NANO-DEV Nanotechnology for development

POLICY BRIEF

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Nanotechnologies in India

The government of India has been investing in nanotechnologies since 2001. How did India deal with the challenges raised by nanotechnology? Building on an extensive review of Indian nanotechnology, this policy brief addresses this question and formulates policy lessons for the governance of nanotechnologies in India.

Nanotechnologies promise to bring major changes. Nanotechnologies may cross disciplinary boundaries and disrupt sectorial divisions; they may challenge standard ways of decision-making; create new ethical dilemmas; and it may turn out that established forms of risk assessment will be unsuitable for testing the effects of nanotechnologies on human health and the environment.

An earlier NANO-DEV policy brief explored what nanotechnology can mean for development. This policy brief explores how this is put in practice in India. How does India deal with the challenges raised by nanotechnology?

The policy brief first outlines the nanotechnology initiatives taken in India. Then the outcomes of these initiatives are discussed, followed by an overview of public discussions and silences. Finally, we draw some policy lessons.

Governance

The Government of India (GOI) is playing a key role in Indian nanotechnology. The government has been investing in nanotechnology as a distinct area of research since 2002. A dedicated program was launched in that year, designated as Nano Science and Technology Initiative (NSTI), initiated and

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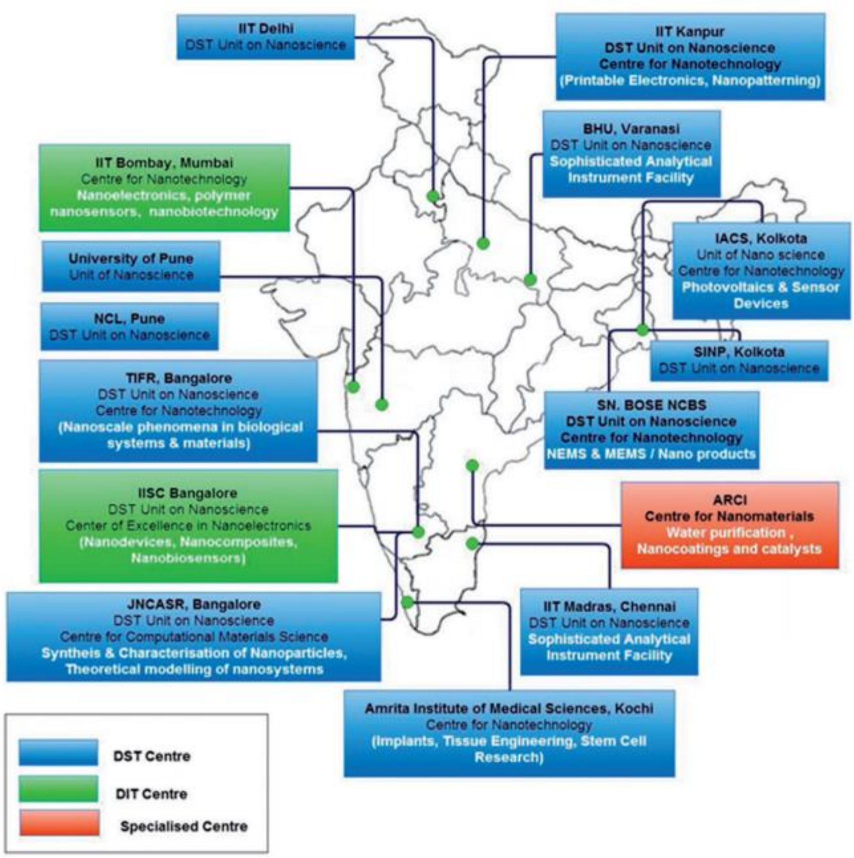
implemented by the Department of Science and Technology (DST). In 2007 the DST launched the largest and most visible funding initiative to date – the Nano Mission – with a budgetary allocation of 10 billion rupees (about USD 170 million) for five years. The total budget proposed for various schemes and programmes run by the DST in the Eleventh Five Year Plan (2007–12) was 193 billion rupees.

The main driving force has been the urge to be at the forefront of this technological wave, so as 'not to miss the bus'. The government's priority has been to create a strong institutional base, infrastructure support, and skilled manpower to develop nanoscience and technology. The government for instance liberally provided funds for research projects on various domains of nanotechnology research in different sectors, capital intensive equipment was acquired, and a series of centers of excellence was created (see the graph on the right. Source: Beumer & Bhattacharya, 2013). India also entered into several bilateral nanotechnology programmes with Northern as well as Southern countries.

