Mapping S&T Innovations:

*A cross-country study of patenting - **Phase II***

Project Sponsored by

NSTMIS, DST, New Delhi

N G Satish

Project Investigator

Administrative Staff College of India

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2013

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Executive Summary

Mapping S&T Innovations: A cross-country study of patenting

Executive Summary

There has been an attempt to enthuse all the concerned players to enhance innovation. This study examines the innovation as manifested in the US patents granted to China, Israel, and India during 2001-10, and patents obtained by Indian entities during the same period in the Indian Patent Office. This is an attempt to understand the strategies adopted by these countries for enhancing their technological innovation, and look for the possible learning from the same. The US Patents assigned to India has plateaued around 250 annually in the past ten years. The present analysis shows that the other countries have invested substantially in R&D. They have also broad based the innovation both in terms of number of innovators and institutions / firms working on them. Invariably industry has dominated patenting elsewhere. These countries have exercised technology option and have focused on a set of them to gain advantage. Incremental innovations have facilitated China not only in obtaining a large number of patents, but also with minimal time lapse in their grant by the USPTO. China's patents are largely soft innovations such as ornamental designs of the products and the like. The country's export oriented manufacturing base has also facilitated innovation. Israel has focused on niche technologies like computer software, medical instrumentation and the like, to balance their technology trade.
India has been patenting innovations coming out of laboratory intensive research, which are slow to come by and is also observed to take longer time for granting rights by the USPTO. Indian patents granted by the Indian Patent Office are relatively more in number. The analyses of these patents indicate the availability of motivated innovators in the IPR regime. Patent examination process in our context is slow and possibly trust in the IPR protection low. We need to adopt short and long term strategies to showcase our innovation capability and also to protect our market from within and outside the country. Technology forecast studies to understand the existing gaps, encouraging industrial sector into innovation mode through policy options, incentivising the process and strengthening the institutional mechanisms In patent protection are among the options suggested to catch up in the innovation game.

Innovation refers to exploiting new ideas leading to the creation of a new product, process or service. Innovativeness has become a major factor in the context of science and technology (S&T). Prominent among the measures of innovativeness of a country or an organization is the patents assigned to the same.
The current study examines the patents granted to China, Israel, and India by the USPTO, one of the three important patent offices in the world. The United States of America is the biggest economy and any worthwhile idea/ technology would have to succeed in that market, and hence, in most cases, would be patented in the country. More than 50 percent of the US patents originated from non-us sources. Apart from this, confining the study to the USPTO also ensures a common benchmark for the comparative study. This research also examines the patents obtained by Indian entities in Indian Patent Office (IPO).
The objectives of this study were the following:

1. to examine the patents granted to China, India, Israel by USPTO during 2001-10 in numerical and qualitative terms;
2. to analyze patents granted to Indian entities by Indian Patent Office during the years 2001-10;
3. to Identify the core areas of innovation activities and its growth;
4. to analyze the information on innovator as also assignee affiliation and collaboration;
5. to present a few cases that would take a closer look into the technologies patented within a given focus;
6. to infer the patenting trends, active components of the national innovation system and strategies adopted by the countries for obtaining the patents, and also elicit possible learning from the same, and finally.

Methodology & scope

The study considered all the patents assigned by the USPTO during the years 2001-10 to the selected countries. All the patents were examined individually and the same were categorized as appropriate to the context. The variables considered include, assignees, innovators, subject focus, and broad grouping of patents on technology level, time lapse in grant of patents, apart from growth trends of patents during the period. Technology levels of the patents were broadly classified into high, medium and low. High technology was defined to include cutting edge technologies originating from the lab-based research. These include nanotechnology, drugs and pharmaceuticals, semiconductor related research, and a host of related ones. Low technologies are those that are soft innovations or ones belonging to commonplace products. These also include soft innovations such as ornamental designs and the like. Medium technologies are the ones which do not fall in either group and cover innovation on a wide ranging products and processes. The classification broadly corresponds to embryonic, growth and maturity stages of technology S curve. Indian patents from the IPO was retrieved from its public domain database

Economic and S&T Backdrop

China:

During the 2001-10 period China tripled its GDP(PPP) and it was US$ 10,170 billion in 2010. Its per capita income also tripled during the period and stood at US$ 6,846 in 2010.

Whether it is the science and engineering papers that China's researchers publish in international journals, the amount of investment made in R&D or the number of patents obtained, statistics indicate that their S&T capabilities are developing rapidly. China has the stated ambition to be an *innovation-oriented country* by 2020, and one of the world's leading science powers by 2050.

China has been taking great strides on the R&D investment, which has grown from US$ 6.5 per capita in 1999 to over US$ 63 in 2010. It has also registered a steady growth in the expenditure on R&D as percent of their GDP. Business expenditure on R&D has grown ten-fold during the decade. Interestingly the number of R&D personnel has also grown four-fold during the same period. The country has the second largest workforce of scientists and engineers, second only to the U.S.

Israel:

Israel is 100th smallest country with population of seven million. During the 2001-10 period the country registered promising economic growth and its GDP (PPP) stood at US$ 218 billion in 2010. In the same year the country's per capita income stood at US$ 28,298.

Israel's S&T tradition predates formation of the country. The country has the highest ratio of university degrees to the population in the world, and has one of the highest per capita rates of patents filed.

Israel's expenditure on R&D and per capita expenditure on R&D is way ahead at 4.41 percent of its GDP and US$ 1242, respectively, in 2010. However, considering Israel's population is small, per capita measure does not add up to big numbers. Israel has seven R&D personnel for every 1000 people.

India:

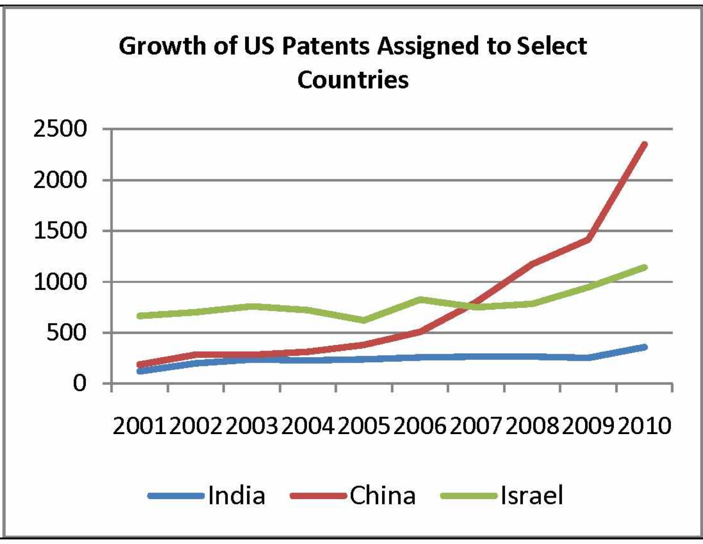
During the 2001-10 period India registered a promising economic growth resulting in almost four-fold increase its GDP (PPP), which stood at US$ 1,648 billion in 2010. Our per capita income during the same year was US$ 3,523.

Excepting for the size of the economy, India is comparatively on the lower end as to the parameters relating to R&D. Business expenditure on R&D has registered an increase in the recent years, though it is too meagre to make a considerable impact. R&D expenditure as percentage of GDP stands at 0.85, and the per capita R&D expenditure was $ 11.77 in 2010. Business expenditure on R&D has also registered a four-fold increase during the 2001-10 period and was US$ 2,800 million in 2010. Total R&D personnel, as per the data available, works out to be as small as one in every 5,000 people.

Analysis of Patent Growth

Growth of US Patents

	India	China	Israel
2001	121	186	665
2002	199	283	701
2003	237	282	760
2004	227	312	722
2005	239	380	621
2006	257	508	825
2007	266	800	750
2008	266	1174	783
2009	253	1414	947
2010	**358**	**2350**	**1142**



China:

China has registered a steep increase in the patent productivity in recent times. During the 2001-10 period of US patents assigned to China has increased over 12 times.

There is a distinct trend of industry dominating the patenting activity in China. They make up 90 percent of the total patents granted to the country. Research institutions and universities have also registered a steady growth of patents in numerical terms, though as a proportion to total they have crossed double digits in only one year. Also to be noted is the significant increase of patents by universities, which has registered a twenty-fold increase during the decade. Patents by research institutions have tripled during the 2001-10 period, though the numbers are relatively small. The trend is indicative of all round growth in innovation activities. China had 2,079 distinct patent assignees during the period

Chinese patents are increasingly an outcome of collaborative R&D investment and these have moved from 09 to 45 percent of the total during the ten year under study.

China also has benefited from international collaboration at assignee level. Starting with a mere 2.2 percent of the total patents in 2001 it increased to 37 percent of the total in 2010.

Sole inventor patents dominated in China in 2001. This trend has corrected itself over the more recent years. The changing trend could be an indication of increasing sophistication of innovation. It has changed from 70:30 - Seventy being single inventor - in 2001 to 67:33 - Sixty-seven, in the latter case, being collaborative - with more than one inventor - in 2010.

A little over eleven percent of the Chinese patents have exclusive foreign innovators, (i.e., invention carried out completely by non-Chinese) over the 2001-10 period. On a year-wise analysis this figure shows a steady decline from 23 to 7 percent of the total.

On the whole 12 percent of the Chinese patents could be classed as high technologies; 47 percent as medium, and 41 percent as low.

A closer look at the annual trends reveal that Chinese high tech patenting is on a gradual rise from 22 patents in 2001 to 242 in 2010, all along registering an increase. Chinese medium technology patents have risen from 17 to 57 percent of the total. The corresponding figures for low technology ones show a decline from 70 to 30 percent. However, the low tech patents have increased in actual numbers.

China seems to have benefited from filing the low technology patents in ensuring a quick grant of the same. Over 62 percent of the low technology patents taken by Chinese are ornamental designs and the rest are minor modifications of one or the other commonly used products. It could be observed that Chinese seem to have rapidly increased their patent count with an emphasis on low technology and low-end innovations. Analysis shows that a large portion of Chinese patents is granted by the USPTO with in a year or two.

China had initially depended on outsourcing the innovation in toto. They graduated into international collaborative research, more in medium technologies. The high technology patents are increasingly local in all its collaboration. Chinese seems to work with an intention to showcase an increasing innovation trend, as reflected in patent growth, and the plan seems to be holding good so far.

Chinese patents for the years studied fell under more than 359 distinct main classes of the US patent subject classification. China had 10,125 successful inventors as per this study and per capita patent per inventor works out to 0.76.

Major subject focus of Invention by China:

Designs patents (23 classes from D19 through D99)	1977
Electricity & Electrical machinery (US PTO Subject classes 361,439,324,60)	578
Textiles (US PTO Subject classes 94,141,19,26,58,28,57))	774
Office systems / supplies (US PTO Subject class D19)	164

China has defined its S&T objectives in various plans categorically, channeling the resources and efforts. Increase in the country's innovation base is also a result of China's emphasis on manufacturing oriented export trade. China has also taken the route of rewarding successful innovators through prize money at various levels, among other things, for moving towards its declared goal of innovation-based economy.

Israel:

Israel was ahead of India and China in 2001 and, in numerical terms, has been holding steady during the ten-year period. In fact, a look into the total patents assigned to Israel during the previous years shows that the number has been growing, though marginally, over the last ten years and from 2001 onwards it has been around 700. This number has shot up during the last three years of the decade.

Industrial sector dominate the patent scene in Israel. This sector has obtained nearly 87 percent of the total patents granted by the USPTO to the country, during the first decade. Absolute number of these patents going with the universities and research institutions are also relatively high, considering that the country has only eight universities and around 50 research institutions. Universities and research institutions have also carved a niche for themselves in innovation activities in Israel. Both universities and research institutions have annexed business organs to deal with the IPR and technology transfer issues. The country has earned considerable revenue through the technology transfer and has achieved a technology trade balance.

Israeli patents are mostly inventions by single entities (96%) and collaboration of two or more entities is a minor affair, both in actual numbers and as a proportion to the total. Foreign collaboration, as reflected in patents jointly assigned to the country, is below two percent of the total. Collaboration, however, is present at the inventor level. Eight percent of the patents have resulted from foreign inventor collaboration and 4.2 percent of the total had exclusive foreign inventor(s). One-third of the Israeli patents are also technologies developed by single inventors.

Low technology patents form a small proportion with less than 10 percent of the total. Medium technology patents, including those relating to software procedures, plants - mainly cultivars - cryptographic methods; engineering and electrical equipment make up almost two-thirds of the total. The rest of the patents grouped as high technology and add up to 10 percent of the total.

Foreign inventor collaboration could be noticed both in medium and high technology patents. It is more so in the high technology, amounting to 13 percent of the total in that category.

Israel has clearly earmarked sectors like software, biotechnology, pharmaceuticals, medical instrumentation, and agriculture, among others, for innovation activities. They seem to have made the best of available technical manpower, considering it is a small country with smaller population base. In support of this Israel has vigorously administered the government grants for R&D, and even encouraged MNC collaboration in R&D through official grants.

Israel's patents could be categorized under 217 main classes of USPTO classification. However, a few major categories make up a half of the patents. In all, there were 2,400 unique assignees in Israel and 9,475 unique inventors were identified from the data. Per capita patent per inventor works out to 0.84.

