Dimensions of India's Innovative Activity
Trends in Policies and Outcomes since 1991

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Outline

- **The Dimensions**

1. India is one of the major scientific nations in the world (Slides 3-7)
2. Growing importance of business enterprises in the performance of R&D and the concentration of it in a few industrial sectors and enterprises (8-15)
3. Patenting from India has increased, and there has been a major shift in the technologies emphasized by Indian patentees while patenting new inventions abroad (16-20)
4. Growing globalisation of innovation and India's participation in it (21-26)
5. Governmental scientific agencies vis-à-vis business enterprises (27-28)
6. What ails Agricultural R&D ? (29-33)
7. Hub of frugal innovations (34-35)
8. Maintenance of technological capability in high technology industries (36-40)

- **The Four main challenges** (41)
- **Conclusion** (42)

First dimension
India -emerging as a major scientific nation in the world

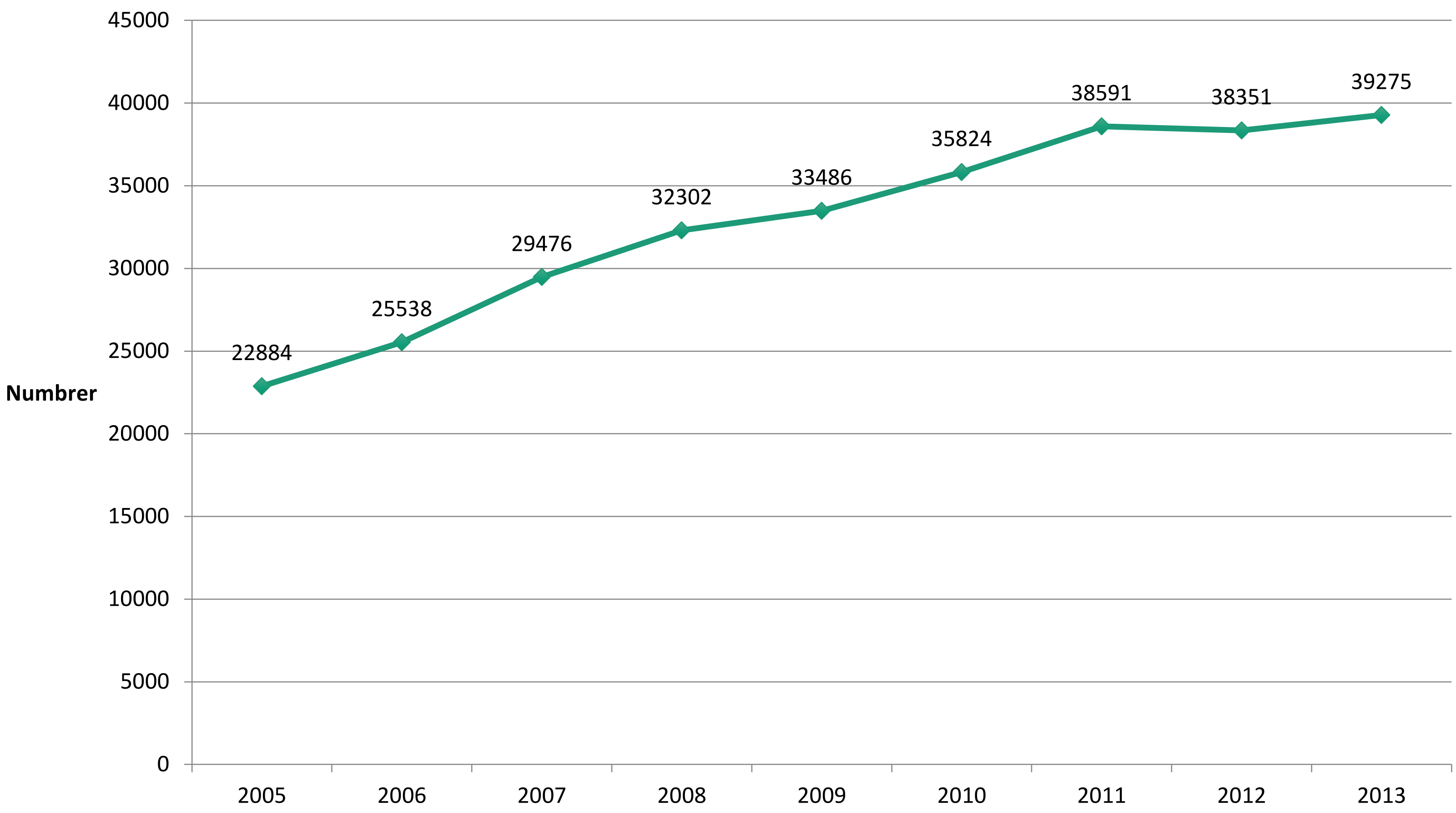
- **Participation in prestigious international projects-**

For instance, it is participating in the establishment of an accelerator in Germany, the *Facility for Antiproton and Ion Research* (FAIR), which will host scientists from about 50 countries from 2018 onwards-For instance, high-energy physicists from India, mainly from the Tata Institute of Fundamental Research (TIFR), have been participating in experiments at CERN (European Organization for Nuclear Research) since the 1970s. India's Atomic Energy Commission has participated in the construction of the 'Large Hadron Collider' – the world's largest and most powerful particle accelerator

India became the first country to place a spacecraft in Mars' orbit on its first attempt-

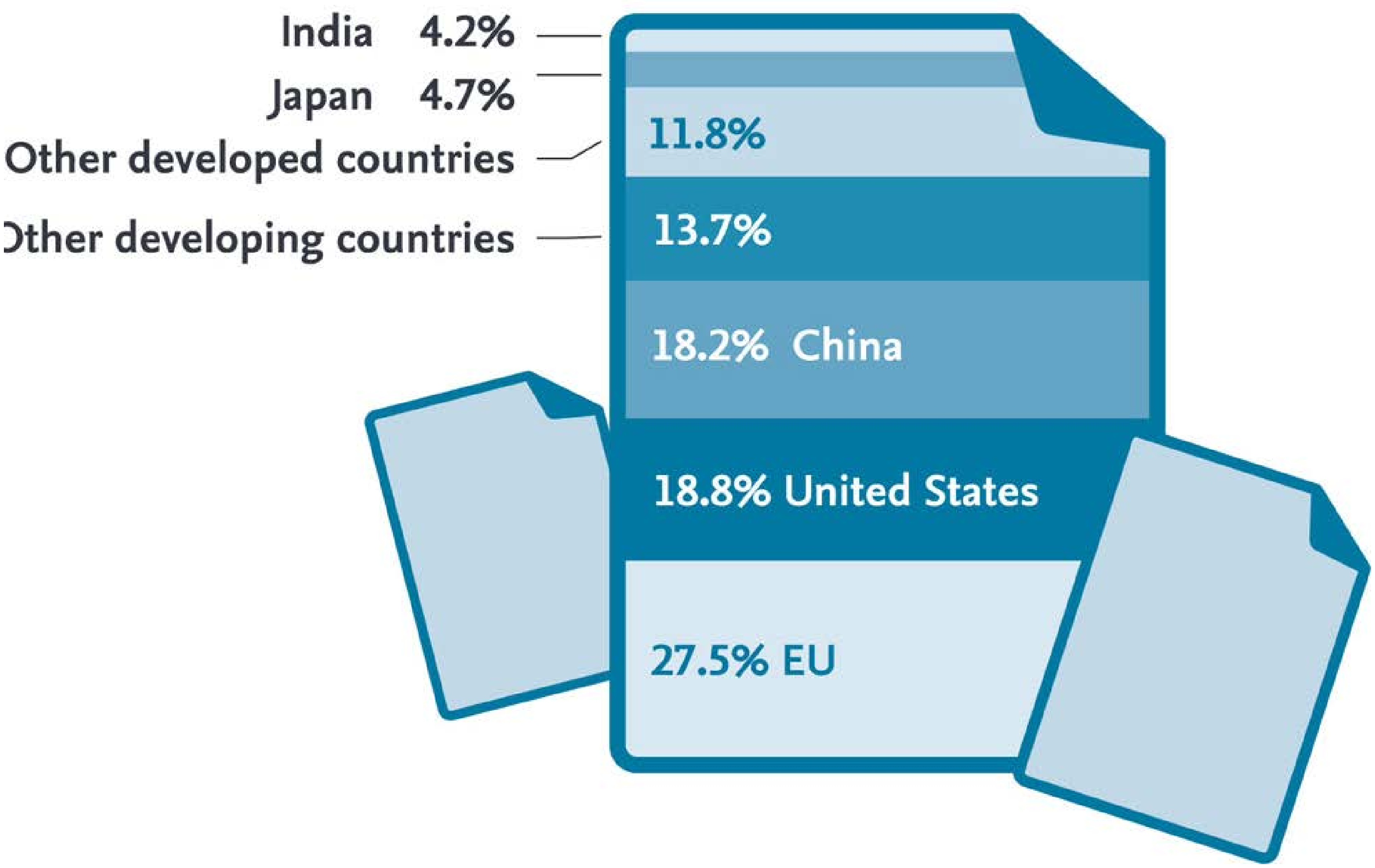
The feat was all the more remarkable in that India had developed its *Mangalyaan* probe at a cost of just US$74 million. This is a fraction of the cost of NASA's US$671 million Maven probe, which arrived in Mars' orbit just three days ahead of *Mangalyaan.*

Trends in the number of scientific publications

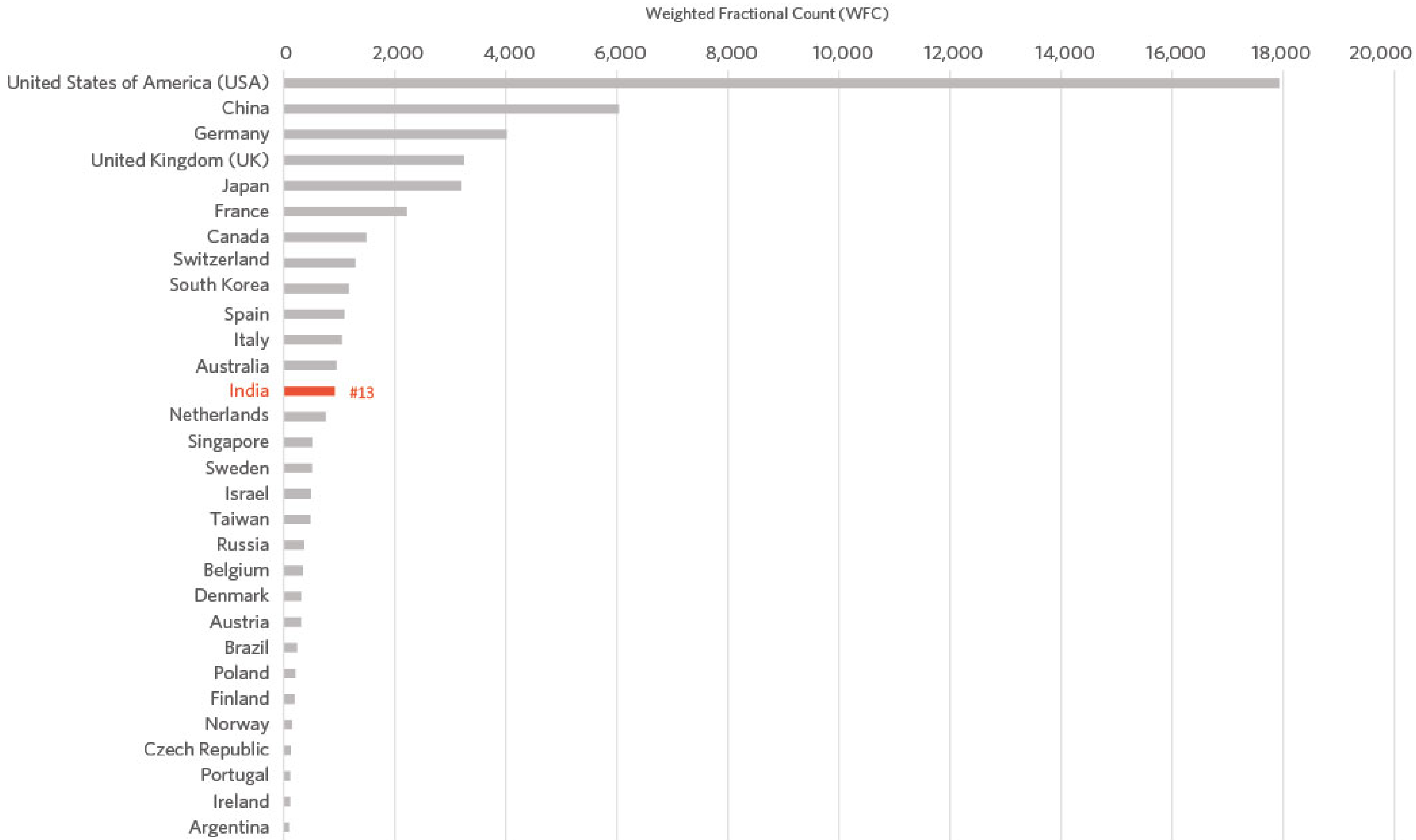


Global share of research publications, 2013

(Source: National Science Board (2016), Science and Engineering Indicators 2016)

