job creation

Other figures have been produced that do not relate to expenditure or money value but still concern the economic benefits of nanotechnologies. One key, much-discussed indicator for trade unions is the trend for nanotechnology-driven job creation. Lux Research estimates that more than ten million jobs will be created world wide by 2014. At first glance, the job creation potential seems promising. But, these figures cannot be interpreted properly without additional information on things like structural changes in the general job market. For example, this figure takes no account of jobs lost in other sectors as company interests shift towards nanotechnology-related work.

A report published by the European Commission's DG Research[7] claims that many of the jobs will be created in small and medium-sized new nanotechnology start-ups. A significant proportion of the jobs are also created by many already well-established companies which have expanded their technology portfolio to nanotechnology in order to stay competitive. The question is whether that expanded portfolio requires more or just different workers. The figures do not disclose these kinds of details, and so are open to misinterpretation.

The market research reports are open to question on two key points. The Lux Research figures refer only to "evolutionary nanotechnology", which is only about improving existing processes, materials and applications by scaling down into the nano realm and exploiting the unique quantum and surface phenomena at the nanoscale. This trend is driven by companies' ongoing quest to improve existing products by creating ever-smaller components and better performing materials, all at lower cost. Truly "revolutionary nanotechnology", where functional devices and entire fabrication systems are built atom by atom, are not included in those reports. It is impossible at present to put a market value on this visionary technology and its future products, and it is therefore not covered in any of the nanotechnology market size reports.

The other issue is how the market size figures break down between nanomaterials, nanointermediates, and nano-enabled products. Actual nanomaterials are seen to contribute less than 0.5% – so little as not even to register in Figure 2. It may be argued that nanotechnology should not be looked at as a product industry but rather as a set of enabling technologies that support many existing industries.

Stakeholders are shaping the future

It is important to appreciate the power that these kinds of future value calculations and expectations have to shape outcomes. As precursors to modernisation, means for articulating and spreading visions around have always existed, and multiply over time. These must be given weight, for it is widely accepted that expectations influence the current attitudes and behaviour of social agents. Many visions of the future are generated with the sole purpose of justifying change in the present, visions are therefore used to anticipate and rationalise change[8]. This makes it important to know which stakeholders are producing those visions, since the different actors' expectations are related to their (present and future) interest. Visions from key government departments, or large multinational corporations, may be more apt to attract support than a radical vision put forward by an environmental group.

There is a "nanotech network", as it were, comprised of the key stakeholders in nanotechnology development, e.g., scientists, government, different international platforms, NGOs, trade unions and the business sector in general. Most of these stakeholders have future expectations and visions about nanotechnology development but not all have a clear idea of the economic perspectives of this new technology. This makes them reliant on market research and those intergovernmental reports that actually cite the figures produced by market researchers. And while those "trillion dollar" figures might help make the case for huge investment in nanotechnology research by governments or the European Union, they do not reflect the real economic value of nanotechnologies.

The literature generally has not considered the media as important in creating economic perspectives for nanotechnologies.

7. Hullmann, A 2006, *The economic development of nanotechnology: An indicator based analysis*, European Commission, DG Research.

8. Berkhout, F 2006, "Normative Expectations in System Innovation", *Technology Analysis and Strategic Management*, vol. 18, n° 3-4, p. 299-311.

9. Lewenstein, BV 2005, "Introduction: Nanotechnology and Public", *Science Communication*, vol. 27, No. 2, p. 169-174.

Lux Research estimates that more than ten million jobs will be created world wide by 2014.

Some analysts, however, did argue that the media has a big influence on the “nanotech network”, not only as mediators between the different stakeholders, but for their power in manipulating information.

The media cover stories that are "new", often focus on the controversial aspects, and provide far fewer details than scientists would like to see. The general public is relatively uninformed about the detail of science in general, or the particulars of these specific areas. But it does generally support the development of science and technology. Issues of risk and uncertainty are often more important than matters of scientific detail, and scientists and journalists often disagree about how those risks and uncertainties should be portrayed[9].

Scientific information or findings about nanotechnologies necessarily produce uncertainty, whether among scientific communities, the public or investors. Popularising scientific knowledge requires uncertainties to be managed by reducing complexity and ambiguity into simplified research results. In building the "nanomarket", far-reaching contingencies, risks and expectations are managed, and much of this management is mediated through financial news and information. Consequently, those who perform a mediating role between scientists and financial investors in scientific innovation - the journalists, public relations and marketing professionals and financial services institutions that are central to the public understanding of science - play an important role.

The fact that financial news stories about nanotechnologies are surfacing in more mainstream outlets shows the big effort to market the field as a profitable area, even if those profits may be future ones. Financial news is one area where nanotech figures are aired, which guarantees nanotechnology a place among the topics that investors are talking about. In this way, the media creates the market place.

No such thing as a single nanomarket

One way in which the media glosses over the uncertainties is to portray nanotechnologies as a unified industry in order to build an investible market by using terms like “the nanotech market” or “the nanotech industry”, ignoring its problematic and unwieldy nature. In this way it turns a heterogeneous science into an investible instrument. Another form of media manipulation is through informal agreements between journalists on what the new nanotech story should be before leaving a press conference or sharing leads on breaking stories to put across a consistent media agenda. The homogeneity of media coverage underpins the achieved reality of the object, nanotechnology. The media therefore has a relatively important role in the nanotechnology development value creation process, although its real impact on the other players in the "nanotech network" is difficult to define or measure.

In our commercialized world, the different stakeholders have a complicated structure of dependency, interest and influence. This is also true of nanotechnologies; the balance of risks and benefits is determined by a complex matrix of stakeholders and by their predictions about future nano development. Accordingly, there are many predictions but no main, generally recognized and accepted indication about the exact economic value of nanotechnologies. There are two reasons for this: there is as yet no such thing as a homogeneous nanotechnology market. Nanotechnology applications are sector-specific and it is currently difficult to keep track of all applications. The other reason is that forecasts of nanotech figures may be shaped by vested interests These gaps in the data suggest that an independent, commonly approved agency should be established to produce hard economic forecasts. Without such a resource, the economic value of nanotechnology applications can only be expressed in sector-specific terms. The existing superficial and ill-defined economic forecasts for nanotechnologies are open to misinterpretation. And while the influence they have on the future development of nanotechnologies makes them an important consideration they must be approached with extreme caution.