Major areas of innovation by Israel

Subjects	Patents
Communication - Multiples / Digital (US PTO Subject classes 370, 375, 340, 379)	675
Drugs (US PTO Subject classes 514, 424)	629
Medical Equipment (US PTO Subject classes 600, 604, 606, 623)	673
Optical systems (US PTO Subject classes 356, 359, 385)	419

India:

India was along with China in the number of patents in the year 2000 and also, even as late as 2003, in utility patents. India's annual patent count has been around 250 during the ten years under review. The composition of Indian patents granted by USPTO is interesting. The share of research institutions, which was as high as 63 percent in 2001, has reduced to 23 percent in 2010. The decline has been steady and it has occurred, both as a proportion of the total and also in actual numbers. As opposed to this, the industry has registered a growth from 37 to 74 percent of the total over the same period. The relative contribution of industry and research institutions has changed, almost depicting a scene vice versa of the one in 2001. The universities show a dismal picture all through the period. The picture is not rosy when we consider the actual numbers. There is a considerable decline in the patents granted to the research institutions. The annualised growth is only marginal during the decade.

Indian patents are increasingly outcome of non-collaborative R&D investment both for industry and research institution. Even among the academic bodies - universities and research institutions - the trend in India has been to 'go alone'. Inter institutional collaboration, be it between more than one research institution, more than one university, or research institution and university, is negligible. Also, there is no noticeable international collaboration in innovation in our context.

The patents, however, have increasingly come from collaborative teams of inventors and such instances have remained above 80 percent all through the years for India. Around 4,800 inventors obtained 2,420 patents, making it about a patent for two inventors over the decade. India had 386 distinct patent assignees during the study period. Indian patents falls under 181 US patent main classes.

Relatively greater proportion (56 percent) of Indian patents comes under high technology, and low technology innovations are less than ten percent of the total. This distribution reflects our patenting priorities, which tend to be less of low end products and more of lab based processes and the like.

Major areas of innovation by India

Chemistry of organic & inorganic compounds (US PTO Subject classes 160, 423, 435,536, 540, 544, 546,560, 562, 568, 548, 549,	798
Drug, bio-affecting and body treating compositions (US PTO Subject classes 514,424)	517

Due to the presence of MNCs with their R&D laboratories in all the three countries they have lost their local innovative potential to other countries. That is, invention by Chinese, Indians and Israelis, as the case may be, but the patents assigned to an entity other than the respective countries. In fact, during the decade China and India have lost more innovations to others than the countries have as their own. It is also the case with Israel though not to the same extent. This trend exists despite the growth in number assigned to countries during the period. What is alarming is that this trend has consistently increased for India and has declined for China in recent years. Only 7.15 percent of our US Patents (173 our 2420) are licensed as technology trade.

Case Studies:

Case study of the patents in the US Patent Class 370/641- thermal conduction of electronic equipment - reveal that China took up to patenting on the technology when the innovation on the technology was on the decline elsewhere. China learnt the technology through collaboration with Taiwan and later continued on its own. Most of the patents they obtained in the process were based on fine-tuning at the sub-component level. These patents could be categorized as either exploitative innovation or creative imitation. The new patents provided a learning opportunity for China and also helped in bringing in small improvements in the electronic products they were putting together. It would have also helped in avoiding license fees to other IPR holders on the technology.

Case study on design of pens, which could be categorized as soft patents, reveals that initially Chinese firm co-opted with Taiwan by outsourcing the innovation. After this learning period it took up to patenting new designs. A careful study of the trade figures show that through these exercise, along with the cost advantage, China could garner substantial world export share on the product within a short span of time.

Case study on medical device patenting by Israel show that the country promoted innovation on the technology in the late 1990s and carried on during the next decade. As there were well-established players in this technology market with patent wall in place, Israel’s innovation could at best plug the holes in the technology. The patents obtained were in group B and C category technologies, which fall in low-moderate and moderate-high risk group of products. Nearly 25 percent of all these patents (169 out of 690) were licensed out by the original assignees as technology trade. More recently Israel has moved into innovation in Cryosurgery – relatively new technology, with limited players. This way, the strategy seems to be in the forefront on the technology. This approach contrasts with that of Chinese method of coming late in the process and innovating at the margins.

Case study on patents obtained by Israel on multiplexers - a software driven network device – show that innovation on this technology spans over 122 sub-classes with varying narrower foci in none of these sub-classes Israel is a domineering player in numerical terms. Yet, closer examination of the data indicates that 56 percent of these patents were licensed to other users in the value chain (210 out of 372). Thus, the country's innovation in this technology is at the cutting edge level and has facilitated technology trade.

Indian Patents Granted by Indian Patent Office

Analysis was also carried out on the patent records obtained from the public access database of the IPO. As per the available records Indian patents obtained from the Indian Patent Office shows a more promising trend. The patent growth shows a prominent upward trend and reached an annual grant of 2056 patents in the year 2008. This number declined in the last two-years of the decade. Over all the number adds up to a substantial 7,899 for 2001-10 period.

Unlike Indian patents in the US PTO, within the country, industrial firms have assumed a leader role with 45 percent of the total for the decade. Considerable number of patents is also assigned to research institutions and universities. Universities make up six percent of the total, with 465 patents in all for the decade. Included in this list are IITs and other such institutions of national importance. An unusual pattern in our local patents is the dominant presence of the unaffiliated assignees. These are individual inventors who have also mantled the role of assignees. This category makes up almost one-fifth of the total patents for the decade. This phenomenon reflects lack of awareness and low importance given to IPR by some institutions where the patented idea was worked on. Despite considerable increase in the overall numbers, there is no consistent trend of growth for any of the major assignee groups.

Three-fourths of the local Indian patents were obtained by single entities; collaborative research at the organizational level is relatively less. Inventor collaboration, on the other hand, is widely noticeable with two-thirds having two or more inventors. Assistance taken from foreign inventors either through exclusive outsourcing or innovation through collaboration is meager.

Medium technologies dominate the patented innovations, as opposed to our patents obtained in the USPTO. These innovations broadly fall in the category of products in one or the other engineering fields. Only 20 percent of the total could be classified as high-tech, which includes innovations involving laboratory based research or the new areas such as nano-technology and the like. There were only 16 patents that could be categorized as low tech. Absence of soft patents such as designs under our patent law could be one of the reasons for this low number.

Subject-wise classification shows that our innovations are skewed towards chemistry based processes, (including pharma products) and mechanical engineering, (including auto-components etc.). These are followed by innovations in metallurgy, electronics, electrical goods, food technology based products and medical devices. Relegation of electronics to the secondary level and medical devices that are only in the Group A (low risk) category does not speak highly of our innovation priority, considering the market potential for these products.

Indian innovator base, as per the IPO records, is strong with 11,855 individuals who have obtained one or more patents. Assignee base is also strong with 2,663 entities in the IPR game. CSIR owns nearly 20% of the total patents granted, followed by Hindustan Unilever (643), BHEL (199), SAIL (165) and the IITs (162).

Patent granting process in Indian Patent Office is slow and on an average it has taken nearly six-years for the grant and in an extreme case the figure stands at 17 years.

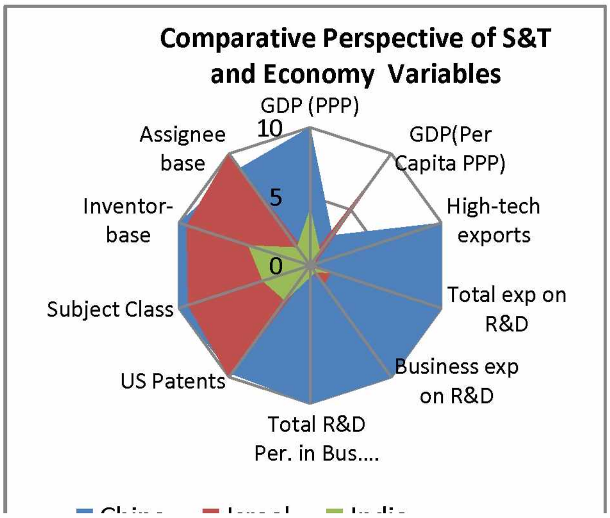
Innovation trend on the whole indicates the availability of the talent and also eagerness to patent. There is a need to strengthen the institutional base for IP protection, including providing a credible database of the patents in the public domain. There is also a need to spread greater awareness of the patentable innovations.

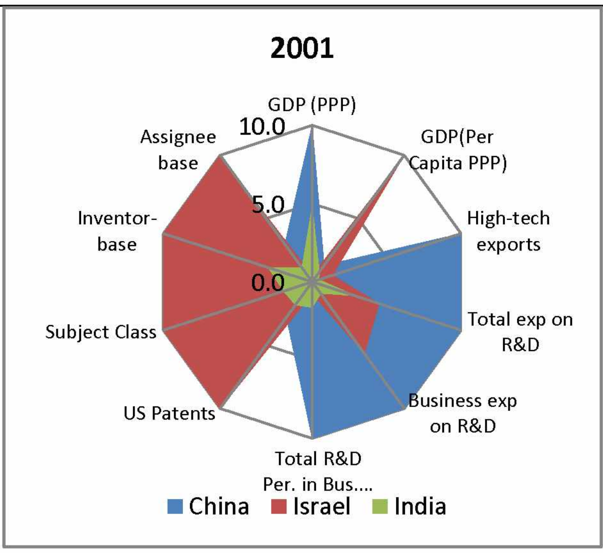
Summary table of R&D and US patent data 2001-10

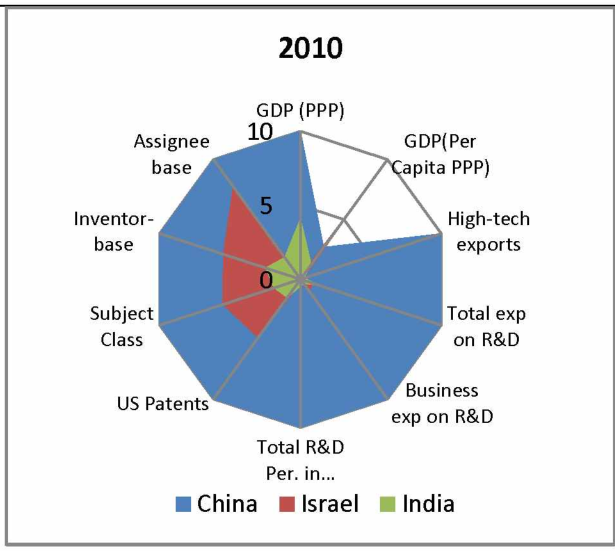
	GDP * (PPP)	GDP(Per Capita PPP)*	High-tech exports*	Total exp on R&D*	Business exp on R&D*	Total R&D Per. in Bus. Ent.*, **	US Patents 2001-10	Subject Class 2001-10	Inventor-base 2001-10	Assignee base 2001-10
China	10169.52	7583.54	223795.39	44252.10	31450.85	1046.13	7679	4717	10125	2079
India	4194.86	3523.04	5427.31	7354.42	2001.39	87.25	2420	1681	4794	386
Israel	217.84	28298.66	6067.36	6973.54	5457.38	44.57	7916	4372	9475	2400

- Annual average for the period 2001-10 (US $ million)

** (FTE thousands) (Indian figures were calculated on the basis of 2006 figures)





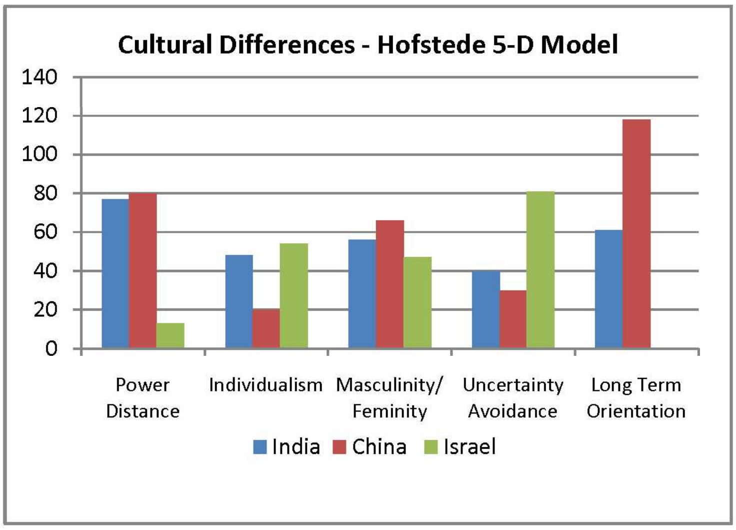


2001	GDP (PPP)	GDP(Per Capita PPP)	High-tech exports	Total exp on R&D	Business exp on R&D	Total R&D Per. in Bus. Ent.	US Patents	Subject Class	Inventor-base	Assignee base
China	3334.18	2612.44	49409.51	12595.14	7611.82	532.10	186	156	259	122
Israel	130.39	20059.38	6741.83	5661.84	4318.19	39.14	665	595	1227	411
India	1616.45	1571.30	2286.51	3610.85	697.81	87.25	121	114	361	46

2010	GDP (PPP)	GDP(Per Capita PPP)	High-tech exports	Total exp on R&D	Business exp on R&D	Total R&D Per. in Bus. Ent.	US Patents	Subject Class	Inventor-base	Assignee base
China	10169.52	7583.54	406089.69	104317.56	76592.23	1873.91	2350	1606	3997	653
Israel	217.84	28298.66	7978.96	9566.84	7635.00	49.35	1142	886	2191	505
India	4194.86	3523.04	10086.63	14015.21	2803.25	87.25	358	303	993	119

Cultural Dimensions

To examine the possible cultural difference in innovations comparative national scores on variable such as power distance, individualism, masculinity/ feminity, uncertainty avoidance, and long term from Greet Hofstede's 5-D model was compiled. Innovativeness is known to correlate with communication across hierarchy in organization, risk taking behavior, individualism, among others. The data for the three countries indicate that Israel is distinctly different on several dimensions. There is a considerable overlap between India and China on all the five dimensions. On power distance, individualism and uncertainty avoidance, China scores relatively low compared to India. In its record growth in patents during the decade, China has fared well, despite some of the possible cultural obstacles. The success points to a host of policies China adopted to enhance their performance.



http://geert-hofstede.com/national-culture.html

Innovation Strategy of China, Israel:

Strategy is the art of devising and employing plans towards accomplishing a goal. Patent or IPR strategy is a part of the larger technology management strategy.