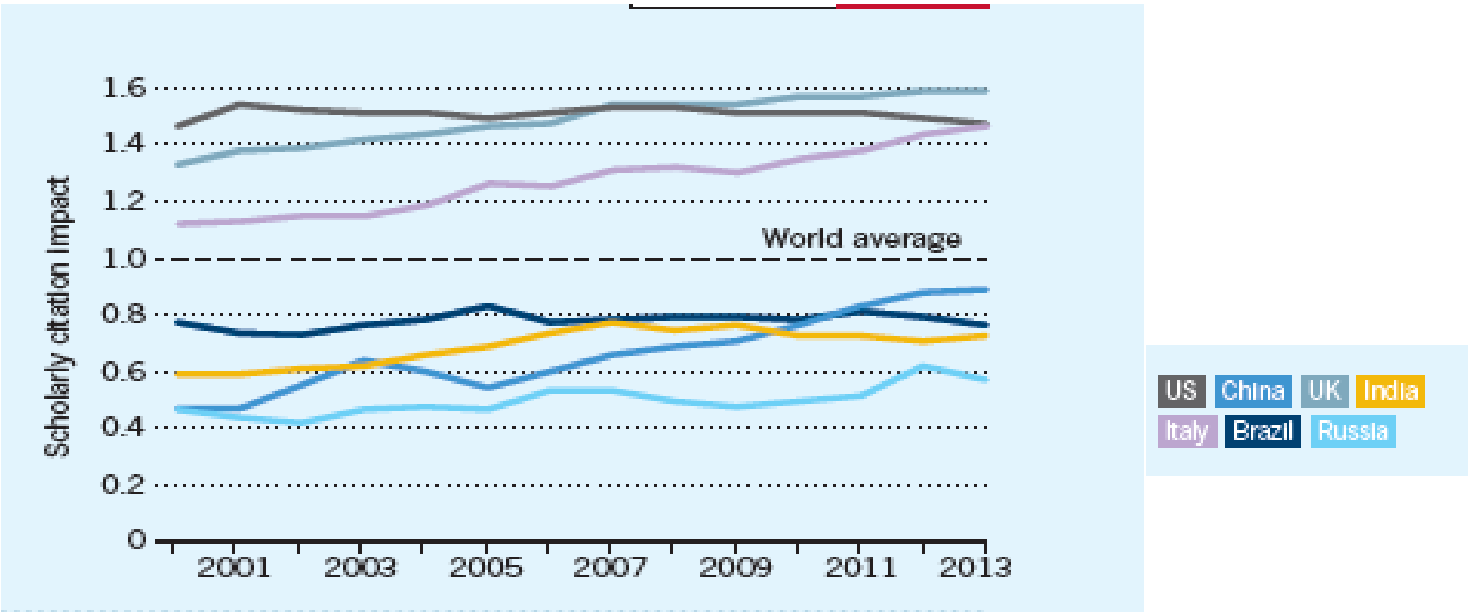


Global Top 30 in the Nature Index 2014
(India is ranked no: 13, Source: Nature Index (2015))

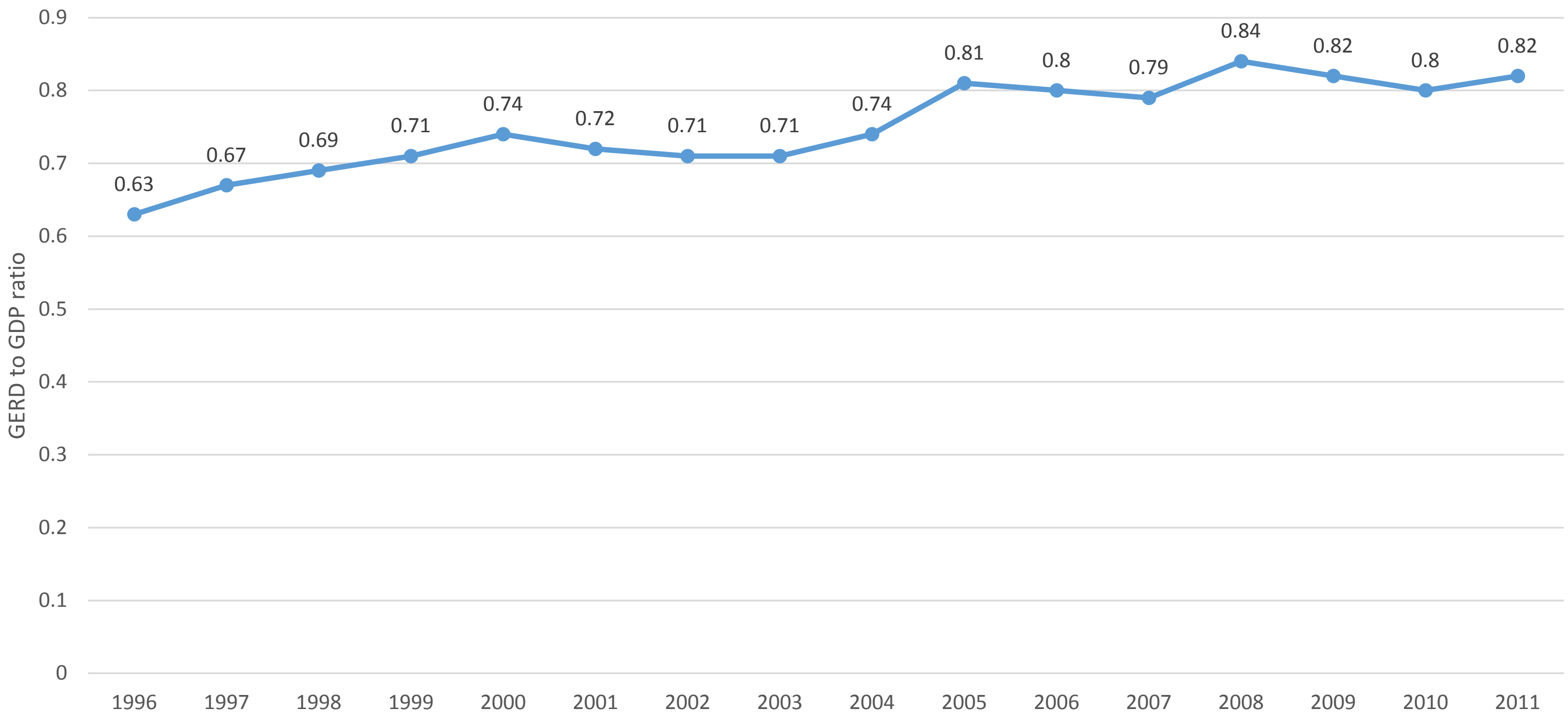


But quality of Indian scientific publications, although improving is still below world average by as much as 30 per cent

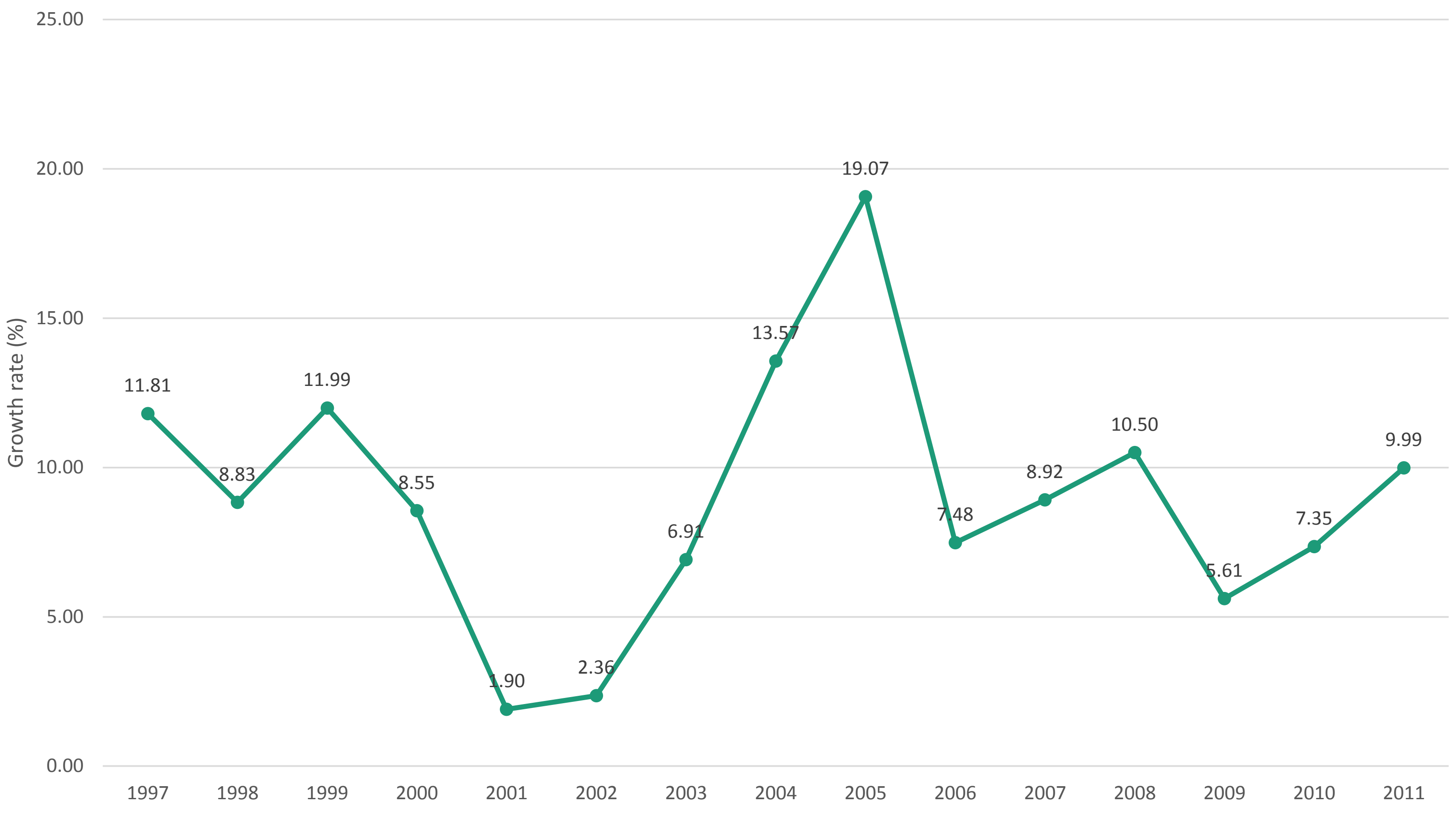
(Source: Van Noorden, R (2015) based on Elsevier's Scopus database .)