Following DST lead, a host of other government agencies has since stepped in. The Department of Information Technology (DIT) and the Defense Research and Development Organisation (DRDO) have dedicated programs for nanotechnology. As per figures available, DIT has invested Rupees 325 crores (about 60 million USD) into nano-electronics. Among the major outcomes are the creation of two centers of excellence at IIT-Bombay and IISc focusing on nano-systems. Within these centers, they have started a programme facilitating access to the facilities for researchers across the country.

Also various other departments and state governments are funding nanotechnology research as well. Information on the precise number and the nature of the other investments is not available. The agricultural ministries have been noticeably absent.

Besides building research development capacity, the government also tried to build bridges between science and industry. For instance the government created the Center for Knowledge Management of Nanotechnology (CKMNT) that provides information services, several conferences were held that provided platforms for academia-industry interaction, and the Nano Mission offers the opportunity to fund science-industry collaboration.



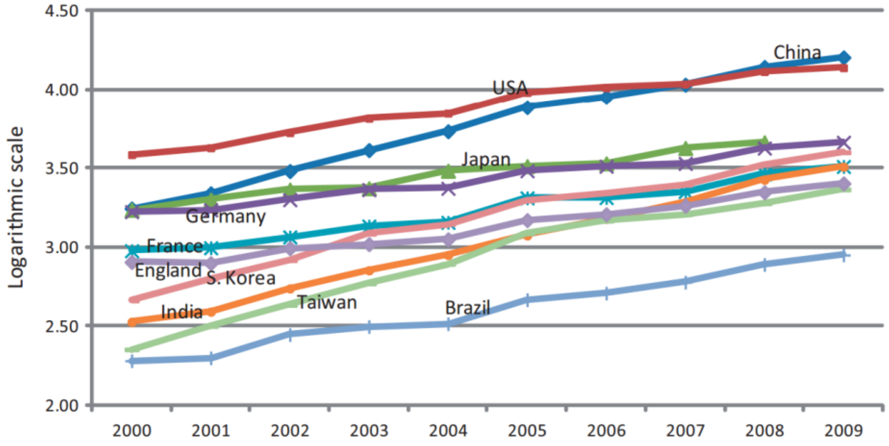
Also various courses have been initiated. The Nano Mission for instance supported 14 MTech programmes in different engineering schools and 3 MSc programmes in universities. They also developed a model curriculum for an MTech programme and has provided scholarships to students.

The governance landscape in India is thus complex, with multiple actors involved.

Non-governmental actors are also present. The Confederation of Indian Industry (CII) has for instance taken initiatives to increase industry involvement and The Energy and Resource Institute (TERI), a civil society organization active in nanotechnology since 2007, has organized several workshops that brought together a wide range of stakeholders.

Companies only recently got involved in nanotechnology R&D and are generally absent in decision-making bodies. Around 300 companies are involved in nanotechnology with around 50 companies showing dedicated engagement. These include large industrial consortia and companies focusing on drug delivery systems, software products, and the manufacture of nanomaterials as well as business consultants, distributors of instruments, conference organizers, and firms offering education to industries. Unfortunately, the total investments made and the nature of industry involvement, are hard to determine.

The Bureau of Indian Standards has been participating in the technical committee on nanotechnology standards of the International Organization for Standardization and from 2007 onwards the Nano Mission occasionally funded risk research. Government funding for risk research was sparse in those early days. The funding for risk research has recently increased but a strategy for dealing with risks is lacking.



In terms of regulation the Government of India has not been very active. In 2006 the National Institute of Pharmaceutical Education and Research announced it would develop regulatory guidelines for nanotechnology-based drugs but as of now these have not yet appeared. In January 2010, the Nano Mission announced the creation of a nanotechnology regulatory board (following a public discussion over genetically modified eggplant). Subsequently an expert committee on health, environment and safety aspects was created in the fall of 2010 but their agenda and activities have long remained unclear.