Technology management strategy includes:

- Recognition of technological threats and opportunities,
- Exploitation of existing technologies,
- Identification and evaluation of alternative and emerging technologies,
- innovation activities,
- Protection and exploitation IPR.

An innovation strategy guides decision on how the resources are to be used to meet a firm's / country's objective for innovation and thereby build value and competitive advantage. It entails judgment about what kind of innovation process is more appropriate for the circumstances and ambitions. The strategy identifies technologies and markets it should best develop and exploit, to capture and create value.

Four levels of innovation strategy are recognized. These are: **Reactive** – where the innovation is entirely incremental; **Active** - wherein the innovation, though is not first to market, but are well prepared to follow; **proactive** - in which the innovation is mainly radical in nature; and **passive** - in which case the product improvements take place only on customer requirement.

Patenting strategy involves mechanics of achieving exclusivity in a technology area. At the firm level these include:

- Broad or narrowly claimed patents
- Patent flooding or blanketing around an original patent.
- Wall strategy, in which the firm knows that the patented technology would be surpassed in functionality. The gain is in the time delay imposed on the competitor.

Patent strategy at the national level is part of -

- S&T policy, which may sometimes include an exclusive innovation policy
- Industrial policy, which may include growth strategies desired, such as export led growth or focus on internal market through protection mechanisms, and
- Industrial manpower policies, which could include capacity building, among other things.

Israel has consciously opted for technology and innovation led growth model. Considering the relatively small population base, the technologies opted by the country are the high end ones such as medical devices, IT, drugs and pharmaceuticals etc. The government has also devised ways for risk absorption in innovation process, through grant programmes at all levels of technology development process, namely embryonic, growth and maturity stages. It has also encouraged formation of technology-based enterprises through venture capital mechanisms and funds operated for the purpose. International and bi-national interactions for technology development are facilitated through specific programmes intended for the purpose. The results of this are reflected in the patents obtained by the country.

China has explicitly stated goal of transforming the country in to an innovation-based economy by 2020. Among the strategies adopted towards that goal are -

- Manufacturing export led growth;
- Import of technology to facilitate manufacturing, mainly through open door policy for trade and industrial establishment;
- Protection of local markets through appropriate IPR legislation, such as
    - Utility model patent;
    - Making local patenting mandatory for MNCs engaged in R&D within the country;
- Changing labor laws to make the manufacturing process competitive;
- Encouraging local innovators through incentivization at various levels;
- Restructuring the S&T organizational set up to make them competitive;
- Selectively developing universities to achieve the best standards and establishing benchmarks;
- Adopting a slew of measures, such as venture funding, tax based incentives to facilitate innovation and patenting;
- Continuously revising the national policies, which have also earmarked a set of technologies to focus on in the coming decades.

The outcome of these measures in terms of innovation and patenting is immense. These have resulted in new innovators and firms harnessing the IPRs.

One of the outcomes of the active and proactive innovation is the patent rights and is less so when the innovation strategy is reactive. China's innovations range from '*proactive to* '*reactive*' '. They are, however, skewed towards '*reactive*'. This is reflected in their innovations, which are minor improvements of old products and designs. The country is also involved in an '*active*' innovation strategy in certain medium technologies. China is also engaged in science-based inventions - particularly the ones emanating from its universities. The trick in the rapid growth on patent graph is that much of the low technology products, nominal design improvements that are normally not widely appropriated as IPRs have been converted as patents. Protectability of many of them could be an issue, and its intrinsic worth in the market is debatable.

Nonetheless, this exposure to patenting has broadened the innovator base, spread awareness of IPR, its commercial importance, and generally prepares for a wider innovation culture. China, through its policies, is aiming for such a change.

Israel's strategy is to engage in '*pro-active*' to '*active*' inventions on select technologies. In technologies such as computer software, medical instrumentation, biotechnology and drug development the country is proactive and engage in cutting edge research. In several other areas invention is pursued at a level that could be adopted directly by the industry. Active venture capital firms facilitate the inventors / entrepreneurs. The government also facilitated in lowering the R&D risks through imaginative programmes. This has served the intellectual property generation very well for the country.

Indian patents largely fall in the categories '*active*' and '*reactive*' inventions, the bouquet, however, is small.

Learning from the others' Experience:

Innovation cannot happen in a vacuum. In our plan to enhance this activity we could realistically consider the desirable social, economic and political environment, along with S&T factors to facilitate technology development and patenting.

While we examine our relative strength there is a need to increase the inventor base. We are lagging behind both in terms of sheer number and also in the productivity of the existing stock. We also have to broaden the subject coverage in the range of innovation activities. The innovation plan must enthuse to engage with the peculiar local needs going with our socio-cultural background and the way of living while preparing technology wish list and idea generation. Though innovations of that nature may not be cutting edge, we would not face foreign competition on such ventures and those technologies would also cater to the market needs.

SOCIAL ENVIRONMENT

Philosophy of Life
Social Conditions

POLITICAL ENVIRONMENT

External / Internal Environment
Leadership

Individual Capacity
Motivation

Innovation

ECONOMIC ENVIRONMENT

Economic Strategy
Industrial Scene
Manufacturing /
Labour Policies

S&T ENVIRONMENT

S&T Policy / Innovation Policy
Science Institutions
Patenting Organization
Higher Education Institutions

The country already has several schemes to encourage research and innovation. They cater mostly to science based research and development. These include:

- ✓ Industrial R&D Promotion Programme;
- ✓ Technology Development and Demonstration Programme;
- ✓ Technopreneur Promotion Programme;
- ✓ Technology Management Programme;
- ✓ International Technology Transfer Programme;
- ✓ Consultancy Promotion Programme;
- ✓ Technology Information Facilitation Programme;
- ✓ Technology Development & Utilization Programme for Women.
- ✓ Innovation in Science Pursuit for Inspired Research

There are also various such programmes under different union ministries to encourage extra-mural research. Considering that these schemes are already in vogue for several years, there is a need to evaluate their efficacy.

Immediate attention could be given to some of the following:

- ✓ A proper appreciation of what is 'patentable innovation'. We seem to have a different notion on what is patentable. This is reflected in our focus on lab-based innovations.
- ✓ Broad basing the R&D grants to accommodate technology development risk and failure as is done by Israel. S&T grants could be administered through regional offices for better inventor spotting, immediacy of innovators, and project monitoring.
- ✓ A re-look at the tax-based incentive for R&D.
- ✓ Considering direct grant to industry when taken up in collaboration with academic institutions.
- ✓ Examine the adequacy of the support base for prototype development activities, which are essential components of innovation eco-system.
- ✓ Broadening the inventor base through incentivizing patenting in a major way.
- ✓ Strengthening the local patent offices and bringing in an element of professionalism in their activities.
- ✓ Encouraging hands on innovation activities and the importance of new ideas and products at various levels.

Introduction

Introduction

In the globally interconnected world of today, nations and regions have been increasing opportunities for success and overcoming hurdles. Inventions play an important role as nations seek competitive advantages.

Innovation is a powerful force. It creates new businesses, social institutions, cultural artifacts, and destroys, replaces or leaves behind the old ones. Innovation feeds on the known and converts it into the new. Innovations help some individuals, firms, and nations win, while others lose.

Invention (used synonymously with innovation) refers to exploiting new ideas leading to creation of a new product, process or service. Innovativeness is a major factor in the context of science and technology (S&T). Innovation also means exploiting new technology and employing out-of-the-box thinking to bring in new value to products and processes. It has been acknowledged that innovation leads to wealth creation. Currently when almost every organization and business is feeling the impact of globalization, technological and knowledge revolutions, innovation acquires added value as it contributes to the economy in a variety of ways.

Innovation and technology development are the result of a complex set of relationships among actors in the system, which includes enterprises, universities, government research institutions, and other agencies. It is now widely recognized that innovation includes a series of activities: science, technology, organization, finance and commerce.

Schumpeter[12] developed a theory of dynamic competition in which innovation is a perennial gale of creative destruction that can open up new domestic and foreign markets, and revolutionize economic structures from within, incessantly destroying older ones, incessantly creating a new one. Intellectual property is one of the strongest of the tools available to stimulate and channel innovation.

Social factors that facilitate innovation are individualism; risk taking behavior; scientific outlook; and religion / cultural tolerance. Economic influences on innovation include availability of investment capital and lack of cheap labor.

Innovations occur at two levels. There is an initial personal urge to create and there is a subsequent social force that captures and expands the innovation overtime so that it makes a difference to society.

Intellectual property rights (IP) system is central to the process of innovation. This system drives individuals to innovation and social adoption of the new process or product. IP system lays down the rules of innovation game for its larger benefits - who, how, when, etc. Patents, an outcome of the IP system, encourages people to be creative, It rewards people after they are creative, and gives people rights to the fruits of their creative labor. Patents promote public disclosure of new inventions and facilitate transfer of technology. Patent is an institutional mechanism to give exclusive rights to intellectual property. This feature facilitates investment in innovation and helps implementation of industrial policy

Patents are in vogue from the 15th century, when Venitian Patent Decree of 1474 was made which resulted in issuance of patents. Modern patent system was initiated across Europe during the Renaissance period.

The industrial revolution led to the continuous expansion of IP laws. And, in mid 1800s many European countries adopted their patent laws. In 1883, 11 nations established Paris Convention to require member states to treat foreigners and citizens equally in patent laws. WIPO was established in 1893. This convention and other IP organizations of WIPO administrate treaties relating to IP.

From ancient to current times, successful societies have been those that promote, reward and capture individual creativity and innovation. Those who fail to innovate, or copy the innovators, are overwhelmed and replaced. It is also mentioned that inventions are usually the result of cumulative incremental improvements.

Modern nations will continue to compete for leadership in electronics, software, agriculture, medicine, and media. Today globalisation has overcome geographic conditions as a force of creative destruction. As Friedman notes in his book - World is Flat (Ferrar, Straus & Giroux, 2005) - the playing field is now much more even for countries such as India. The expansion of IP laws around the world can be seen as further leveling the playing field, making the world more flat, but tipping it in the favor of those who know how to use IP to their own advantage.

Innovation requires both individual creativity and broader social adoption. Societies that support both do the best. The evidence of creative competition, simultaneous inventions, and continued incremental improvements proves that all inventors are important.

The main objective of the debate on innovation is to understand the factors that contribute to the varying performance of the countries in the innovation matrix. Underlying such a debate is also to help improve the innovation performance of the country. Varying matrices have been devised to understand the relative position of economies on innovativeness. Global innovation index[5], for instance, considers variables such as:

- R&D as percent of GDP; quality of the local research infrastructure; education of the workforce; technical skills of the workforce; quality of IT and communications infrastructure; broadband penetration as direct drivers.
- Political stability; Macroeconomic stability; institutional framework; regulatory environment; tax regime; flexibility of the labour market; openness of national economy to foreign investment; ease of hiring foreign nationals; openness of national culture to foreign influence; access to investment finance; protection of intellectual property; popular attitudes towards scientific advancements, as indirect drivers.[4]

Global Innovation Index [5] [CII and INSEAD] include 85 variables in arriving at its country ranking on innovations. These are grouped under - institutions, human capacity, ICT & uptake of infrastructure, market sophistication, business sophistication, science outputs, and creative outputs.

In broad basing the requirements, these measures look for possible sustainability of innovativeness under a given economic philosophy. Considering the social, economic and political variations in the societies, the resultant policies are supposed to reflect these variations.

As technology is central to innovation, the concept of technology strategy has been part of the technology management literature since the late 1970s.[6] It encompasses the acquisition, management and exploitation of technological knowledge and resources by the organization to achieve its business and technological goals. Intellectual Property Rights, as manifested in patents - a direct consequence of innovation - is a major component of technology exploitation.

A patent is a temporary monopoly awarded to inventors for the commercial use of a newly invented device. For a patent to be granted, the innovation must be non-trivial, meaning that it would not appear obvious to a skilled practioner of the relevant technology, and it must be useful, meaning that it has potential commercial value. If a patent is granted, an extensive public document is created and made accessible. Before the grant, the novelty of the innovation is established in a foolproof manner. Patent office, where such rights are requested, would make sure of the novelty of the idea / technology. A patent, as per the prevailing agreements, has a lifespan of 20 years. Patent right granted to the assignee are exclusive to a given geographical territory.

Patents obtained by organizations/ institutions of a country are prominent among the measures of innovativeness of a country. In recent years intellectual property has received a lot more attention because ideas and innovations have become the most important resource, replacing land, energy and raw materials. As much as three-quarters of the value of publicly traded companies in America, for instance, comes from intangible assets, up from around 40% in the early 1980s.[10]

The current study examines the patents granted to a set of countries including, China, India, Israel by the USPTO. The USPTO is one of the three important patent offices in the world, Japan Patent Office and European Patent Office, being the other two. The United States of America is the biggest economy in the world and any idea/ technology worth the novelty would have to succeed in the market, it would, in most cases, be patented in the country. Apart from this, confining the study to the USPTO also ensures common benchmark in validating the innovation. The present analysis is an effort in this direction.

Objectives of the study are as follows:

1. Examine in depth the decennial [2001-2010] trend of patenting in India, China and Israel.
2. Explore the approaches to innovation and patenting adopted by China and Israel, which have made them fare better economically.
3. Study the patents obtained by Indian firms and institutions in the Indian patents office during the 2001-10 period and analyze them on various parameters.
4. Understand the policy and other support system in these countries in obtaining patents locally and abroad.
5. Propose alternative approaches to enhance innovation and patenting in the country.