Overall research intensity
(GERD to GDP ratio)



Real growth rate of GERD
(in constant 2005 PPP$)

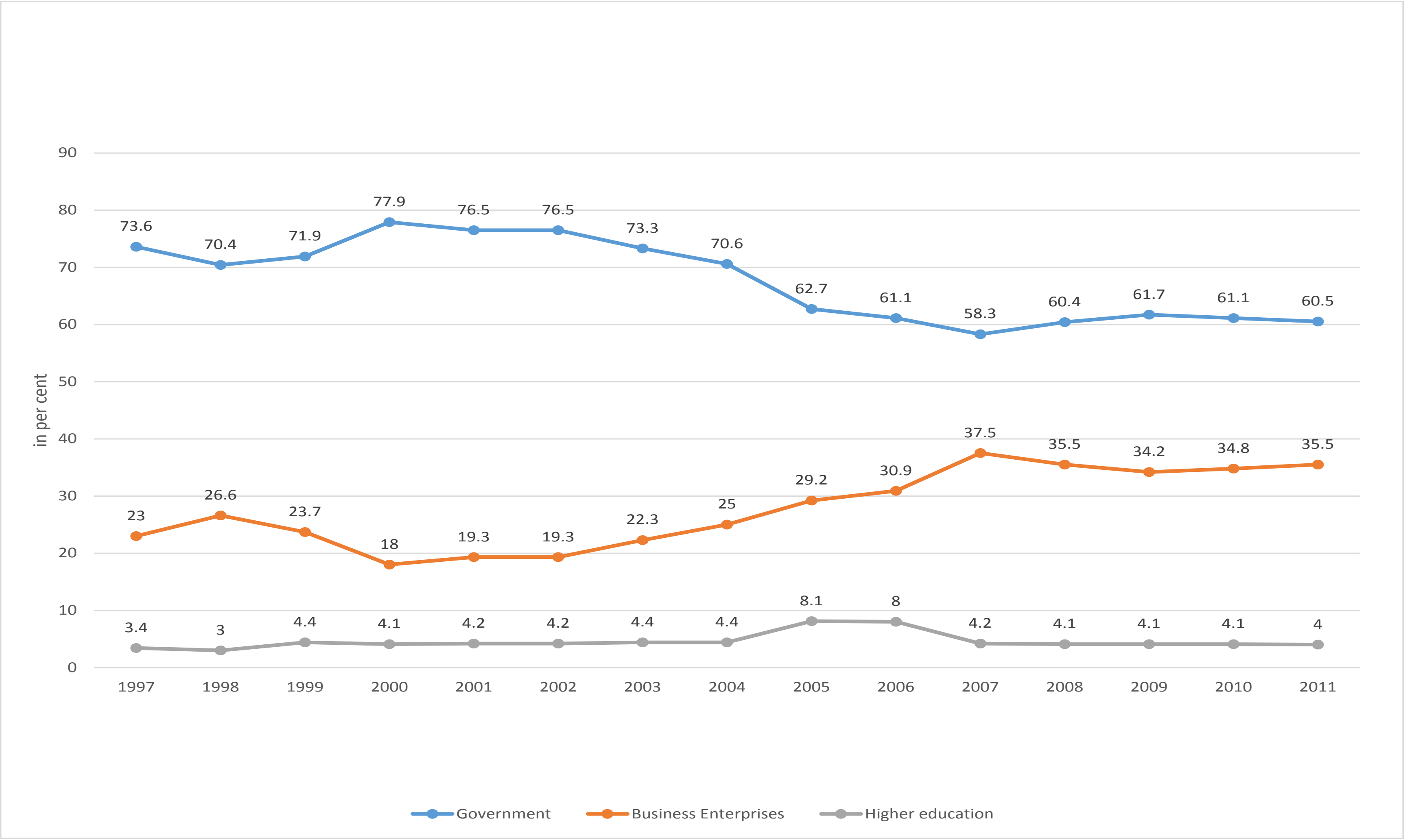


Second dimension
Business enterprise groping towards the core of India’s NIS

- Evolution of India’s NIS
- Concentration of BERD in a few industrial sectors and within these sectors by a few business enterprises
- BERD is generously subsidized- subsidies are to be reduced from fiscal 2017 onwards- it is also not clear whether R&D subsidies have resulted in additional amounts of R&D by business enterprises

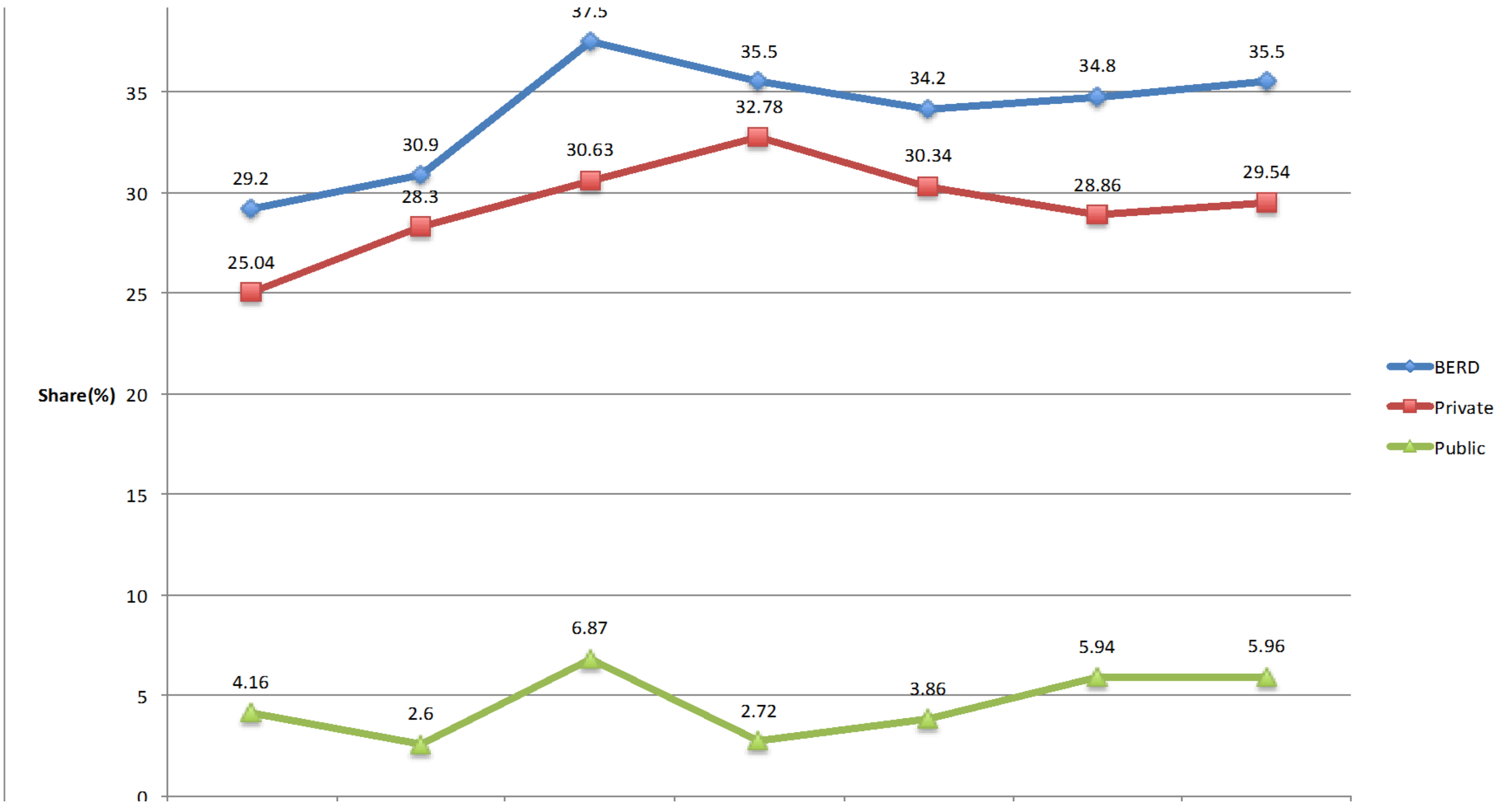
Evolution of India's National System of Innovation

(share of GERD performed by various sectors)



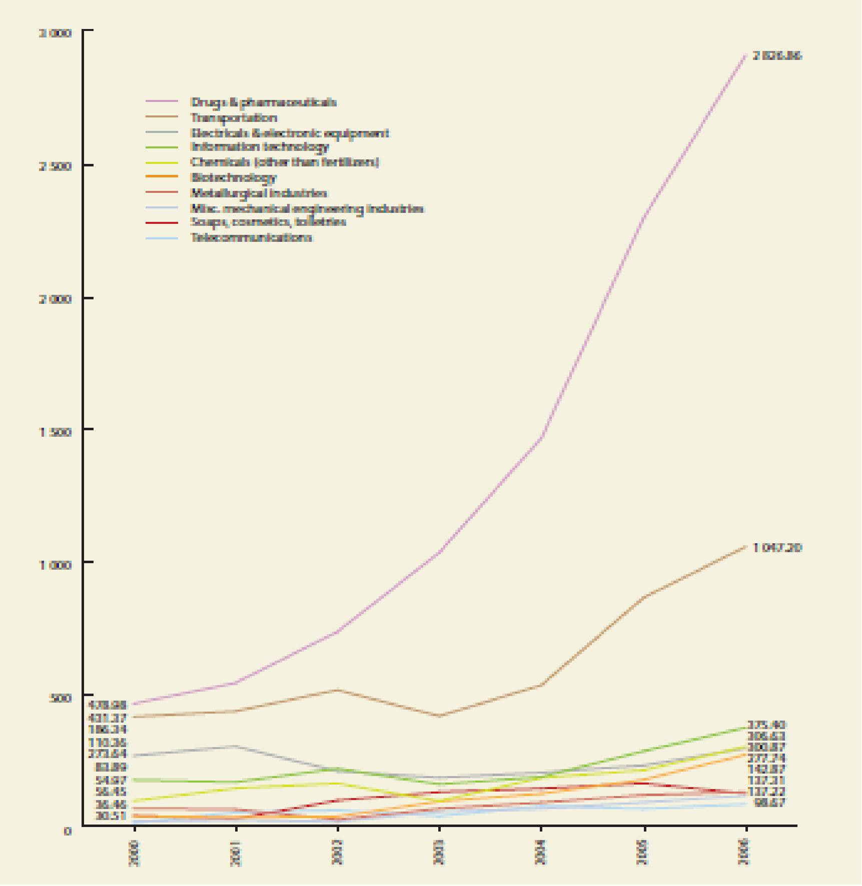
Distribution of BERD between public and private enterprises

(based on percentage share of GERD)