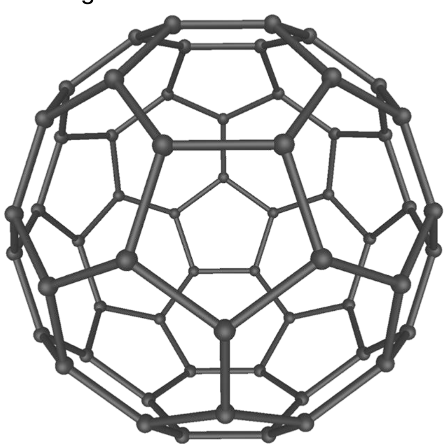
The most concrete event was the publication, in 2011, of a guidance document for safe handling of nanomaterials in the laboratory. The authors from the Indian Institute of Toxicology Research recommend “that all nanoparticles are considered potentially hazardous unless sufficient information to the contrary is obtained and should be treated as same as a radioactive substance” (Dhawan et al. 2011, p. 220). This guidance has been converted into guidelines for the safe handling of nanoparticles but this is not yet available as it is currently being discussed in the DST. The expert committee also prepares guidelines for doing toxicology research on nanoparticles and currently develops a roadmap for arriving at nanotechnology regulations.

Outcomes

Investments in nanotechnology research had a visible impact. For instance in the period 2000–2009, India published 13,092 papers in nanotechnology. There has been a steady increase in the number of nanotechnology publications, particularly since 2007. In 2000 India accounted for 2% of the total number of papers (global rank 17th) and in 2009 it accounted for 5% of the total number of papers (global rank 6th) in nanotechnology, even surpassing England. The graph on the previous page shows the publication activities from key OECD and emerging economies from 2000 to 2009 (source: Beumer & Bhattacharya, 2013).

Indian researchers are publishing in journals with reasonably good impact factors. In terms of citation scores, however, Indian researchers perform less well. Countries with less publications, like Singapore, Switzerland and Spain, score better when it comes to citation scores.

An increase in the number of institutions involved can be observed: 423 institutes were involved in publishing in 2000 whereas 1,349 institutions were involved in 2009. Overall, the academic institutions and research laboratories (mainly the laboratories of the Council for Scientific and Industrial Research, the Indian Institute of Science, and the Indian Institutes of Technology) that already had good reputations were most prolific. Industry has only a limited role in publishing, accounting for only 139 papers during the period 2000–2009. Although the majority of these papers concerned collaborations with public research institutes, the small number of publications provides an indication for the nascent stage of science-industry linkages.



Also the number of patents filed increased since the middle of the previous decade. But despite some encouraging examples, the overall number remains low. Until the early half of 2010, only 35 nanotechnology patents had been filed by Indian actors in the USPTO, of which only 15 have been granted. In the Indian Patent Office (IPO) 1,356 patent applications in nanotechnology have been filed by early 2010, mostly by foreign companies, and only 101 patents had been granted, of which 46 patents were granted to Indian institutions.

Overviews of products using nanotechnology on the Indian market are hard to acquire but here the image is not much more positive. Although there are certainly more products than the two items mentioned in the Woodrow Wilson inventory of nanotechnology consumer products (Project on Emerging Nanotechnologies, 2011), the numbers arguably remain low.

Public discussions

We grouped public discussions on nanotechnology into five clusters.

Funding

The level of funding has been subject to discussion in India. Some are satisfied with the money flowing to nanotechnology research, which is relatively high in comparison to other fields of research in India. Others are less satisfied and point to foreign investments. In comparison to American or Chinese investments, those of India are said to be “a drop in the ocean” (Varadarajan 2008).

The perceived absence of venture capital has also been discussed. Critics have noted that investors are only interested in finished products that passed the venture funding stage.

Also related are arguments about the lack of a clear investment strategies that are more transparent, concentrated on different areas of use, and focused on strategic areas rather than providing generic investments in fundamental research.

Capacity

Scientists have discussed the

question whether India has sufficient capacity to be successful in nanotechnology. Some argue that India has an "excess of talent" (The Hindu 2010) and therefore is "poised to benefit" (Sen 2008). Others, on the contrary, have argued that the major challenge for India is to train the manpower to work in this demanding field.

Also the presence of the capacity to provide a fruitful regulatory environment has been debated. Civil society organizations have raised the concern that India may not possess the regulatory capacity to deal with potential risks and to deal with intellectual property rights.

Commercialization

Commercialization – or the lack thereof – is perhaps most intensely debated. Various actors have expressed the concern that the number of products are not in line with investments made.

Most actors argue that products are absent because of a gap between Indian science and industry. Scientific research is not translated into products because scientists and industry do not manage to find each other.