The study would provide background policy options in our effort to enhance innovation in general and patenting in particular.

This exercise is expected to give an understanding on the patenting trends, active components of the national innovation system, and also strategies adopted by the countries for obtaining the patents, and possible learning from the same. The comparison of our performance with a set of countries would help us understand where we stand within the variables that make up the patents granted to the country. This may, in itself, help us address some of the issues in the innovation and patenting process.

An analysis of India owned patents in the USPTO 1990-2002 was done by NISTADS in 2005.[7] The study has noted the primacy of pharmaceuticals patents in the context and dominance of the CSIR among the research institutions. It called for the formulation of IPR Policy by the ICMR, the ICAR and similar bodies. It also recommended the spread of awareness and patenting in emerging fields, including computer science, etc. The current research aims at a comparative analysis, with an intention to carry the learning from the strategies adopted by the select set of countries in increasing their patented innovations.

Methodology & scope

The study considered all the patents granted by the USPTO during the years 2001-10 to India, Israel and China. These patents were downloaded from the USPTO database with all its components. Reissued patents, however, were excluded. The patents were examined individually and the same were categorized as appropriate in the context. In the case of China, the patents assigned to Hong Kong were also taken in their count. Patents issued by Indian Patent Office to Indian entities during the 2001-10 period, as made available in their database, were also analyzed separately.

The variables considered include the following:

Inventors:	Geographical affiliation - local or foreign; Collaboration - sole inventor or collaborative team; nature of collaboration; team size; Number of the inventors who were awarded the US patents during the period.
Assignee:	Local or foreign collaboration; Broad category of affiliation, viz., University, Industry, Research Institution and others; Collaboration among the affiliates in R&D; Extent of assignees during the period.
Technology:	Broad grouping of the patented technology classes as design, plant and utility; Classification of the patents on level of technology, viz., high, moderate and low; Subject classification of the patents based on the US Patent Classification (USPC); Number of distinct subject categories.
Others:	Time duration in the grant of patents for countries.

Data on all the variables considered in the analysis were directly obtained from the patent documents as was represented in the US PTO database. The patents were examined individually for categorizing the technology as high, moderate and low.

It is true that all the patents granted invariably have a novelty element. None the less, it is noticed that there is a tendency of countries specializing on certain technologies and consequently obtain a series of incremental patents. It is also true that innovation in certain technologies call for extensive research and laboratory work, including field testing and the like, compared to others which could be relatively easy to come by. With a basic appreciation of the value of every patent granted, the entire set of records was analyzed to categorize them as high, medium and low technologies. The categorization was thoroughly checked to ensure the appropriateness of classification. The classification was based on the following methodology:

The patents were examined separately and the relative level determined with the help of a 2*2 matrix.

Concept/ process Technology	Low / mod Sophistication	High sophistication
Commonplace	LOW	MED
Others	MED	HIGH

Technologies that are commonplace include those associated with long proven concepts. Low level of innovation would fall into the category of those associated with small improvements, modification relating to ergonomics, and the aesthetic improvements and the like. This category also includes those technologies that synthesize two or more common place products / concepts to present it as a novelty product. Patents that come in this category include: handicrafts; mechanical hand tools; furniture; stationery, etc. This class of patents is grouped as **low technology**. The design patents are also referred to as soft patents in the literature on innovation in more recent years. [8]

Some examples of this category are as follows:

7303028 Adjustable handle for a power tool
7303424 Battery cover assembly for portable electronic device
D557121 Castor wheel
D556138 Changeable plugs system
7301762 Computer enclosure with static protection device
7301769 Fan holder
D556414 Golf cart
D555992 Hedge trimmer
7299524 Hinge assembly for electronic device
7286343 Lock mechanism for digital disc player
D556227 Palace shaped watch display box with single watch winder

7293367 Power-operated tape measure
D556223 Refrigerator with three doors
D556933 Solar light
D556454 Tooth brush
D556335 Vibrating massage device
7306480 Wire holder for electronic device

Patents that were categorized as high sophistication include cutting edge technologies, and the ones based on very specialized and usually long drawn laboratory based research. Cutting edge is a relative term based on the currency of the concept / discipline. Patents that come in this category during the current times include: bio-technology, genetic engineering, pharmacology, complex computing, nano-technology, VLSI, semi-conductors, and the like. These patents are grouped as **high technology**.

Patents that fall in this category are as follows:

7297490 Authentication of biologic materials using DNA-DNA hybridization on a solid support
7291319 Carbon nanotube-based device and method for making the same
7300902 Catalyst for polymerization of ethylene, preparation thereof and use of the same
7298446 Liquid crystal display device and method of manufacturing rework
7286958 Method and system for yield similarity of semiconductor devices
7307016 Method of processing metal surface in dual damascene manufacturing
7291664 Multicomponent composition for photodegradable and biodegradable plastic articles and the use thereof
7309786 Oligonucleotide antagonist for human tumor necrosis factor .alpha. (TNF-.alpha.)
7306683 Shape memory material and method of making the same
7294697 Short chain neurotoxin from sea snake-Lapemis hardwickii and genes encoding the neurotoxin
7304057 Substituted 6-membered N-heterocyclic compounds and method for their use as neurological regulator
7298187 System and method for power on reset and under voltage lockout schemes
7294708 Telomerase reverse transcriptase fragments and uses thereof

It is also possible to take a new look at commonplace technologies, with conceptual improvements and evolve them to a new level of sophistication. [Example: learning shoe for children - No. 5240418]. There are also technologies that are not commonplace, yet the idea or the research associated with that are relatively less or moderately sophisticated in evolving a novel process / product. These two categories of patents are grouped as **moderate technology**. Patents that come in this category for example, include:

7295415 Circuits for circuit interrupting devices having automatic end of life testing function
7298101 Continuously variable frequency swinging armature motor and drive
7298097 Driver system and method with multi-function protection for cold-cathode fluorescent amp and external-electrode fluorescent lamp
7294247 Electrophoretic separating device and method for using the device
7297192 Flame retardant and flame-retardant resin composition containing the same and its use
7295842 Handover method in mobile communication system
7295437 Heat dissipation device for multiple heat-generating components
7296617 Heat sink
7295439 Heat sink fastening assembly
7298060 Magnetoelectric devices and methods of using same
7298593 Micro-actuator including a leading beam pivot part, head gimbal assembly and disk drive unit with the same
7296098 Portable data converting and processing storage device with standard interface wherein the body unity does not include any built-in flash memory
7297043 Toy rocket launcher for multiple soft toy rockets
7296279 Transmitting device for feeding mechanism of information recording/reproducing apparatus

Any categorization on these criteria cannot be watertight, instead would have a grey band. The classification was carried out for understanding the possible patterns in innovation and patenting trends. It can also be noted here that this classification of patents fit in the pattern of technology S curve, wherein technology growth and maturation is patterned into three stages: Embryonic, early growth and mature periods.

Patents – International scenario

A patent is a legal document assigned by the patent office of a country to a firm, an institution of academic nature or in some cases to individuals giving the assignee the exclusive right to stop others from making, using or selling the invention without the permission of the assignee. Patents are granted for a fixed period of time and become the property of the assignee. Patents are usually taken in their country of origin but can also be obtained in more than one country. European Patents and World Patents cover more than one country.

Patents are usually obtained for novel processes/products and functional/technical improvements to the existing ones. They are granted to new products, including chemical compounds, foods, and manufactured products of all sorts, and now even software, plants and other genetic materials.

Patenting has come a long way from the first modern patent granted in Venice, Italy, in 1474. The "big three" - the European Patent Office, the United States Patent and Trademark Office and the Japan Patent Office have dominated the global patent landscape.

In 2010, the total number of patent applications filed across the world was estimated to be around 1.5 million. The USPTO during the year received 490,226 applications. http://ipstatsdb.wipo.org/ipstats/searchresultsTable

Over the past two decades, there has been a significant increase in the share of non-resident patent filings, mainly as fallout of the globalization policies and perceived need for market domination. In 2006, the share of non-resident patent filings in various patent offices accounted for 43.6% of total filings. It could be expected that innovations are protected in significant economies and markets. It could also be expected that overseas patents tend to be serious innovations, which the inventors would want to protect.

The following graph shows the patents filed in top patent offices in the world. The USPTO currently receives more filings than the other two major patent offices. Table 1 shows recent data on patent filings in the USPTO by countries figuring in the top of the list.

Table 1 - Patents filed in the USPTO by Select top ranking countries

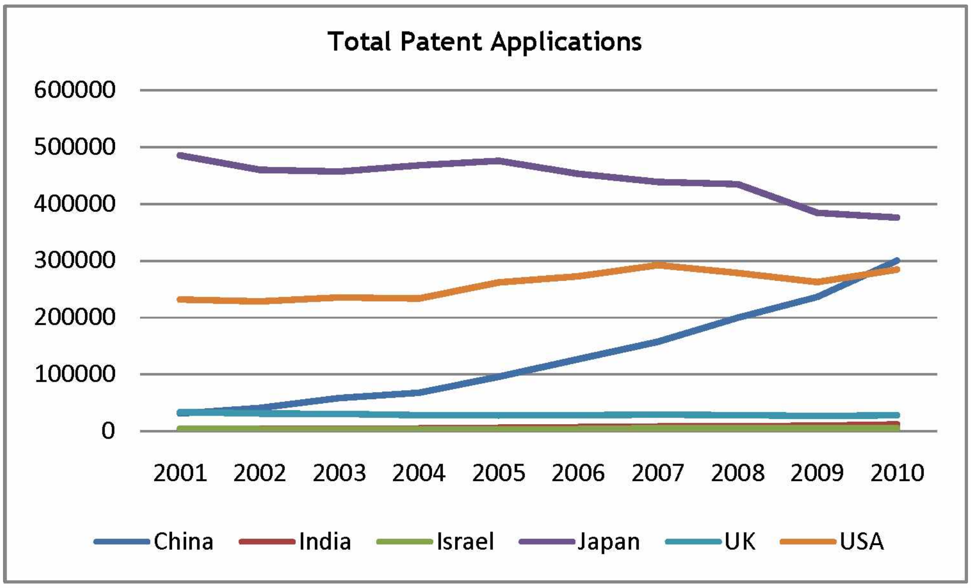
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total	326,508	334,445	342,441	356,943	390,733	425,967	456,154	456,321	456,106	490,226
Total Foreign	148,997	150,200	153,500	167,407	182,866	204,183	214,807	224,733	231,194	248,249
U.S.	177,511	184,245	188,941	189,536	207,867	221,784	241,347	231,588	224,912	241,977

Japan	61,238	58,739	60,350	64,812	71,994	76,839	78,794	82,396	81,982	84,017
Germany	19,900	20,418	18,890	19,824	20,664	22,369	23,608	25,202	25,163	27,702
Korea, S	6,719	7,937	10,411	13,646	17,217	21,685	22,976	23,584	23,950	26,040
Taiwan	11,086	12,488	13,786	15,057	16,617	19,301	18,486	18,001	18,661	20,151
Canada	7,221	7,375	7,750	8,202	8,638	9,652	10,421	10,307	10,309	11,685
UK	8,362	8,391	7,700	7,792	7,962	8,342	9,164	9,771	10,568	11,038
France	6,852	6,825	6,603	6,813	6,972	7,176	8,046	8,561	9,331	10,357
China	626	888	1,034	1,655	2,127	3,768	3,903	4,455	6,879	8,162
Israel	2,710	2,645	2,539	2,693	3,157	3,657	4,410	4,550	4,727	5,149
India (15)	643	919	1,164	1,303	1,463	1,923	2,387	2,879	3,110	3,789

http://www.uspto.gov/web/offices/ac/ido/oeip/taf/appl_yr.htm

The data suggests that the countries seek to file patent applications in increasing number in the USPTO. As has been suggested earlier, this may be because any idea/ technology worth the innovation would have to succeed in the U.S., and has a relatively better chance to do so, as it is the largest economy in the world. In recent years the foreign applications in the USPTO have exceeded the local ones. The patent database size of the USPTO is the largest in terms of number of records. This ensures the novelty of the patents in the world scene. These factors make the study of the US patents one of the better options available to learn about the S&T innovation of a country.

Trends in Patent Filing



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China

China aspires to be an innovation driven economy and world leader in technology. China's science policy evolved in stages during the post-cultural revolution period in the late 1970s. S&T policy reforms evolved in four main phases in national S&T conferences - 1978, 1985, 1995, and 2006. The evolution could also be seen as follows in a time-frame: [1,2,3,4]

1975-78 Rectification

1979-94 trial stage (1979-84) official reform (1985-94)

1995-2005 Deepening reform

1995 Decision on accelerating the progress, National strategy on Science and Education

1999 Strengthening Technical Innovation and high-tech industrialization and national strategy on sustainable development

2006-20 Towards an innovation driven nation. Strategy for revitalizing the nation by talents, strategic plan for development of S&T

Reform in Chinese S&T policy started in earnest in 1995 when china adopted "revitalizing the nation through science and education strategy", which initiated a new phase of S&T reform and policy. This change in strategy had in its backdrop Chinese entry into WTO, which necessitated accepting the international norms.

The ensuing strategy led to change in the focus of public research organization centred R&D to enterprise centred innovation system. In all these phases China learnt from the western policies. The 2006 National Science and Innovation Conference and the adoption of the Medium to Long-term Strategic Plan for the Development of Science and Technology are the current phase in strengthening of national innovation system.

Even before the beginning of the reforms PRC had build up a comprehensive S&T system since 1949, despite political disruptions. S&T system is not without its share of problems. In the 1950s at the wake of Mao's Regime, Soviet Union was the main source of policy learning. China followed the Soviet model. The system relied on central state control, specialization and concentration of overlapping tasks in one organization to avoid competition and redundancy. The organizations were monopolistically structured and it was so for its S&T system as well.