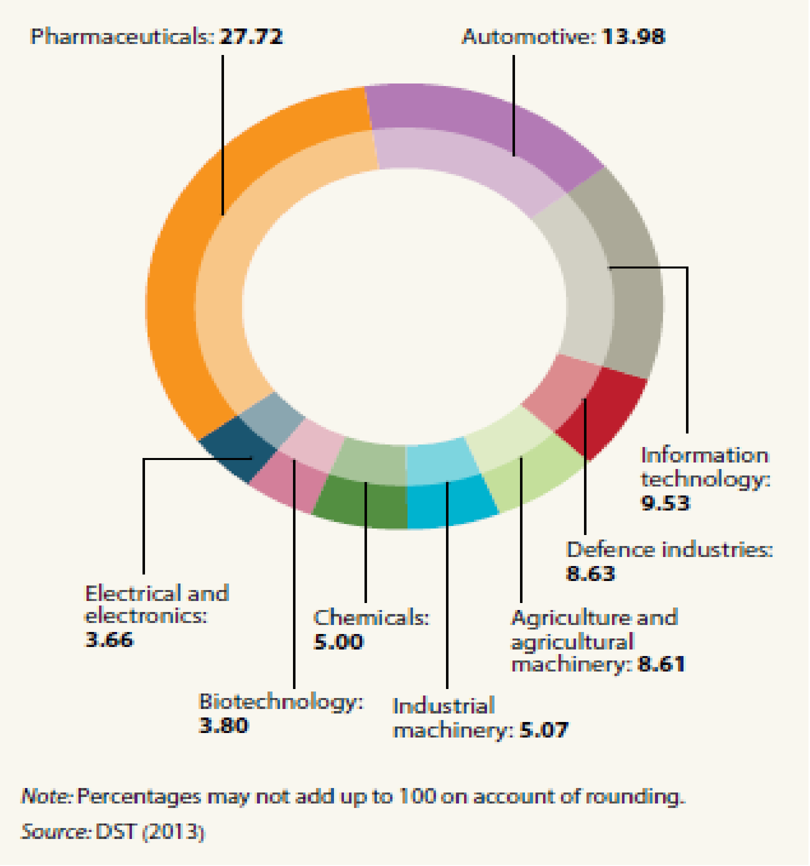


R&D by business enterprises is concentrated in a small number of industrial sectors, 2005 and 2010

2000-2006

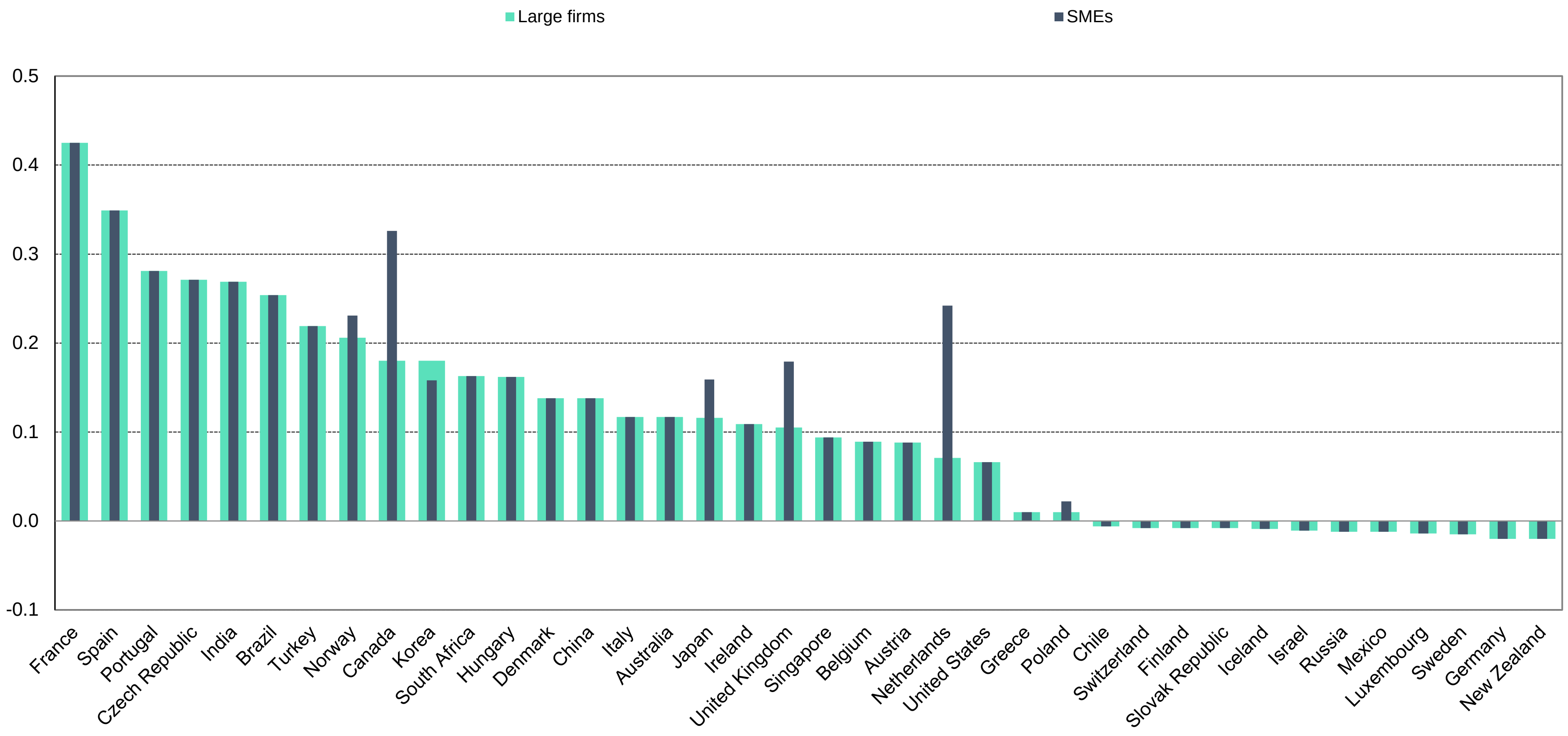


2010



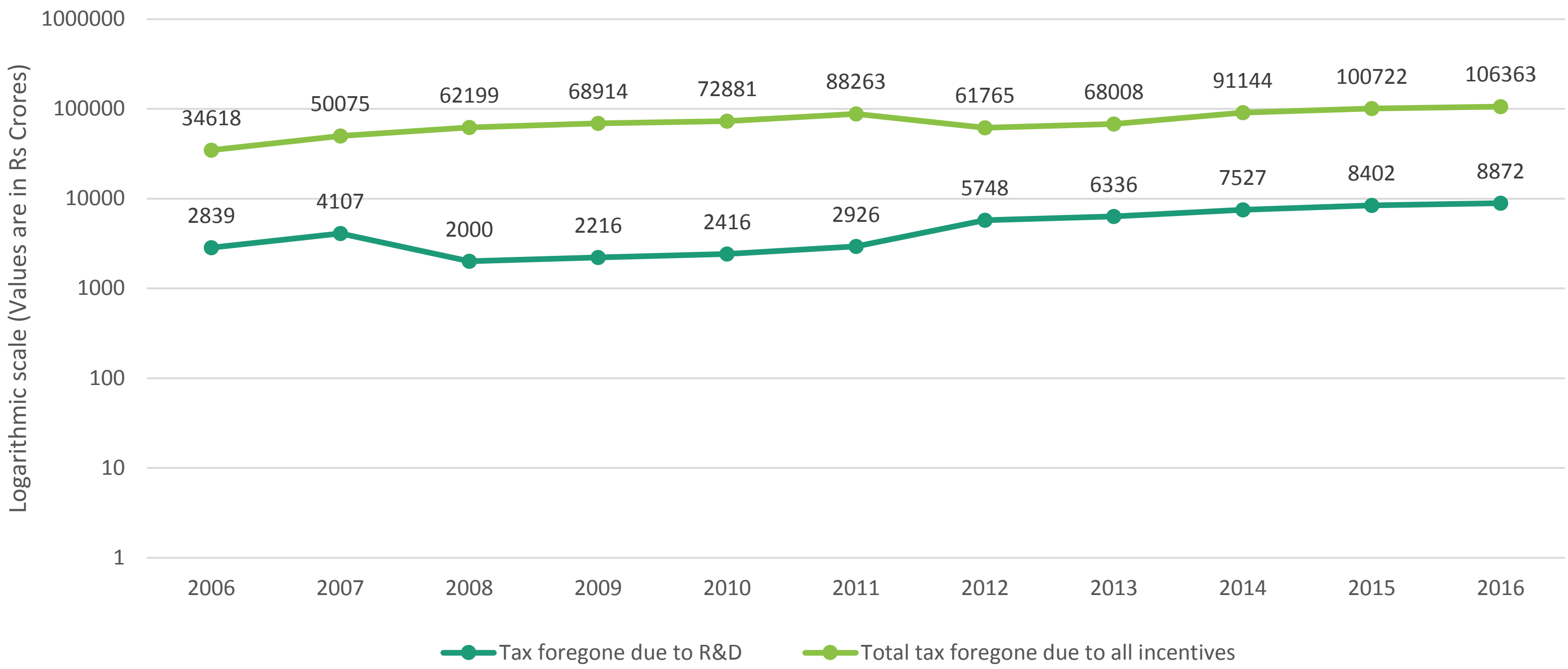
India has one of the most generous tax regimes for R&D subsidies

(Tax subsidies are calculated as 1 minus the B index. For example, in India , 1 unit of R&D expenditure by large firms results in 0.269 unit of tax relief)



Tax foregone due to R&D subsidies have been growing at 17 per cent per annum and forms 8 per cent of all corporate subsidies

(Values are in Rs Crores)



Third dimension
What does patent data tell us?

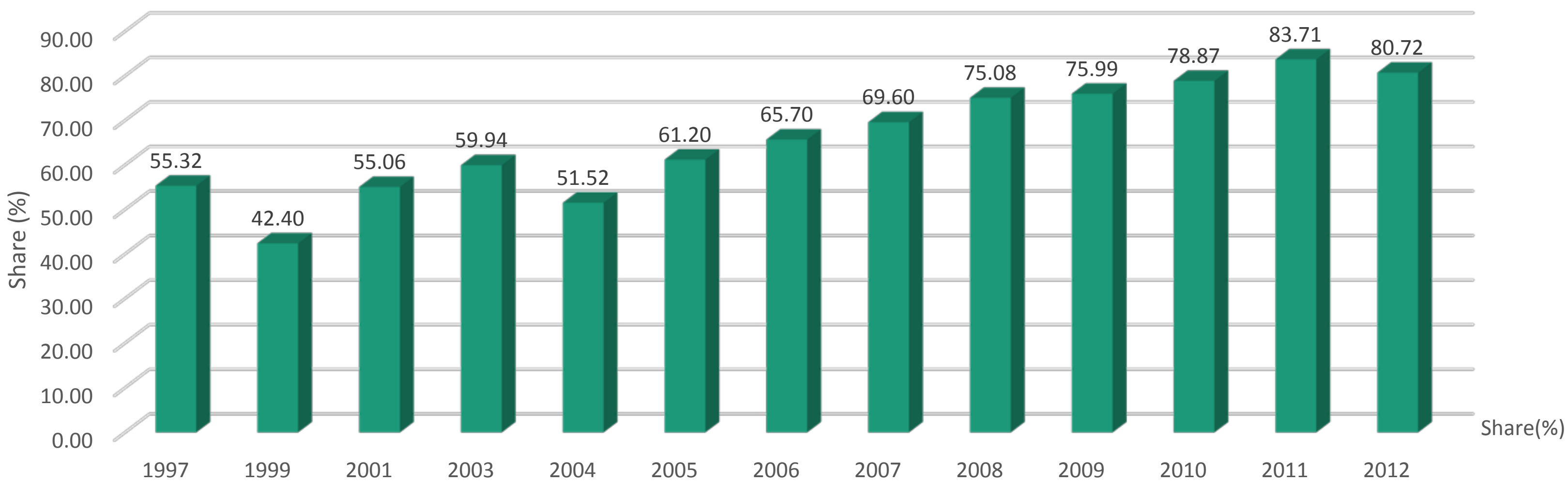
- (i) there have been significant increases in patenting by Indian inventors and the share of high technology patents in it has shown some sharp increases as well; and
- (ii) there has been a very discernible change in in the technological specialisation with pharma going down in importance and IT related patents showing a pronounced and increasing trend
- (iii) However most of these patents are owned by MNCs