Opinions diverge, however, about how this problem can be solved. Some scientists argue this is the responsibility of companies. "Unlike in the West," so the argument goes, "the industry here wants to enter at level 10; they want a ready-made product" (Singh, 2010). Others instead point to scientists. Indian scientists, according to this argument, have an overly strong affinity for fundamental research.

Regulation of risks

Compared to Western Europe and the United States, risks were not debated in India for a long time. Potential risks of nanotechnologies only become an issue of debate by the end of the last decade.

This debate was spurred by a series of reports and workshops by The Energy and Resource Institute as well as by continued toxicological research by Indian and foreign scientists. Also the controversies over genetically modified organisms created higher sensitivity over the risks posed by emerging technologies. Even industry, although not outspoken on the issue, identified the lack of safety measures as an important factor in the governance of nanotechnology.

The debate about risks is not polarized and is largely focused on regulatory aspects. Some actors have argued that entirely new legislation is required for nanotechnology but most actors have called for existing regulations to be amended. Civil society and individual scientists have urged the government to speed up this process.

Distribution of benefits

Finally, there is some discussion about the nature of benefits that should be aimed for. On the one hand several actors argue that the focus should lie on what nanotechnology can do for "the masses of India" (AzoNano, 2008). On the other hand most attention is paid to the economic growth that nanotechnology may bring.

It is important to note that these two views on the distribution of potential benefits are not always mutually exclusive. Several technologies at the nano-scale are being developed in India that focus on the so-called 'bottom of the pyramid' and thereby aim to bring useful products to the 'masses' while simultaneously pursuing economic profits.

Silences

Drawing on a comparison with international discussions about nanotechnology, we identified some notable silences.

First of all, there is a unanimously favorable opinion towards nanotechnology in India. Commentators usually take nanotechnology as the starting point and only then connect this to societal and industrial problems. Perhaps because of this, nanotechnology is never juxtaposed to other possible solutions to the problems that nanotechnology is said to solve.

Secondly, the ethical consequences of nanotechnology are hardly ever addressed. In 2008 Vice-President Ansari argued that India should prepare itself to deal with the moral dilemmas following nanotechnologies but little is done to address such challenges.

Key message: India has made significant strides in the field of nanotechnology but continues to face challenges in translating research into products and in dealing with potential risks.

Governance and developments

- Nanotechnology in India is a government-led endeavor.
- Priorities lie with creating a strong institutional base, provide infrastructure support, and train skilled manpower.
- India is strong in publications, number of researchers and institutes involved but stays behind with patents and products.

Public debate

- There are public debates about the level of funding, the capacity required to be successful, the ability to develop products, the regulation of risks, and the distribution of benefits
- There is an unanimously favorable opinion towards nanotechnology and there are no discussions about ethical consequences of nanotechnologies.

Lessons

- Significant challenges remaining include translating scientific research into products and responsibly dealing with potential risks.

References – AzoNano (2008). India announces further investments into development of nanotechnology'. 17 December 2008 <http://www.azonano.com/news.aspx?newsID=9199>; **Beumer, K. & Bhattacharya, S.** (2013). Emerging technologies in India: Developments, debates and silences about nanotechnology. *Science & Public Policy. Vol. 40*(5), pp. 628-643; **Dhawan, A., Shanker, R., Das, M. & Gupta, K.C.** (2011). Guidance for safe handling of nanomaterials. Journal of Biomedical Nanotechnology. Vol. 7(1), pp. 218-224; **Sen, P.** (2008). Nanotechnology: The Indian scenario. *Nanotechnology Law & Business, Vol. 5*, pp. 225-231; **Singh, S.** (2010). The micro machines have arrived. Who'll get them to market? *LiveMint.Com*. 15 June 2010 <http://www.livemint.com/2010/06/15221433/The-micro-machines-havearrive. html>; **The Hindu**. (2010). India should invest in nanotechnology. *The Hindu*. 20 November 2010 <http://www.hindu.com/2010/11/20/stories/2010112063020200 .htm>; **Varadarajan, N.** (2008). Taking baby steps into the nano world. *Business Today*. 12 May 2008 <http://businesstoday.intoday.in/bt/story/taking-baby-steps-into-the-nano-world.html/1/2144.html>.

About us

The NANO-DEV project is a partnership of three research institutes led by Maastricht University. Besides Maastricht University (the Netherlands), it includes the University of Hyderabad (India) and the African Technology Policy Studies Network (Kenya). Further details are available at **WWW.NANO-DEV.ORG**

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