China's research and higher education system till recently consisted of three branches, with several tiers. Teaching was done by colleges and universities with research concentrating on more theoretical topics. Applied projects were allocated by a bid or patronage system to branches of the Chinese Academy of Sciences (CAS) or special schools established under different departments of the government.

In the wake of Cultural Revolution in the sixties, scientists were accused of playing the role of lackeys of the US imperialism. They were dubbed to oppose Mao's principle of striving vigorously to build up the might and prosperity of the country by relying on our strength. During this phase contributions of China's highly trained scientists could make in the process of discovery was considered to be of less relevance than the innovative skills of the workforce. Between 1966 and1977 there was total cessation of graduate studies. This also resulted in suspension of publication of scientific journals. The Chinese communist party's S&T policy during this period was based on maximalist view. [30]

S&T policy and disagreements concerning the role S&T could play in the process of economic modernization were main subjects of political conflict throughout the seventies. Deng Xiaoping and his followers in the O**utline Report** on the work of the CAS set out their views on S&T and its role in China's modernization programme. The report stressed the role of S&T in promoting economic development and indicated that the revitalization of S&T lay at the heart of the whole modernization prorgramme. It was stated that without this, modernization of industry, agriculture, and national defense would be impossible.

Deng Xiaoping spelt out on 18 August 1975 address that China -

- Must stress the idea of taking as the foundation—modernisation of agriculture
- Must adopt new technology. To import, we must export a few more things.
- Step up science research work in enterprises. Some intellectuals have not put to use the skills they have learnt.
- Must attach first priority to quality as a major policy. [5, 30]

China's articulation for strengthening S&T came much before its liberalization policies. The rectification to the S&T system was introduced during 1975-78 period.

Since 1978 the Deng Xiaoping's conception of S&T has been at the base of theoretical and ideological formulation of China's S&T policy. According to Deng, S&T is a primary productive force. Intellectuals, including S&T workers, belong to working class and their talent must be respected. The reform of the system for managing S&T, like the reform of the economic structure, is designed to liberate the productive forces. The new economic structure should promote technological progress, and the new S&T management system should promote economic development.

It was soon noted, that despite the government reorganizing the role of S&T research and introduction of measures based on them, the ultimate success of China's S&T reforms in providing what the leadership wants will depend on two external factors:

- The reforms of the urban industrial economy must provide the necessary 'pull' to ensure that appropriate research is undertaken and the necessary technologies developed.
- The party must ensure that an atmosphere that encourages the research environment is created.

Much progress has been made in this direction to date.

Most of the initial S&T targets in Ten year National Economic Plan—1976-86, coming immediately after the regime change, were very ambitious. In broad terms the plan set several objectives to be achieved by the S&T establishment by 1985:

- To bring the professional research working up to 8,00,000
- To set up a number of up to date centres for scientific R&D
- To complete a nationwide system of R&D in S&T
- To reach advanced world levels of the 70s in a number of S&T branches
- To narrow the gap with advanced countries to about ten years, and
- To lay the basis for catching up or surpassing advanced world levels in all branches in the ensuing 15 years.

The targets of this plan were redrawn towards making S&T serve the economy and society. In mid-1984 the S&T system became the central component of national policy.

After 1979, when it was decided to broaden the decision making powers of the enterprises, experiments were also introduced to give greater powers to research institutes. This experimentation began in 15 provinces and municipalities in the ministries of machine-building industry, chemical industry, aeronautics and astronautics.

During 1979-84 the reforms were in a trial stage. On the basis of this experimentation, in April 1984, State Scinc and Technology Commission and the State Commission for reform of the Economic System formulated 'suggestions on the experiment of changing R&D Units from the System. Under this plan operating expenses were paid directly by the state to the system. They were expected to fulfill a contract with the enterprises they serve'. This document formed the basis for extending the use of contracts throughout the system.

By the end of 1984, 535 such institutes were experimenting with the paid contract system and they were expected to become financially independent. This represented 12% of China's 4,450 independent research institutes.

Decision on the reform of the S&T system (1985) by the Central Committee was one of the four decisions on S&T. Several initiatives were taken to reform the S&T scene. The decision pointed out three areas which called for immediate attention: The operating mechanism, institutional structure, and S&T personnel management. [6, 29]

The Government felt that restructuring of the S&T was required in the wake of open door policy to absorb the imported technology. The older system suffered from -

Separating R&D from production functions
S&T result being perceived as free public good
Lack of mobility for S&T personnel
R&D was separated from education

The official reform initiated during 1985-94, addressed these problems. This period saw the initiation of several plans and programmes targeting S&T activities in general and also among specific groups.

Key Technologies R&D Programme

The Key Technologies R&D Programme was launched in 1982 as the largest science and technology programme in China in the 20th century. Oriented toward national economic construction, it aims to solve the key and comprehensive problems directing the national economic and social development, covering agriculture, electronic information, energy resources, transportation, materials, resources exploration, environmental protection, medical and health care, and other fields. This programme, engaging tens of thousands of persons from more than 1,000 scientific research institutions nationwide, has been so far the largest national scientific and technological plan that has been invested with most funds, employed most personnel, and made the greatest impact on the national economy.[7, 13]

The 863 Programme (State High Tech R&D Programme)

The first national level government programme specifically providing capital for technologically promising businessman. The 863 Programme (representing March 1986, the date of a speech launching the idea) advocated government preparation of a well endowed fund to assist high technology project research that could lead to usable products. The fields of automation, biotechnology, energy, information technology, lasers, new materials, and space technology are the priorities under this programme. The 863 Programme is one of the main supports for the current drive for "indigenous innovation." It is focused largely on applied research and is organized around nine principal areas of high technology—the seven areas of technology described above, with the addition, in the mid-1990s, of ocean technology and resources/environment technology. Funds in the 863 programme largely goes to projects solicited from major university scientists showing some commercial 'fruits' in their ideas.

Torch programme

The key objective of 'Torch Programme' was to serve as a government-provided bridge between the previously isolated domains of academia and business activity. Torch programme extended central government support to focus on SMEs. The project requirement under this were less stringent than those for 863 programme for demonstrated success of idea, but still involving initial screening by a panel of scientists. Torch recipients were, to begin with, geographically targeted for urban areas with pools of appropriately trained, skilled workers and an environment open to industries and ideas from outside China, to facilitate technology transfer. The stringency of the programme requirements promoted affiliation of enterprises with established R&D institutions such as CAS and universities. These plans supplied necessary ingredients such as financial capital, physical surroundings, scientific personnel, advice on various aspects from technology to managerial.

Spark Programme

Launched in 1986, the Spark Programme aims to revitalize rural economy through science and technology and to popularize science and technology in rural areas. Today, there are more than 100,000 scientific and technological demonstration projects being carried out in 85 percent of rural areas throughout China.

Reforms in Chinese S&T in the 1980s focused on ensuring that development of S&T kept pace with economic reforms. By 1990s, the guiding principle underlying the Chinese government's **industrial** policy for the high tech sector was to make technological programmes and improved workforce lay foundation of economic development. There was, therefore, a great emphasis on the commercialization of research results. With this objective during 1990-92 four important plans were implemented[7]

1. National S&T achievements spreading programme (1990)
2. The S&T development loan programme (1990)
3. National Engineering Research Centre programme, implemented to speed up commercialization of academic research results.
4. Plan for joint development and engineering projects between industry and university - collaboration of industry - academia (1992)

In 1996 Law for the commercialization of S&T research results was enacted to provide legal framework for dealing with problems relating to the commercialization of research results.

This ensued encouragement of town and village enterprises (TVEs) tied into the development of a new spatialization of the production chain. There is also plans to forge links between towns and cities as heavy industries were relocated from dense urban populations to outlying areas.

To facilitate these the Central Committee took a decision on accelerating S&T progress (1995). This phase is also referred to as 'deepening of the reforms'.

Restructuring of Research Institutions, Knowledge Innovation Programme, and the push to produce marketable advanced technology in the 1990s were among the programmes initiated during this period.

Main objective of Knowledge Innovation Programme was to renew and reinvent the CAS as a research organization, following a centre of excellence approach. The goals of the reform are to establish about 80 national research institutions with powerful S&T innovation capabilities and sustainable potential. Of these 30 are to be internationally recognized research institutes by the year 2010, five of which were to be world leaders. When the programme was initiated in 1998, CAS has 60,000 staff and 120 institutions.

China's research and higher education system consisted of three branches, with several tiers. Teaching was done by colleges and universities with research concentrating on theoretical topics. Applied projects were allocated by a bid or patronage system to branches of the CAS or special schools established under different departments of the government. From the late 1990s this system was moved towards consolidation with the squeezing out of state owned enterprises and merging of departmental institutions. Universities were encouraged to take up applied research and spin off companies. A top tier of these institutions was singled off for government support and funding. With the decision to accelerate the S&T programme in 1995, spate of new schemes were launched.[8,9,10,12]

The 973 Plan: This is a state level basic R&D programme as a follow up of 863 programme . It mainly involves multi-discipline, comprehensive researches on important scientific issues in such fields as agriculture, energy, information, environment of resources, population and health, and material, providing theoretical basis and scientific foundation for solving problems. The programme encourages outstanding scientists to carry out key basic scientific researches regarding cutting-edge sciences and important issues in science and technology in fields with great bearing on economic and social development. Representing the national goals, it is aimed to provide strong scientific and technological support for significant issues in China's economic and social development in the 21st century.

985 Programme involves selection of handful universities from among keys universities to potentially become world class universities.

Cheung Kong Scholars Programme intends to build an army of leading scholars

CAS Programme one hundred talent programme was set up in 1994 to recruit scientists mainly from abroad under the age of 45.

NSFC Programme - National Science Fund for distinguished young scholars programme (1994) Funds Young Scholars (45 yrs) in seven science fields. The selected scholars can pursue their own research.

***211 Programme** intends to position 100 of 1792 Universities/ Colleges of China's universities as world-class distinguished academic institutions. 100 leading universities and approximately 600 disciplines have been identified as key targets.*

100, 1000 and 10,000 talent programmes Ministry of Personnel has from 1995 administered these programmes which seeks to identify promising scientists, 100 of whom by the year 2010 will be active at the international research frontier, 1000 of whom can be expected to be leaders of advanced research projects, and 10,000 of whom will be capable of high-quality leadership for the development of academic disciplines

Incubators

Spatially restricted zones for foreign economic activity in China were established over a century and a half ago, notably in Hong Kong Island, which is now a re-incorporated economic engine of South China. In the post 1984 period as a continuation of this tradition, the government declared several 'open coastal cities' for foreign and joint ventures of various kinds. These include Economic and Technological Development Zones (ETDZ) Free Trade Zones, which primarily feature tax-free, bonded warehousing, expedited and less expensive import/export of parts and products.

Several ETDZs were created in 1984 to extend the spatial extent of preferred development areas and focus foreign investment in particular sites. In 1985 the Shehzhen Science and Technology Industrial Park was founded by Shehzhen Municipal Government and CAS. This marked the first spatially delineated attempt to lure foreign investment for Chinese high technology development in a spatially developed area. This was first set up as an extension of the TORCH programme.

Spatially designated S&T industrial parks are the incubators for nurturing companies in favoured high technology sectors that can accelerate China's development. This idea of incubators was also encouraged by the 'Decision on Reforms of the Science and Technology System' promulgated in 1985 led to a better financial support, more autonomy and a stronger focus on promoting economic links for research institutions. By increasing marketization of research output, the government sought to make scientists more responsive to commercial needs for products that could realize profits.

National-level Science and Technology Industrial Parks (STIPs) represent a further refinement of this notion. They seek to take advantage of the short-distance 'spillover effect' of technology by locating close to a university of research site. In addition, various levels of government and private entities sponsor a variety of other zones established to attract businesses to their locale without the official approval of the central government.

Several incubator types have evolved in China over the years. These include:

1. General hi-tech incubator centres,
2. Specialist hi-tech incubator centres (medical, new materials etc.),
3. University science parks,
4. Industrial parks for entrepreneurs returning from work or study overseas,
5. International incubator centres—to encourage foreign SMEs and Research institution to establish themselves in China, and
6. Spin-offs incubator centres. [10]

Incentives

Regulation and incentives are the two main aspects of China's industrial policy, with respect to foreign investment in hi-technology enterprises.[8] The governments, at central and regional levels, have extended various incentives aiming at enterprises and also individuals. These include: Value-added tax - Refund beyond a percentage; Enterprise Income tax - Two years exemption; Custom duty and import circulation tax—depending on the investment and R&D and technology and; Export permits and depreciation.

Apart from policy to encourage capital and technology intensive industries and export oriented industry in east China, the government has also measures to encourage such activities in central and West China. Some of these are:

Special projects - where central and west China has advantage; Projects relating to restricted categories of investment and restrictions on foreign share holding; Ancillary loans; Tax incentives; Import duty exemption and; Exemptions (up to 50%) on the individual income tax payment to foreigners.

Encouraging foreign-invested enterprises to develop new technology and establish operational HR in China.

After China's accession to WTO, there has been more emphasis on developing international collaboration. Various incentives provided include exemptions, in varying proportions on enterprise income tax; import duty and import circulation tax; VAT and; business tax

Chinese government also allows foreign R&D centres to participate in national S&T projects, and foreign R&D institutions are permitted to acquire Chinese R&D institutions that have been converted to business enterprise status.

Similar other liberal policies are adopted to facilitate smooth-functioning of such ventures by the foreign companies. Foreign research institutions are also allowed to undertake various forms of collaboration with research institutions, universities, colleges and business enterprises. They are also allowed to make their laboratories, research centres and testing facilities available to the general public for a fee.