Trends in the number of patents granted to Indian inventors at the USPTO

	Utility	Design	Total	Share of utility patents
2002	249	18	267	93.26
2003	342	14	356	96.07
2004	363	13	376	96.54
2005	384	19	403	95.29
2006	481	25	506	95.06
2007	546	32	578	94.46
2008	634	38	672	94.35
2009	679	41	720	94.31
2010	1098	39	1137	96.57
2011	1234	25	1259	98.01
2012	1691	43	1734	97.52
2013	2424	50	2474	97.98
2014	2987	57	3044	98.13
2015	3355	60	3415	98.24

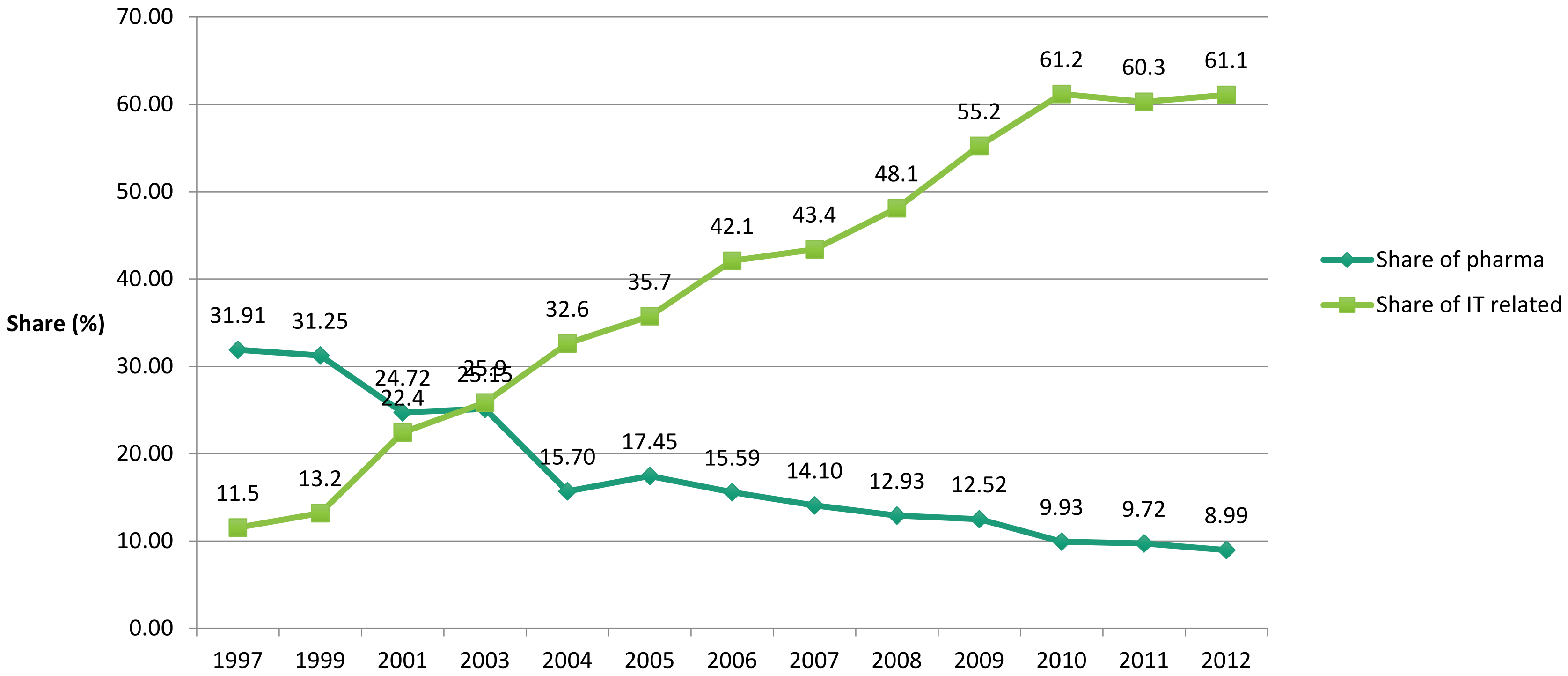
Most of the USPTO patents granted to Indian inventors are in high technology areas

(Share of high technology patents in total patents granted)



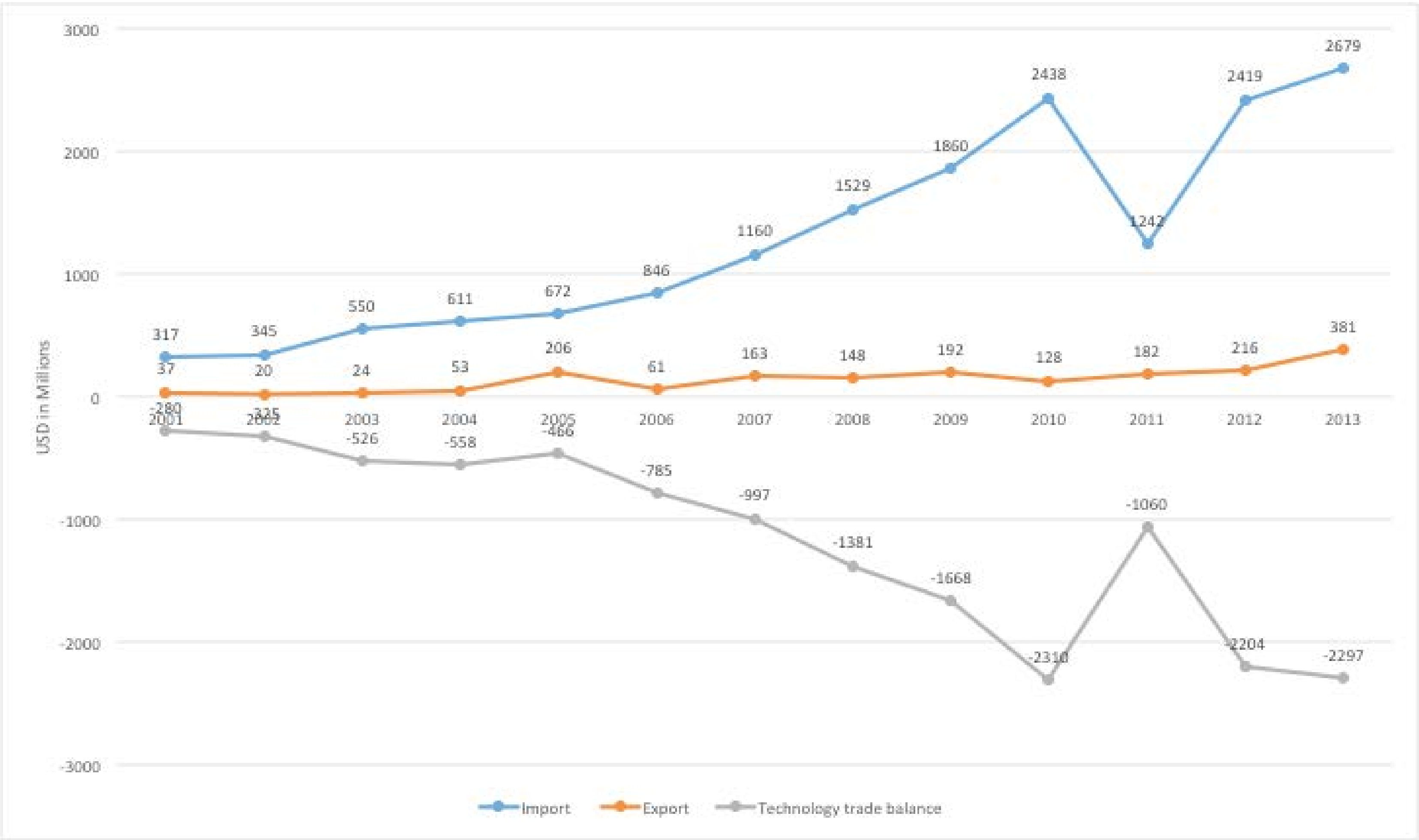
Changing importance of Pharmaceutical vs IT related patents

(percentage shares)



Despite increases in R&D expenditure and patenting, India's technology trade balance has worsened over time

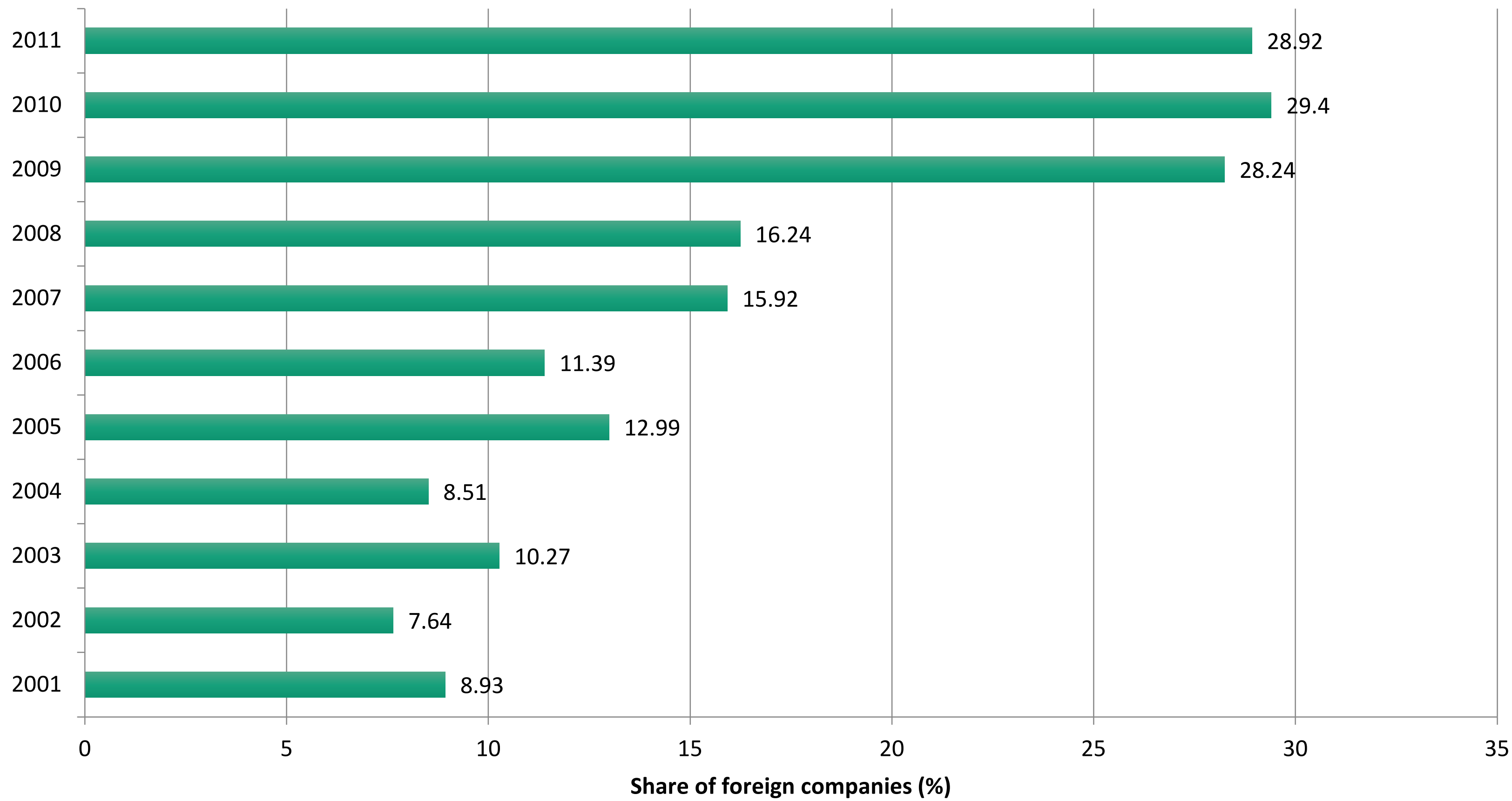
(Millions of USD, Source: UN Comtrade)