There are also incentives, mainly in the form of tax concessions, for the establishment of regional headquarters and also for establishing logistics centres in China.

There are national awards instituted by the governments at different levels such as, Technology progress award; Natural Science award; Star award, to encourage innovation

S&T personnel are allowed to hold more than one job, apply for early retirement and to take sabbaticals.

This is to encourage scientists to venture into commercial technology enterprises collectively owned.

Towards the innovation driven nation

In January 2006, China's State Council adopted the Medium-and Long-term Strategic Plan for the Development of Science and Technology (2006-20) (MLP) and Improving Indigenous Innovation Capability was adopted by the Central Committee (CCPCC) and the State Council. These two documents signify that China is adopting an innovation-driven development model. [8,20]

Under this strategy the country seeks leapfrogging in key scientific disciplines, make breakthroughs in key technologies and common technologies to meet urgent requirements for realizing sustained and co-ordinated economic and social development, and make arrangements for frontier technologies and basic research with a long-term perspective.

Unlike the earlier efforts this plan intends to economize on the material inputs, upgrading economic structure, and enhancement of endogenous innovation capability, protection of environment, balancing urban/rural development, job creation and improving social equality. The overall objectives to be realized by 2020 are as follows:

- Strong improvement in indigenous innovation capability,
- Improvement of the capability of S&T to promote economic and social development,
- Significant increase in the overall strength of basic science and frontier technology research,
- Achievement of a series of S&T results with significant global impact,
- Become a world S&T power by the middle of the 21st century.

These overall objectives are elaborated in specific goals for eight sectors: industry, agriculture, energy, pharmaceutical and medical, national defence R&D and, human resources. In addition, China aims to invest 2.5% of its GDP on R&D by 2020. S&T is projected to contribute 60% to economic development, the degree of reliance on foreign technology should drop to 30% and the international citations of Chinese-authored scientific publications should rank among the top five worldwide.

The plan defines 11 key research areas, 68 priority issues in these areas; 16 major special programmes; frontier technology programmes in eight key technology research areas; and 18 basic research topics. [8]

To implement the guidelines the plan proposes to reform the S&T system and construct a national innovation system with Chinese characteristics. The NIS itself, as it is conceptualized under the plan, divides it into four parts:

- Technology, in which enterprises are the main players,
- Knowledge, in which public research institutes collaborate with universities,
- National defence - where civil and defence sector work together, and
- Regional factors - where the local factors come into operation.

MLP addresses China's weak record of firm-level innovation in commercial technologies that affect solutions to China' fundamental development needs. The plan also calls for 'leap froging' to research frontiers in key science disciplines, such as biotech and nanotechnology. MLP proposes to bring Chinese current technology dependence of 50% to 30% (or less) by 2020. Sustained economic growth, China government thinks requires establishing proper balance between domestic innovations and imported technology. Build an innovative country by endogenous innovation with China's characteristics.

Thus, the country's national innovation system is conceived as a social system where government is in a guiding position; the market plays a fundamental role in developing resources; and various actors of the innovation system interlink high up and network effectively. Such an NIS, the plan recognizes, would have a knowledge creation system—combining higher education, R&D centres based on collaboration, mobility and competition.

With efforts in S&T innovation over the last three decades Chinese policy makers now understand that innovation cannot be imported, it has to be encouraged. It cannot be driven from top down. China is now using incentives as a drive to encourage innovation.

Currently China is a major S&T player in terms of inputs to innovation. It has increased R&D spending 10% every year over the last decade. China's share in the world R&D spending is 12.3% in 2010 and that of the U.S.34.4%. The country's R&D investment is second only to that of the USA. China's innovation system, however, looks smaller when considered from the output side, but relative indicators are growing much faster.

A significant trend is that 60% of the new R&D investment is coming from industry and not government.

Overseas MNCs in R&D China, which are estimated to be around 1500, account for seven percent of Chinese R&D spend.

China's national goal is to become an innovation led country by 2020. The country's strategy in technology management has been to Invite foreign organization with IP in select technologies; Facilitating the process of transferring those technologies to Chinese; Inviting foreign experts in areas of interest to China to government organizational conferences and using the forum to exchange latest scientific knowledge, and Using innovation parks to incubate entrepreneurial companies. China has also been focusing in investment and R&D in areas of its interest in emerging high tech industry.

Moving away from the pre-reforms era approach, China has made its universities the main stay of the industry-science relationships. In addition, universities, learning from the experiences of other countries such as Israel and the USA, run a number of their own S&T companies. The universities are active in all areas of technology diffusion and commercialization. There are university S&T parks and incubators, they have registered a steep increase in patenting activities, and universities have collaboration with business sector and have also made provision for venture capital.

Going along with this, china's expenditure on education for creating manpower resources in S&T has tripled from 1998, number of colleges doubled and number of students quadrupled from 1 m. in 1997 to 5.5 in 2007. China's domestic S&T doctorate awards have increased more than ten-fold over the period, to about 21,000 in 2006. This is almost as many as are awarded in the USA annually.

China has implemented a large number of programmes. While number of programmes is large, some are similer and their focus is not always clearly defined and sufficiently differentiated. These programmes are funded by different sources, such as central and local government, bank loans, enterprise funds, overseas funds. While the central government provided the bulk of funding for 973 and 863 programmes, Local government, enterprises and bank credits have provided funding for Torch and Spark programmes. Complexity of these funding structure and corresponding lack of clarity may be confusing to the users of this programme.[8]

Recent patenting Trends

With the change of stance by the reforming government, after decades of withdrawal from the mainstream science, innovation and patenting has come about as a tsunami of sorts. Thanks also to cash incentives at various levels - city council, state and central - for successful patents. Now Chinese file more patents than any other country in the world. This, for a country, which had no 'notion' of IPRs even as late as 1980.[14,15,16,17,18]

China has relatively higher levels of technological competitiveness in medicine, drugs and chemicals going by its share of patents. The country is also strong in food products; medicines; (Chinese herbal medicine); Inorganic chemicals/fertilizers; biotechnology; metallurgy; engineering/construction, mining; weapons/explosives. In some of the mobile communication protocols Chinese standards (TD-SCDMA) are now accepted as international standards.

Domestic patent applications from locals have increased considerably compared to that of foreign applications since 2003. In 2009 Chinese nationals applied for 90% of these patents. Twenty-six percent of local applications are invention patents. Utility models patents, which is awarded relatively easily by their patent office has played an important role in fostering innovation culture. As per the WIPO data, even at the company level, Huawei, with 42,623 PCT applications, is the second largest applicant for IPRs around the world. However, China's worldwide stock of global intellectual property remains low. The country owns only two percent (134,000) of the world's total patents (WIPO). 95% of the China owned patents are within China. [30]

China's innovation and technology strategy aims to construct an enterprise centred national innovation system. The plan reflects the importance of collaboration and alliances with leading foreign companies to gain access to the latest technologies. To this effect the country has moved several laws which make patenting the outcome of local R&D investment within China mandatory. The MNCs are also expected to hire Chinese manpower in the process. These, and other trends have brought about a sea change in the country's outlook and confidence in innovation. A recent INTEL-Newsweek study found that 63% of Chinese respondents believe that China to overtake the USA in technology, innovation in next 30 years. As per the same survey only 33% of Americans think that the USA would lead the table during the next 30 years.[19,21,22,23,24,26,27,28]

There is, however, a basic difference in general perception of what is innovation. Chinese emphasize of productivity, efficiency and creative problem solving. Americans and Europeans tend to think innovation in technological terms, as to the fruits of innovation. [25]

Innovation in China

China's tremendous all round growth and its economic prowess is in the news over the recent years. During the 2001-10 period the country's GDP has more than tripled [Table 1] and so is its GDP (PPP) per capita growing from US$ 2,372 to US$ 6,845. The widespread ramification of this growth is also seen in its S&T.

Table 1 **Key economic figures for China**

GDP (PPP) Estimates; US$ billions at purchasing power parity									
2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
3334.18	3665.96	4119.47	4664.06	5364.25	6242.14	7338.18	8217.83	9137.49	10169.52
GDP (PPP) per capita US$ per capita at purchasing power parity									
2372.14	2612.44	2853.93	3187.78	3588.07	4102.49	4748.75	5553.80	6188.03	6845.89

Source: https://www.worldcompetitiveness.com/OnLine/App/Index.htm

Table 2 Key R&D Expenditure Figures

2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Total expenditure on R&D Percentage of GDP									
0.95	1.07	1.13	1.23	1.32	1.39	1.40	1.47	1.70	1.77
Total R&D expenditure (US $ million)									
12595.14	15556.36	18600.86	23756.76	29898.41	37662.55	48770.61	66430.12	84932.61	104317.57
Total expenditure on R&D per capita US$ per capita									
8.54	9.87	12.11	14.39	18.28	22.87	28.65	36.91	50.02	63.63
Business expenditure on R&D US$ millions									
7611.82	9517.94	11601.25	15875.34	20426.51	26770.63	35253.76	48666.97	62192.08	76592.23
Total R&D personnel in business per capita full-time work equivalent (FTE 000) people									
480.80	532.10	601.30	656.10	696.84	883.13	987.83	1186.75	1395.90	1647.00

Source: https://www.worldcompetitiveness.com/OnLine/App/Index.htm

China has been taking great strides on the R&D investment, which has grown from US$ 8.54 per capita in 2001 to US$ 63.63 in 2010. It has also registered a steady growth in the expenditure on R&D as percent of their GDP. Annual business expenditure on R&D has grown ten-fold in the ten-year period. Interestingly the number of R&D personnel has also grown four-fold during the same period. In fact, Chinese R&D spending has increased at an annual rate of 19% since 1995*. However, on all these counts China is far behind some of the other countries, and at the same time ahead of India.

Patents Assigned to China:

Overall Growth:

China has registered a steep increase in its US patent productivity in recent time. The country was almost along with India in the number of patents even as late as 2003. In the last ten years the US patents assigned to it has increased over twelve times (Table 3). This is by any account a remarkable progress.

The country has kept up the pace even beyond 2010 and the growth has been phenomenal. This analysis examines the nuances of this growth in terms of its assignee and subject components. It tries to understand the strategy adopted by the country, as it manifests in the US patents that are obtained. Cumulative Annual Growth Rate (CAGR) of US Patents is 45.07%. The decadal output of patents from 1991-2000 was 414 in all for the country, and it had grown from a mere 28 in the year 1991 to 95 in 2000.

+Table 3 **US patents growth**

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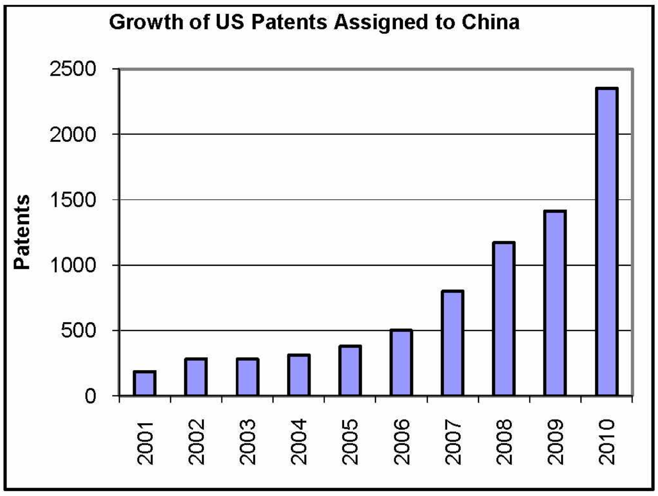
US Patents Assigned	
2001	186
2002	283
2003	282
2004	311
2005	379
2006	503
2007	800
2008	1171
2009	1414
2010	2350



Assignee Affiliation

Assignee of a patent owns the right to invention. Assignees also show the innovator affiliation. Table 4 presents the distribution of assignees on their broad category of affiliation. Four affiliations were considered for tabulation - research institutions, universities, industries, and others. The fourth category included mainly individual assignees, and those that did not fall in the other three.

The data shows a distinct trend of industrial enterprises dominating the patenting activity in China. They make up 90% of the total patents granted to China by the USPTO during the decade, reflecting a closer integration of R&D and the industrial economy. This trend seems to be a direct outcome of the economic reforms, which articulates for such a transition of S&T [31]. The country's research institutions and universities have also registered a steady growth of patents in numerical terms, though as a proportion to total they have crossed double digits only two years during the period considered in this study. Also to be noted is the significant increase of patents by universities after 2008. Universities' patent growth during this short span is twenty-fold, staring with a mere 12 in 2001 to 254 in 2010. Annual patents growth by research institutions have increased four-fold during the 2001-10 period. The trend is indicative of an all round growth in innovation activities.

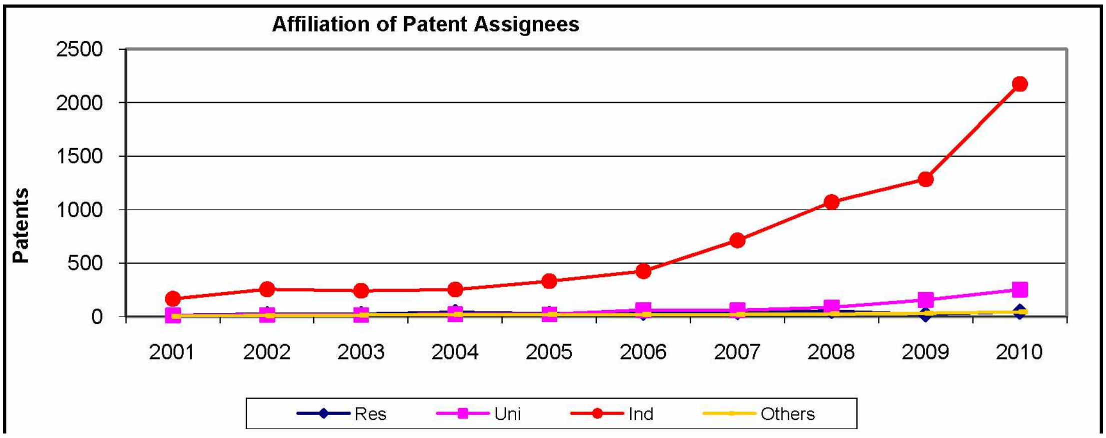
The major patent holders in China are the following:

- Hong Fu Jim Precision Ind. (Shenzhen) Co., Ltd. (Shenzhen, CN) 301 patents
- Fu Zhun Precision Ind (Shenzhen) Co., Ltd. (Shenzhen, CN) 156
- Beifa Group Co., Ltd. (Ningbo, CN) 115
- Huawei Technologies Co. Ltd. (Shen Zen, CN)A 105
- Tsing Hua University (Beijing, CN) 100
- China Petro - Chemical Corporation (Beijing, CN) 88
- SAE Magentics, (H.K.) Ltd. (Hong Kong, CN) 86
- Shenzhen Futaihong Precision Ind. Co., Ltd. (Shenzhen, CN) 65
- Sutech Trading Lilmited (Road Town, Tortola, VG) 63
- Semiconductor Manufactoring International (Shanghai) Corporation (Shanghai, CN) 62
- Positec Power Tools (Suzhoo) Co., Ltd. (Jiangsu Province, CN) 54
- Dong Guan Bright Yin Huey Lighting Co., Ltd. (Guan Dong, CN) 46
- Ningbo Beifa Group Co., Ltd. (Ningbo, CN) 34
- Nanjing Chervon Industry Co., LTD (CN) 33
- The University of Hong Kong (CN) 31
- Zhejiang Lover Health Science and Technology Development Co., Ltd (Zhejiang Province, CN) 30
- C. C. & L Company Limited (Hong Kong, CN) 29
- Headway Technologies Inc. (Milpitas, CA) 29
- Innocom Technology (Shenzhen) Co., Ltd. (Shenzhen, Guangdong Province, CN) 27
- HCT Limited (Hong Kong, CN) 26
- Beijing Reasearch Institute of Chemical Industry (Beijing, CN) 24
- Chervon International Trading Co. (Nanjing, CN) 23
- Research Institute of Petroleum Processing (Beijing, CN) 23
- Grace Semicoductor Manufacturing Corporation (Shanghai, CN) 21
- Nuctech Company Limited (Beijing, CN) 21

Table 4 Distribution of Assignees on Affiliation

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Res. Inst.	12	25	24	43	27	36	43	53	21	47	331
%	(6.5)	(8.8)	(8.5)	(13.8)	(7.1)	(7.2)	(5.4)	(4.5)	(1.5)	(2.0)	(4.3)
Universities	12	16	16	24	22	63	60	87	156	254	710
%	(6.5)	(5.7)	(5.7)	(7.7)	(5.8)	(12.5)	(7.5)	(7.4)	(11.0)	(10.8)	(9.2)
Industry	167	256	242	254	331	426	713	1071	1285	2175	6920
%	(89.8)	(90.5)	(85.8)	(81.7)	(87.3)	(84.7)	(89.1)	(91.5)	(90.9)	(92.6)	(90.1)
Others	5	11	16	19	22	22	21	26	32	46	220
%	(2.7)	(3.9)	(5.7)	(6.1)	(5.8)	(4.4)	(2.6)	(2.2)	(2.3)	(2.0)	(2.9)
Total	186	283	282	311	379	503	800	1171	1414	2350	7679

Figures do not tally as the patents could have assignees from more than one affiliation



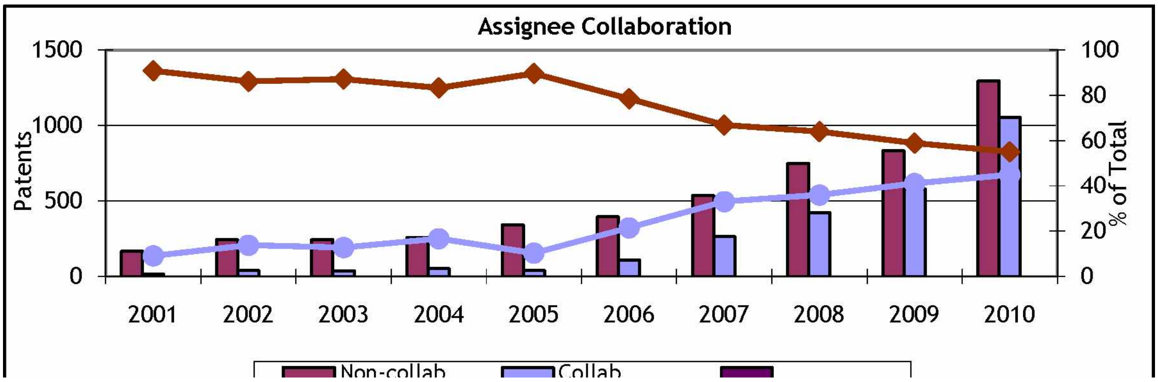
There are as many as 25 entities that have over 20 patents during 2001-10 period for China. In the Chinese top list are two universities (Tsing Hua University (Beijing) 100 and The University of Hong Kong 31) and two research institutions (Beijing Research Institute of Chemical Industry, 24) and Research Institute of Petroleum Processing (Beijing, 23). The industry, however, dominate the scene. On the very face, the list is indicative of broad base of innovation activities of various hues in China.

Assignee Collaboration

Importance of collaboration by institutions engaging in R&D and benefits accruing through such a technology management strategy cannot be over emphasized. Trends in such collaboration are presented in Table 5. Ownership of Chinese patents is increasingly outcome of collaborative R&D investment and it has moved from 9.1% (17) in 2001 to 44.9% (1055) in 2010. The trend of gradual decrease of non-collaborative innovation and the increase of the other, as a proportion of the total, point to a definite strategy for optimal utilization of R&D investment and efforts. This trend could also be seen as innovation moving from simple to complex technologies. However, non-collaborative patents have also increased considerably during the decade from 169 (2001) to 1295 (2010).

+Table 5 - Assignee collaboration

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Non-collab. %	169 (90.9)	244 (86.2)	246 (87.2)	259 (83.3)	340 (89.7)	395 (78.5)	535 (66.9)	750 (64.0)	833 (58.9)	1295 (55.1)	5066 (66.0)
Collaborative %	17 (9.1)	39 (13.8)	36 (12.8)	52 (16.7)	39 (10.3)	108 (21.5)	265 (33.1)	421 (36.0)	581 (41.1)	1055 (44.9)	2613 (34.0)



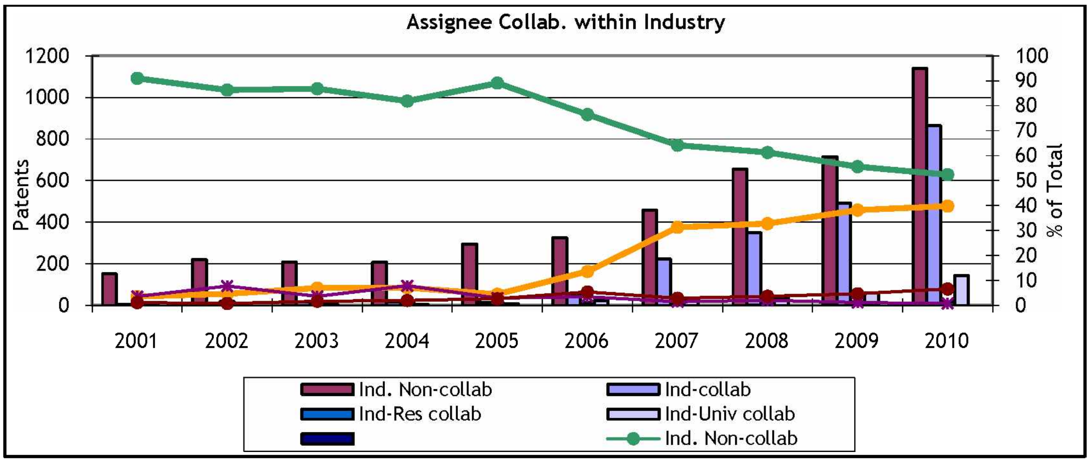
Collaborative patenting among industries:

The next issue addressed is the nature of patenting and collaboration within the industry sector. As we have noticed 90% of the US patents are obtained by this sector during the decade. China seems to be progressing increasingly towards collaborative patents, even in case of industry. Patenting as manifested in collaborative R&D has moved from 3.6% of the total (6) in 2001 to 39.8% (865) in 2010. The spurt has been particularly noticeable during 2007 to 2010, when both industry patents and the collaborative ones in that category have taken a quantum jump (Table 6). However, though the move is towards collaborative innovation, still the majority of patents taken by industry continue to be by firms as sole assignees. Among the collaborations, industry-university and industry-research institutions have also shown a modest move in the right direction - not as a proportion to the total, but in terms of absolute numbers. Between the two, collaboration of industry with universities is significantly more than the research institutions. This could be a reflection of policies which have brought in new talent to the universities from abroad, as opposed to the research establishments which underwent a major overhaul, and still maintain the local researchers.

Table 6 Distribution of Assignees within Industries

	Industry (Non-collab.) %	Industry (Collab.) %	Industry-Res. Inst Collab. %	Ind.Univ. Collab %	Total
2001	152 (91.0)	6 (3.6)	6 (3.6)	2 (1.2)	167
2002	221 (86.3)	12 (4.7)	20 (7.8)	2 (0.8)	256
2003	210 (86.8)	17 (7.0)	9 (3.7)	4 (1.7)	242
2004	208 (81.9)	18 (7.1)	20 (7.9)	5 (2.0)	254
2005	295 (89.1)	15 (4.5)	10 (3.0)	9 (2.7)	331
2006	326 (76.5)	58 (13.6)	15 (3.5)	23 (5.4)	426
2007	458	223	11	21	713

	(64.2)	(31.3)	(1.5)	(2.9)	
2008	656 (61.3)	351 (32.8)	22 (2.1)	40 (3.7)	1071
2009	715 (55.6)	491 (38.2)	16 (1.2)	61 (4.7)	1285
2010	1140 (52.4)	865 (39.8)	18 (0.8)	143 (6.6)	2175
	4381 (63.3)	2056 (29.7)	147 (2.1)	310 (4.5)	6920



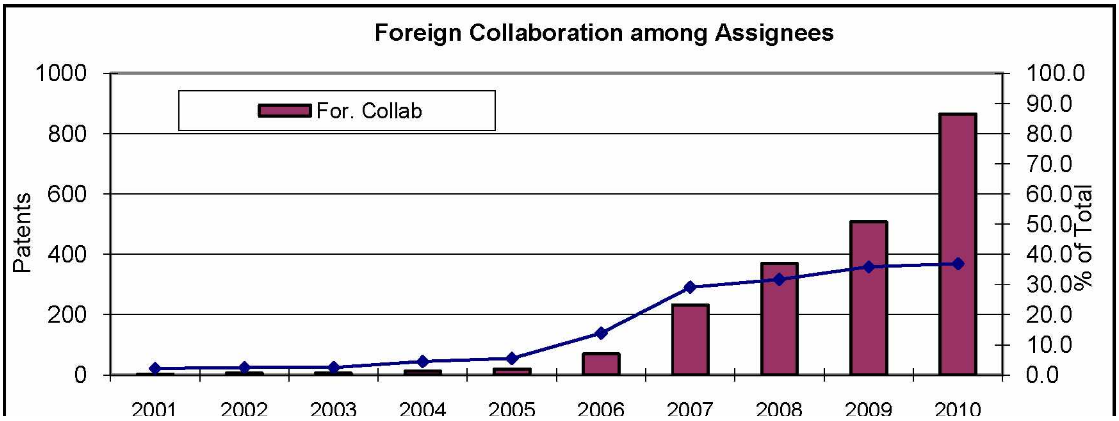
Foreign Collaboration

China also seems to have benefited from international collaboration in innovation (Table 7). Starting with a mere 2.2% (4 patents) of the total in 2001, these figures have risen to 36.9%(866 patents) in 2010. As was the case in overall collaboration, these figures have registered a spurt in the post 2006. On the whole this trend is a reflection of the confidence shown by the foreign industrial firms in Chinese investment in innovation activities. This is also to be seen as a strategy to learn ways of innovation and patenting from the foreign manufacturers. The countries that figure on the top of the list are Taiwan, the US and the UK.

Foreign collaboration in itself may not be an indicator of any significance, if the technology being patented is not a cutting edge one or in the high technology field. However, such collaboration, whenever noticed, indicates the strategy of individual firm's interest in sharing of technologies and expertise. Also, such collaborations facilitate enhancing the IPR presence and the positive fallout of networking.

Table 7 Foreign Collaboration Among Assignees

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Foreign Collab	4 (2.2)	7 (2.5)	7 (2.5)	14 (4.5)	21 (5.5)	70 (13.9)	233 (29.1)	371 (31.7)	508 (35.9)	866 (36.9)	2101 (27.4)



As to the universities and research institutions which have been granted patents - largely the trend has been to 'go alone' (Table 8). Inter institutional collaboration, be it between more than one research institutions; more than one university or research institution and university, is negligible. In actual numbers it is below five in any of these categories.