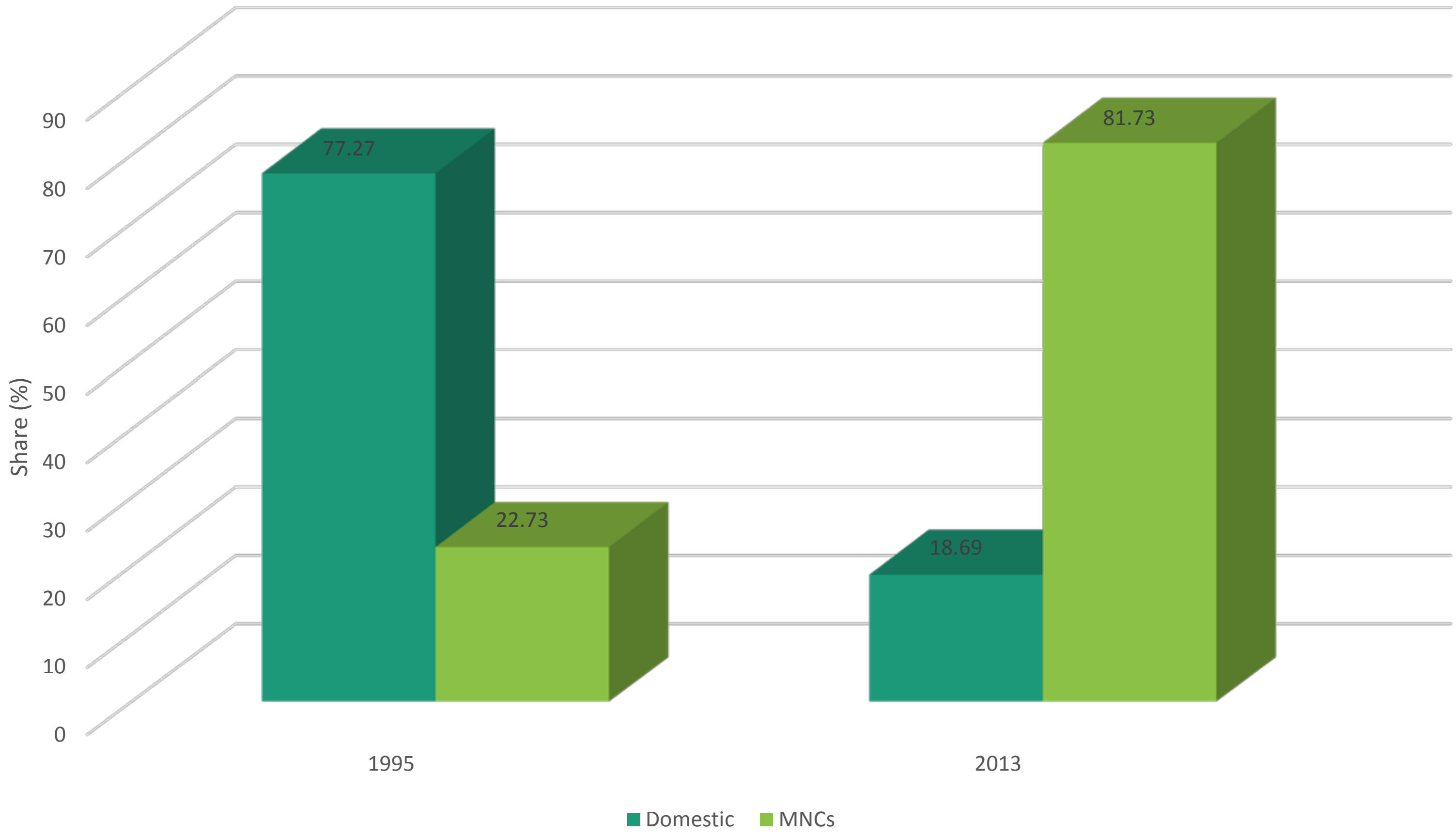
Fourth dimension
Growing globalization of Innovation and India's participation in it

- MNC affiliates account for an increasing proportion of BERD- its implications
- Over two thirds of the patents secured by Indian Inventors at the USPTO are accounted for by MNCs
- India has become a major exporter of technology services- R&D services, Architectural, Engineering and technical services
- Performance of R&D in India has become very efficient over time- this is one of the factors that enabled India to insert herself in the global division of innovation activity.

Share of FDI companies in total BERD

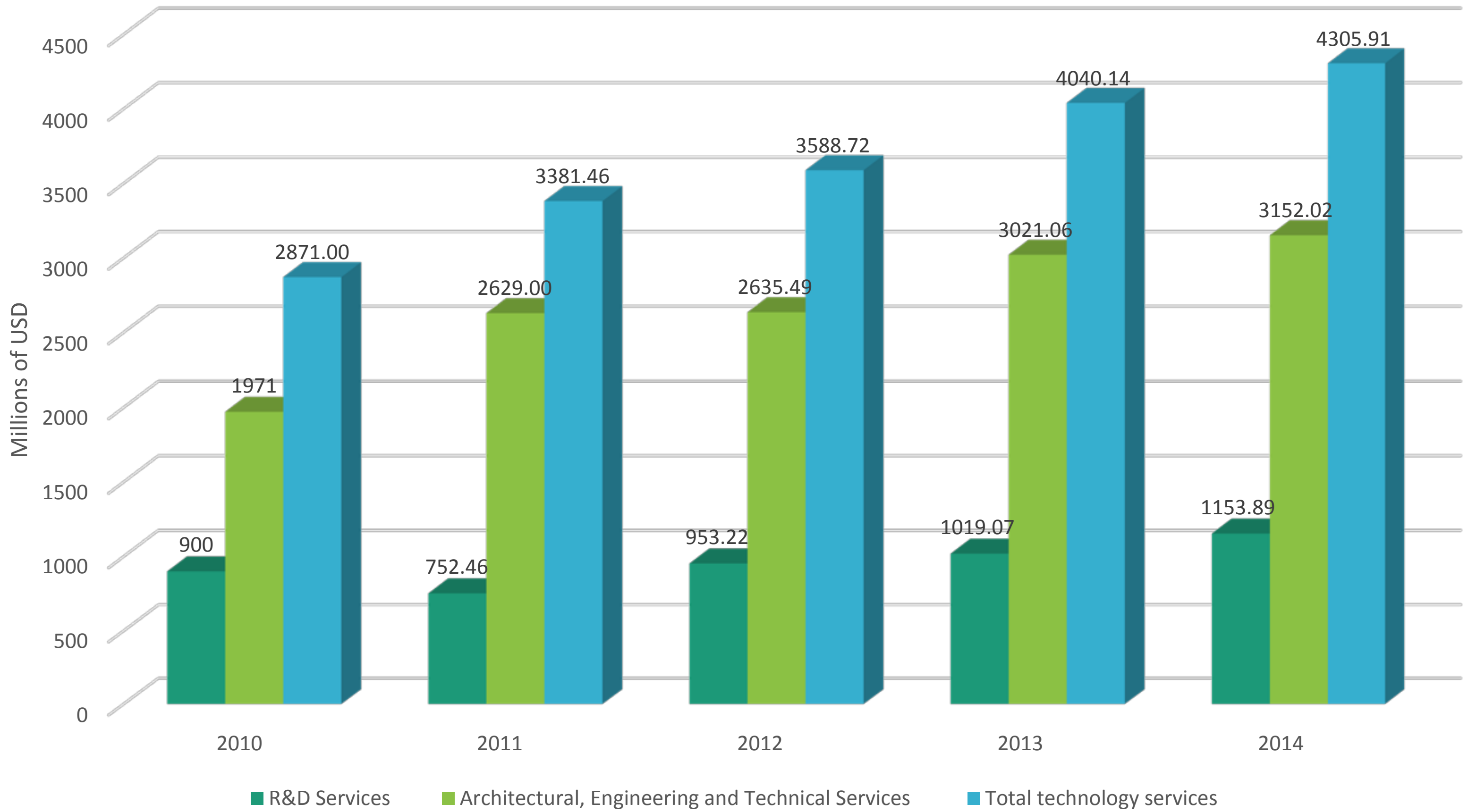


Share of MNCs and Domestic inventors in USPTO patents granted to Indian inventors



India's growing exports of technology services

(Millions of USD, Source: UN Comtrade)

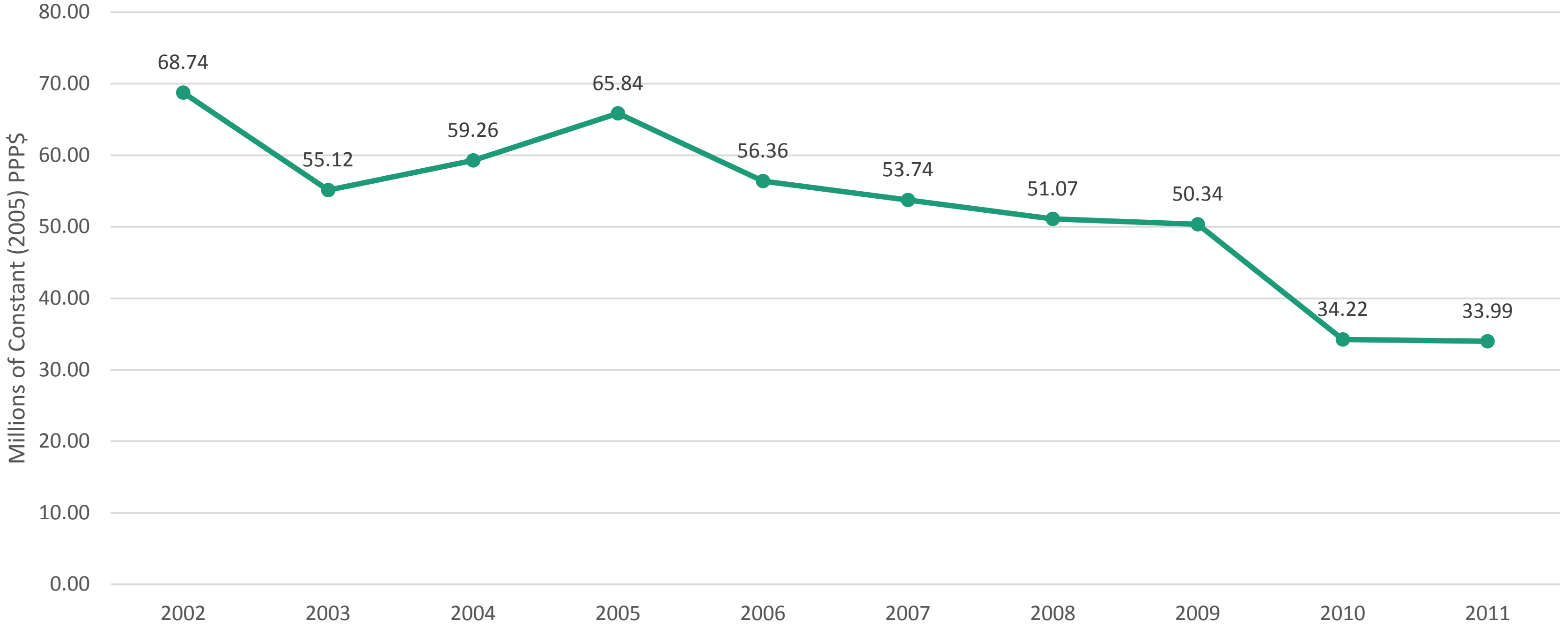


Exports of R&D and testing services from India services from India to the US

	Exports (millions of US $)			Share (%)	
	India	China	Total US exports	India	China
2006	427	92	9276	4.60	0.99
2007	923	473	13032	7.08	3.63
2008	1494	585	16322	9.15	3.58
2009	1356	765	16641	8.15	4.60
2010	1625	955	18927	8.59	5.05
2011	2109	1287	22360	9.43	5.76

Trends in R&D costs of securing 1 US patent at the USPTO

(Millions of PPP$)



Fifth dimension
Government Scientific Agencies vis-à-vis Business Enterprises

- Government organises its R&D through 12 major scientific agencies. Of these, in terms of R&D expenditure, the most important ones are the Defence Research and Development Organization (DRDO) followed by the Department of Space, Department of Atomic Energy, the Indian Council of Agricultural Research (ICAR), and the Council for Scientific and Industrial Research (CSIR).
- Over the period since 1991, on an average, research councils and scientific agencies have performed around 52 per cent of the GERD. Much of this R&D has little or no connection with business enterprises either in the public or private sectors. DRDO, the largest among these, alone accounts for about 17 percent of the GERD.
- Share of research councils in GERD has been going down- deliberate policy since 2015
- Most of the research councils have little or no interaction with the production system in either agriculture or industry.

Funding squeeze on Science research in India ?

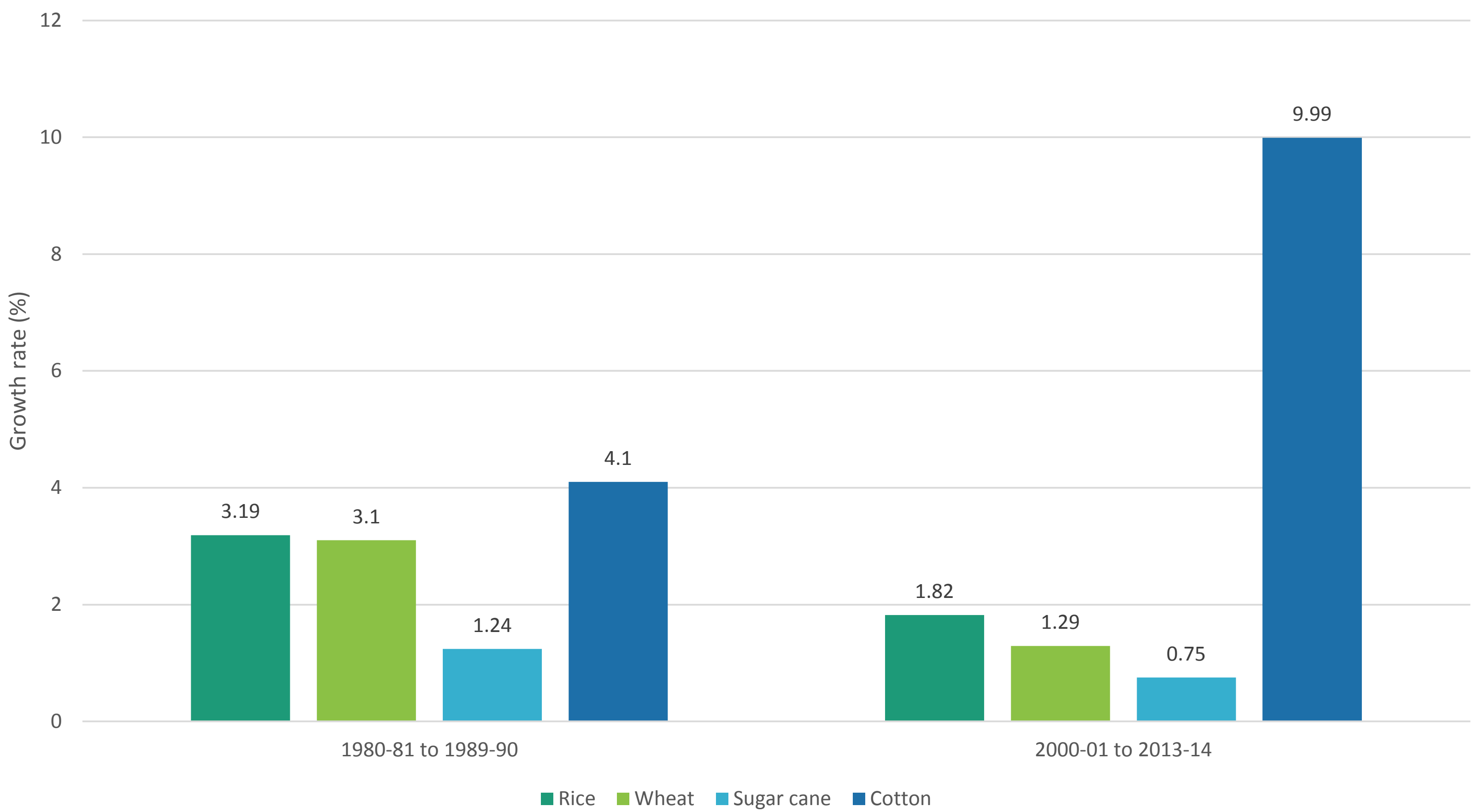
- “The central government, intent on curbing domestic spending, feels CSIR's $600 million budget is a luxury it can no longer afford and has given the labs 2 to 3 years to "self-finance" half their expenditures by winning grants, licensing discoveries, and collaborating with industry. *Prime Minister Narendra Modi's government insists it is not hostile to research: Rather, it wants R&D to better serve national interests*” (Ravindran Shruti (2015), ‘India orders premier labs to pay their own way’, *Science*, Vol. 350, Issue 6261, p617-617)
- Science spending in India is slated to rise 11% in the 2016–17 fiscal year to $1.19 billion, according to the latest union budget for 2016-17. ***The good news is that agricultural research spending will rise by 19% and “earth sciences and renewable energy [are] each set to increase 16%.***” It is also noted that “the higher education sector overall is set to receive a 12% increase to $ 2.24 billion, [but] most of that rise will go to increasing teaching capacity and not for research *per se*

Sixth dimension India’s agricultural sector has not been performing well

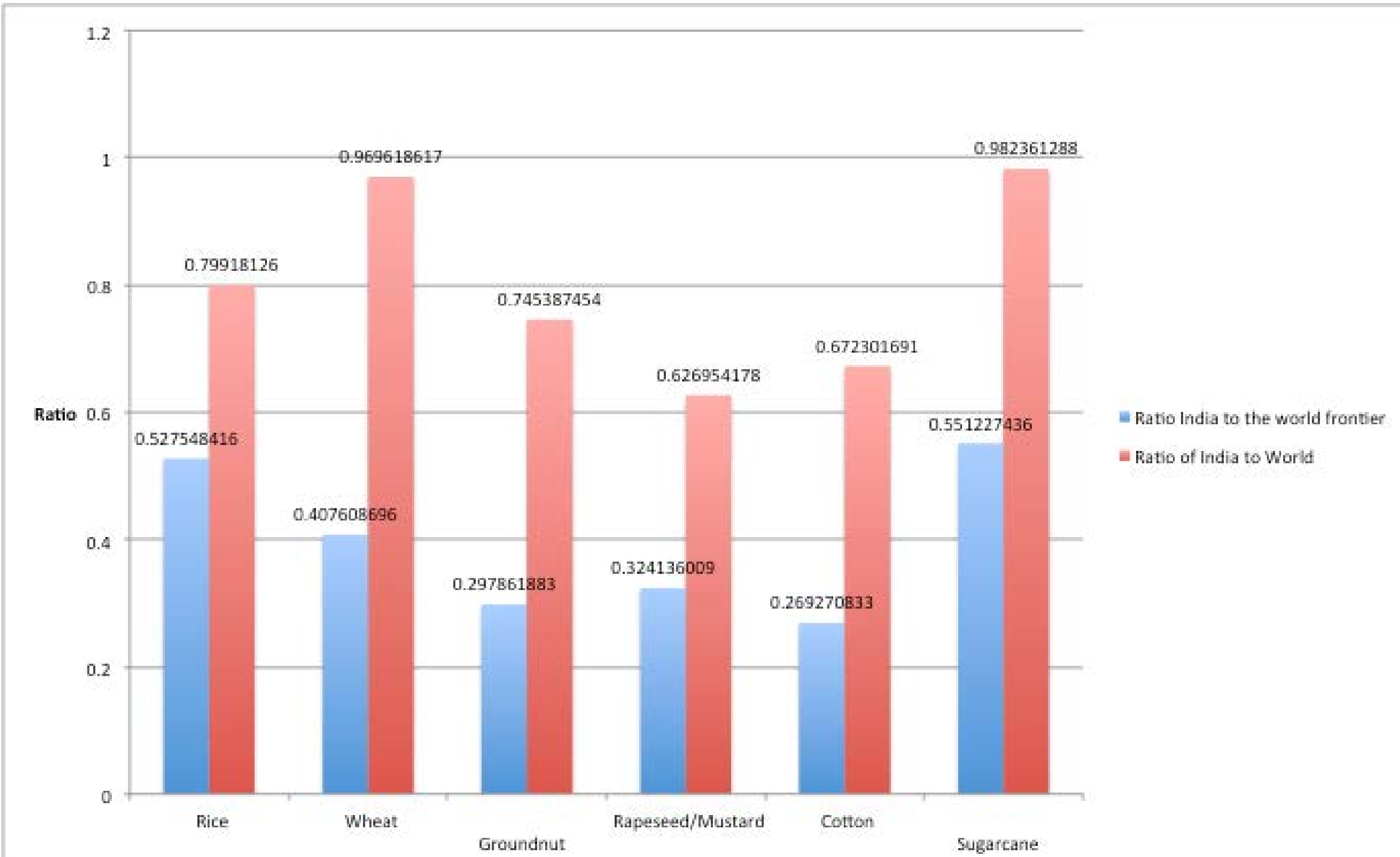
- Not much increase in the increase in productivity of major food crops like Rice and Wheat. The only crop where productivity has actually increased in a secular fashion is in cotton- attributable to diffusion of BT.
- This is because public agricultural R&D has failed to release any new technologies such as high yielding varieties
- However private R&D in agriculture has been increasing

Growth rate in yield of major agricultural crops

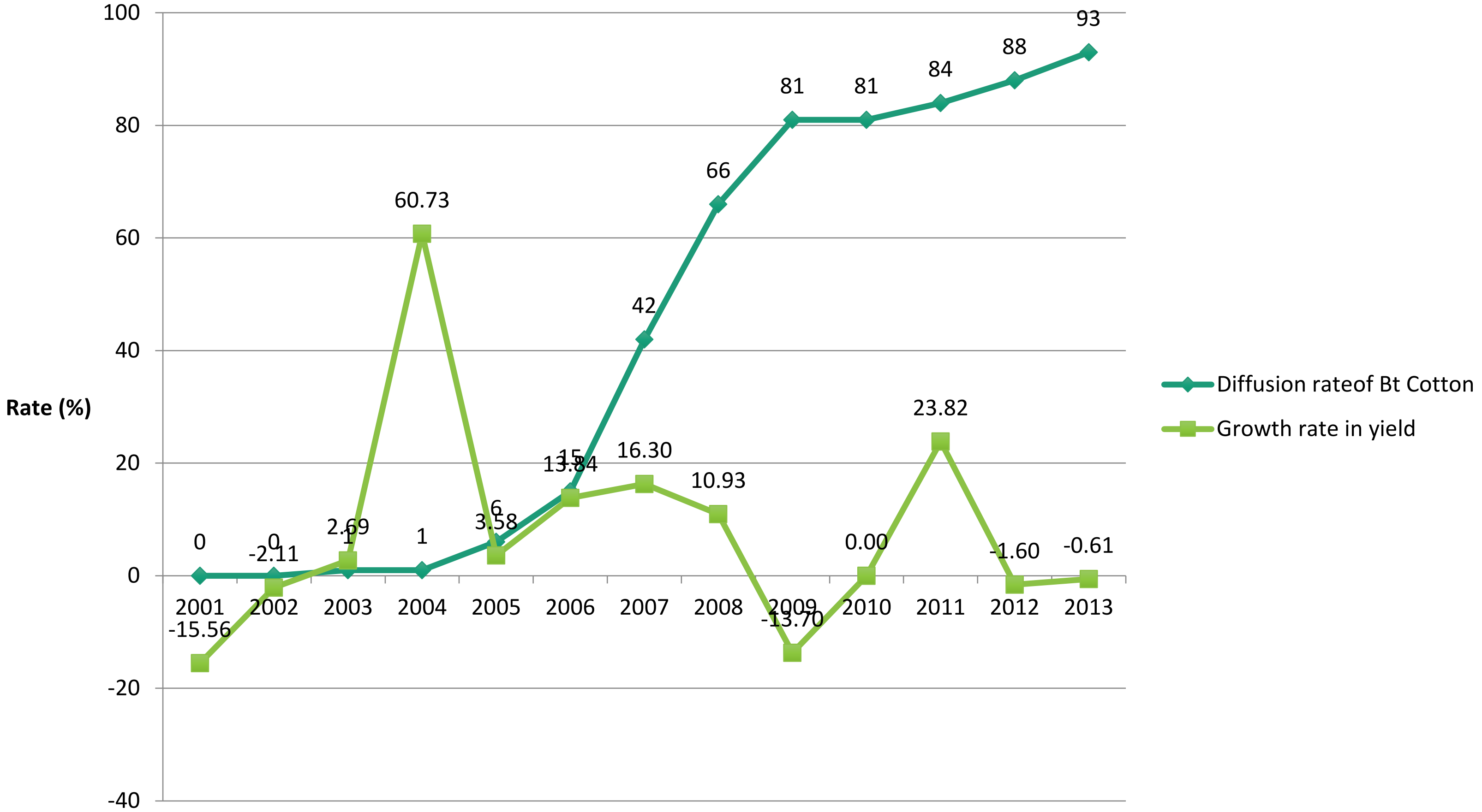
(Average annual growth rate)



Ratio of Indian yield to world frontier



Rate of diffusion of Bt Cotton and growth rate of yield in cotton



What ails agricultural R&D in the country?

- **Funding** -Studies on R&D funding, however, points to an increase in funding both in nominal and real terms, aggregate and per capita terms, and in comparative terms with public funding of industrial research. Even the intensity of agricultural research (agricultural R&D as a per cent of agricultural GDP) too shows an increase over time. So funding per se does not appear to be an issue.
- **Quantity and quality of agricultural scientists**: Numbers on it shows a decline in its stock and the annual flows to it are also constrained by lower enrolment ratios in graduate degree programmes in agriculture.
- So the key to improving yields perhaps depend on increasing both the quantity and quality of agricultural scientists in the country

Seventh dimension
India has become a hub for frugal innovations

- A number of interesting innovations in both manufacturing and services have occurred and some of these have been exported to even developed countries
- In manufacturing, it is most frequently found in medical devices- the Stanford India Biodesign project
- In services, it is found in the distribution of telecommunication services, health services and in banking.

Three counter-intuitive findings with respect to frugal innovations

- Most of the frugal innovations have actually come from the organized manufacturing and services firms- some of them are even MNCs
- Frugal innovation in manufacturing involve fair amount of R&D and technological inquiry
- Not all frugal innovations diffuse- example of the Nano

Eighth dimension India's manufacturing is increasingly becoming high technology- oriented

- Approximately 40 per cent of India's MVA is from high technology manufacturing;

- About 8 per cent of manufactured exports are composed of high technology products.
- Three high tech products that have been showing signs of dynamism are: Aerospace, Pharmaceuticals and Automobiles.
- Specific vertical polices have helped the emergence and growth of these industries.

Role of public policy for high technology development

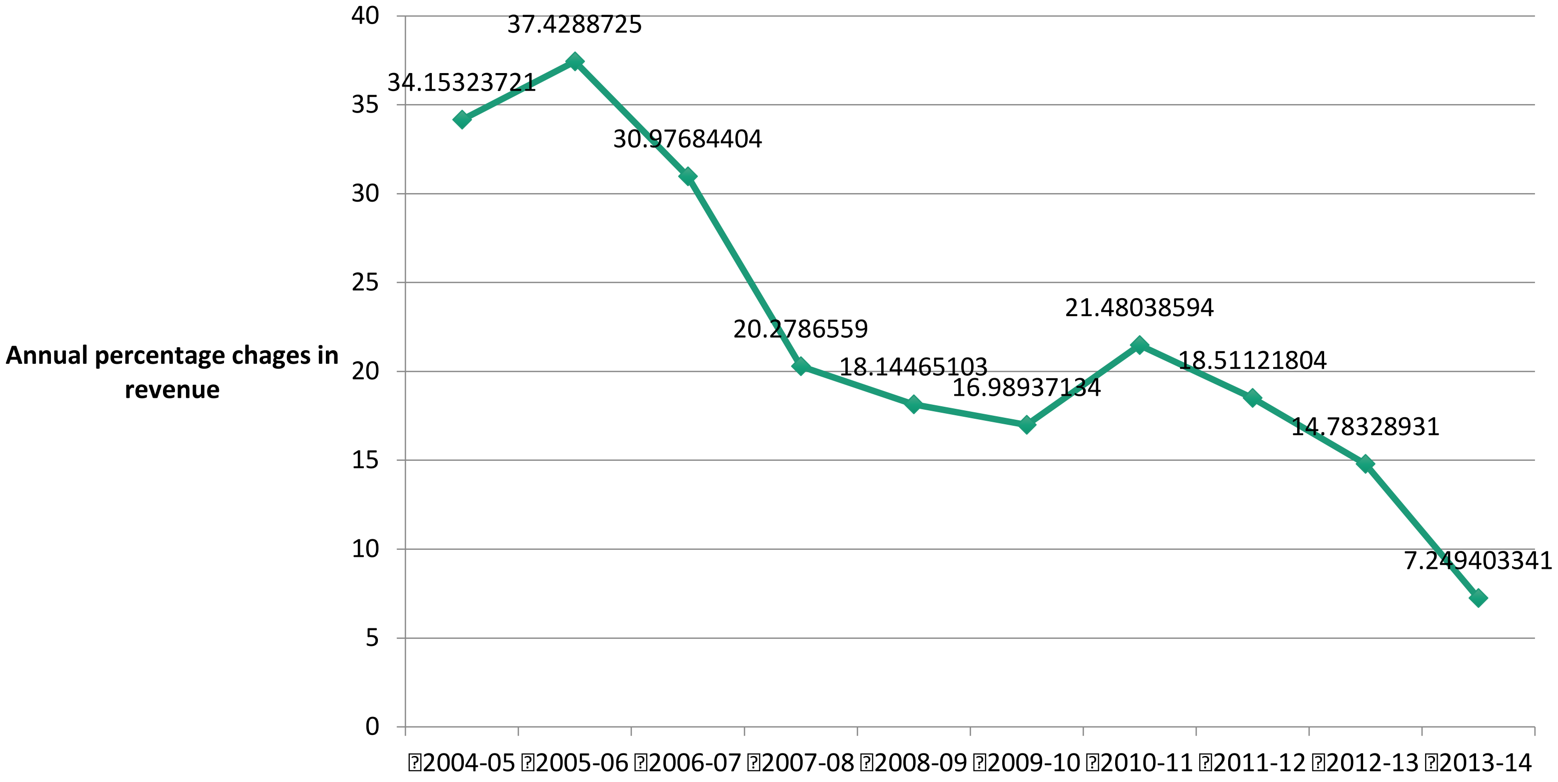
High technology industry	Specific vertical policy that has been crucial	Export rank in the world for the most recent year	Qualitative assessment of domestic technological capability	Nature of government intervention
Aerospace	Offset policy	6th rank, 2.1 per cent of the world in 2014	Fair amount for manufacturing aerospace components, and also for designing, manufacturing and launching satellites and satellite launchers	Indirect for component, Direct for satellites and satellite launch vehicles
Pharmaceutical	Patent policy	12 th , 2.4 per cent of the world in 2014	High technological capability for designing and manufacturing generic versions of known drugs	Indirect
Automobile	Automotive policy	22 nd, 1 per cent in 2014	High capability in designing and manufacturing latest models of fuel efficient cars, two-wheelers and a range of commercial vehicles	Indirect

However there are also high technology industries where government intervention is yet to yield positive results

- Telecommunications equipment
- Biotechnology
- Nanotechnology

Growth performance of the Biotechnology Industry

(annual percentage change in revenue, Source: ABLE Survey data)



Nanotechnology

- Policy has been scientist-centric
- Main instrument- research grants- Nano mission
- According to Department of Science and Technology (2014, p. 211), the output from nano mission, until 2013-14, was 4476 papers in SCI journals, about 800 doctoral degrees, 546 Master of Technology (M.Tech) and 92 Master of Science (MSc) degrees.

- We do not have any further data on innovative activity in this important field.

- The Consumer Products Inventory (Project on Emerging Nano Technologies, 2014) maintains a live register of consumer products that are based on nano technology and are available in the market. The inventory lists only 2 personal care products based on nano technology that have originated from India although the firm which developed these products is a MNC. However the same database lists a total of 1628 for the world as a whole and 59 in the case of China and 56 in the case of

The four policy challenges

1. Improving the quality and density of scientists and engineers engaged in R&D;

2. Financing innovation: India has the most generous tax regime for encouraging investments in R&D. But this has not led to a concentration in the performance of R&D. As such the culture of R&D is not widespread. The country also continues to lack credible research grants for financing innovation;

3. Supporting the emergence of technology-based start ups

4. Linking capabilities in technologies to improve the nation's human development (especially health and education outcomes).

Conclusion

- India has the aspiration of emerging as a technological powerhouse
- She has shown some successes in certain specific areas (Pharmaceuticals, Space research)
- But continue to depend on foreign sources of technology in a large number of areas.
- Her major asset is also her major constraint- the availability of good quality scientists and engineers
- Fortunately, the government is seized of this human resource in science and engineering problem
- But the policies that it has put in place to address this is yet to bear fruit.

Thank You