+Table 8 - **Assignee collaboration within academic bodies**

	Res. Inst total	Ind-res. Inst. [collab.]	Res. Inst. [Solo]	Res. Inst. [Collab]	Res. Inst Univ [collab.]	Univ Total	Ind -univ [collab.]	Univ (Solo)	Univ- [Collab]	Total US Patents
2001	12	6	5	0	1	12	2	9	0	167
2002	25	20	4	0	1	16	2	12	0	256
2003	24	9	14	0	1	16	4	11	0	242
2004	43	20	21	1	1	24	5	17	1	254
2005	27	10	15	0	1	22	9	12	0	331
2006	36	15	18	2	1	63	23	36	1	426
2007	43	11	24	3	5	60	21	34	0	713
2008	53	22	28	1	2	87	40	43	0	1071
2009	21	16	5	0	0	156	61	88	4	1285
2010	47	18	27	0	1	254	143	105	4	2175
Total	331 (4.78)	147 (2.12)	161 (2.33)	7 (0.10)	14 (0.20)	710 (10.26)	310 (4.48)	367 (5.30)	10 (0.14)	6920 (4.78)

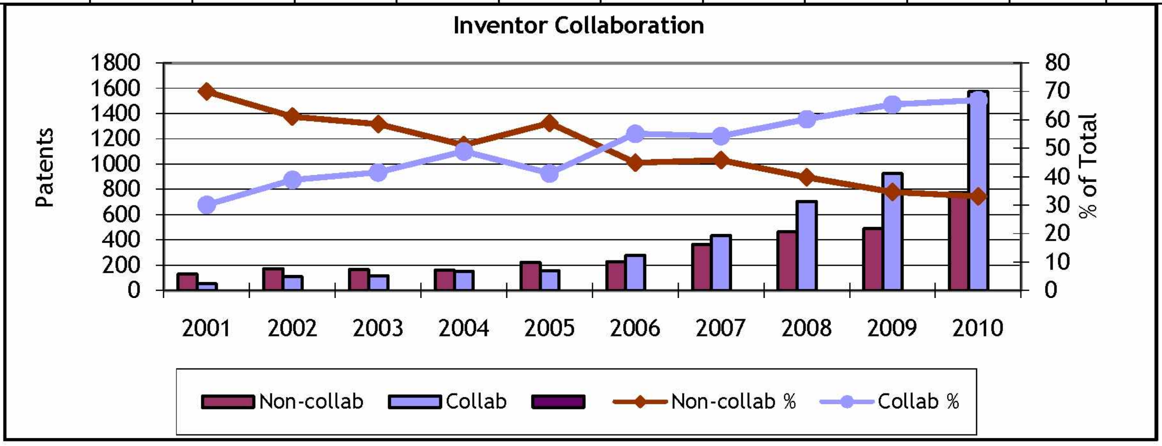
Inventor Collaboration

It is interesting to see the collaboration among the inventors who have actually carried out the R&D that resulted in these patents and their country affiliation (Table 9). Sole inventor patents dominated in the first half of the decade. This trend has corrected itself during the second half. The correction is gradual and seems to be happening for sure. It has changed from an overall proportion of 70:30 - seventy being sole inventor - in 2001 to

33:67 - Sixty-seven in the latter case being collaborative - with more than one inventor - by 2010. But on the whole, over the ten-year period, 41% of the patents in China had sole inventor and 38% of them evolved out of a joint effort by two or three inventors, and the remaining with bigger teams (Table 10).

Table 9 - **Inventor collaboration**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Non-collab %	130 (69.9)	173 (61.1)	165 (58.5)	159 (51.1)	223 (58.8)	226 (44.9)	366 (45.8)	466 (39.8)	489 (34.6)	777 (33.1)	3174 (41.3)
Collab %	56 (30.1)	110 (38.9)	117 (41.5)	152 (48.9)	156 (41.2)	277 (55.1)	434 (54.3)	705 (60.2)	925 (65.4)	1573 (66.9)	4505 (58.7)



China has a large number of sole inventor patents, both in terms of proportion to the total and in actual numbers. Sole inventor patents are perhaps a good strategy to create a ground swell of inventions for the country. The growth of inventor base may lead to more people taking interest in IPR activities and work on patentable technologies. Collaborative efforts may, on the other hand, indicate relatively higher level of problem solving.

+Table 10 - **Inventor team size**

No of Inventors	**1**	**2**	**3**	**4**	**5**	**6>**
US Patents %	3174 (41.3)	1699 (22.1)	1228 (16.0)	730 (9.5)	371 (4.8)	486 (6.3)

An interesting piece of data that comes along with this is the number of distinct inventors. An inventor may have participated in one or more patented inventions. China had 10,125 such distinct inventors with at least one US patent (or part thereof, if it is a case of patents with more than one inventor) to his/her credit during the 2001-2010 period. Those who have participated in only one invention, either as sole invention or in a team, is as high as 89% in China. Many of these could be new patent holders, and given the due assistance could be more productive on this front. Per capita patents for this inventor base work out to be 0.76.

Table 11 Growth in Inventor Pool

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
No of new Inventors	259	425	431	539	454	789	1102	1424	1790	2912	10125
Year on Year increase		164.09	101.41	125.06	84.23	173.79	139.67	129.22	125.70	162.68	133.98

Cumulative Annual Growth Rate (CAGR) : 44.28%

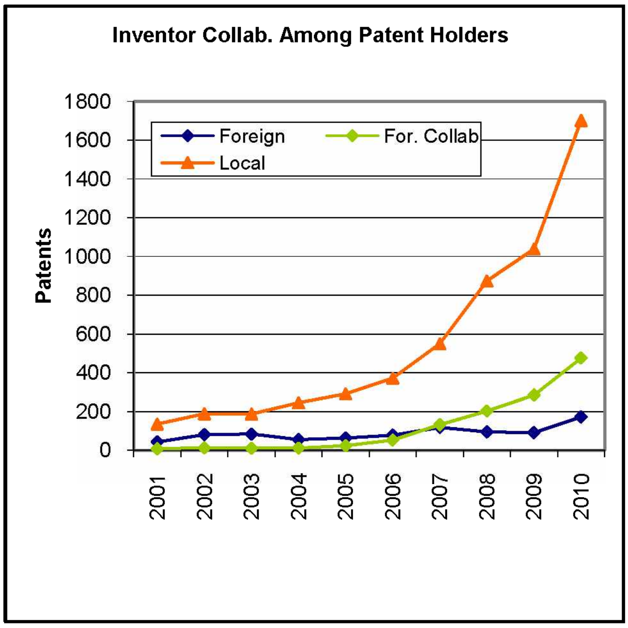
Data was analyzed further to examine whether the pool of inventors is growing with new additions on a regular basis. Chinese inventor base has grown at a CAGR of 44.28% during the decade. The new additions to the inventor pool have ranged from 164.1% in 2002 to 162.7% in 2010, on an year on year basis (Table 11). This is remarkable as the growth has been consistent and has over taken Israel - examined as a part of this study.

Outsourced Innovations

It is known that the patents assigned to institution/industry of a given country need not have been researched on within its own geographical territory. There are always instances of innovations outsourced or carried out by personnel from elsewhere. It is also true that when the innovators collaborate, it could be with other innovator(s) from within or outside the country. Such an analysis of the patents granted to China show that 11.5% (881) of the patents were invented by non-Chinese - invention carried out completely by non-Chinese inventor over the 2001-10 period (Table 12). On a year-wise analysis this figure shows a decline from 29% of the total in 2003 to around 7% in 2010. There is a definite decline in the proportion of invention completely outsourced to inventors from another country, though in actual numbers this has more or less remained the same. Interestingly there is a corresponding increase in foreign collaboration among the inventors in China. The latter has gone up from 4% (12) in 2001 to 20.3% (476) in 2010. A large majority of the collaborative innovation, however, is local and it is to the tune of 73% of the total over the decade. It has registered a gradual growth from 72.6% (135) to 73% (1702) from 2001 to 2010. On a year-wise analysis, though the proportion of end-to-end outsourced innovation has come down, in actual numbers it has not declined. In fact, it shows a significant spurt in 2010. Collaborative R&D work with inventors from abroad shows an upward spurt in the post 2006 period.

+Table 12 - Inventor origin

	Foreign %	For. Collab %	Local %	Total
2001	43 (23.1)	8 (4.3)	135 (72.6)	186
2002	81 (28.6)	13 (4.6)	189 (66.8)	283
2003	84 (29.8)	11 (3.9)	187 (66.3)	282
2004	55 (17.7)	11 (3.5)	245 (78.8)	311
2005	64 (16.9)	24 (6.3)	291 (76.8)	379
2006	78 (15.5)	53 (10.5)	372 (74.0)	503
2007	118 (14.8)	132 (16.5)	550 (68.8)	800
2008	95 (8.1)	202 (17.3)	874 (74.6)	1171
2009	91 (6.4)	285 (20.2)	1038 (73.4)	1414
2010	172 (7.3)	476 (20.3)	1702 (72.4)	2350
	881 (11.5)	1215 (15.8)	5583 (72.7)	7679

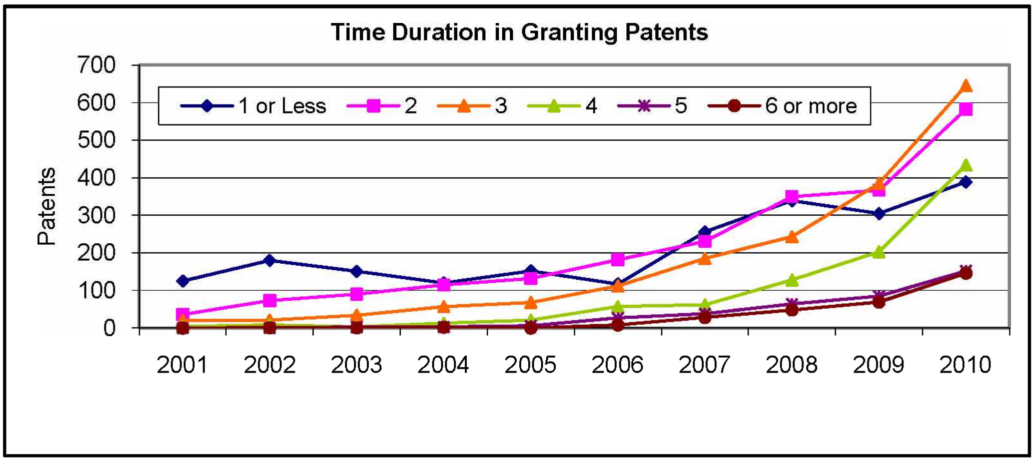


How soon are the patents granted?

China seems to have benefited from filing low technology patents and in this way probably ensuring a quick grant of the same. Table 13 shows that over the years China tends to have got the award sooner. During the ten years under analysis average time duration for grant of patent was a little over two years. This starkly contrasts with the average duration for other countries considered in the study. As could be seen verification of an ornamental design for prior art is easier than the technology content of the utility patents *per se*.

+Table 13 - **Time duration in granting patents**

	1 or Less	2	3	4	5	6 or more	Total
2001	125	36	21	4	0	0	186
2002	180	73	21	8	0	1	283
2003	151	90	34	3	3	1	282
2004	120	115	57	13	3	2	310
2005	152	132	68	21	6	0	379
2006	117	182	112	57	27	8	503
2007	256	231	185	62	38	28	800
2008	339	350	243	128	64	48	1172
2009	305	367	385	203	85	69	1414
2010	389	583	646	434	152	146	2350
	2134	2159	1772	933	378	303	7679



Technology level classification

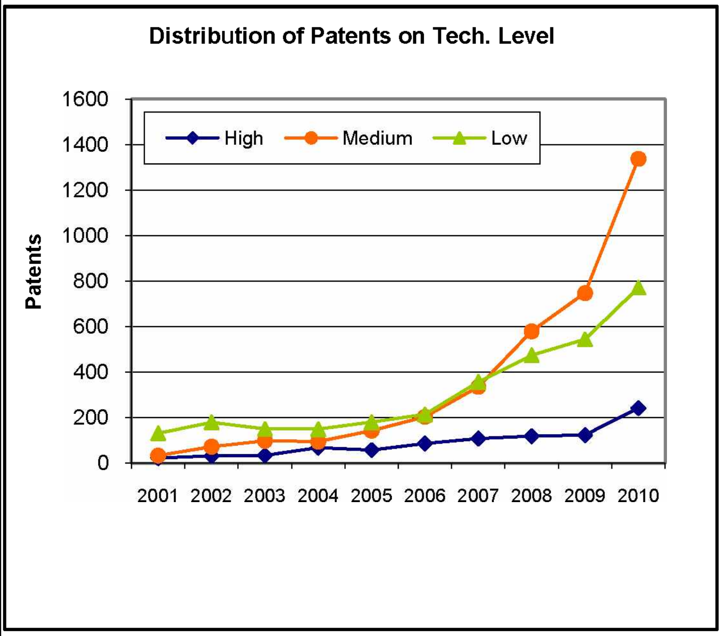
Data show that on the whole 11.6% (890) of the Chinese patents could be classed as high technologies; 47% (3640) as medium, and 41% (3149) as low (Table 14). China's high technology patents are mainly in drugs and pharmaceuticals, semi-conducting devices, biotechnology, organic and in-organic chemical processes. Medium technologies include a wide variety of electrical instruments and the low technology patents are mostly soft patents, in the nature of ornamental designs.

A closer look at the annual trends reveal that Chinese high tech patenting is on a gradual rise from 22 patents in 2001 to 242 in 2010, all along registering an increase.

Chinese medium technology patents have risen from 38 (17%) in 2001 to 1337 (57%) in 2010. The corresponding figures for low technology ones are 131 (70.2%) in 2001 to 771 (33%) in 2010. There is a definite increase in medium technologies and a decline in the proportion of low technologies to the total. As a matter of corollary interest, China has overtaken Israel in medium technology patents in 2008 and technologies at this level have been a source of growth in their IPR. The actual difference in the patent performance of China and India seem to lie in medium and low technologies.

+Table 14 - **Distribution of patents on Technology Levels**

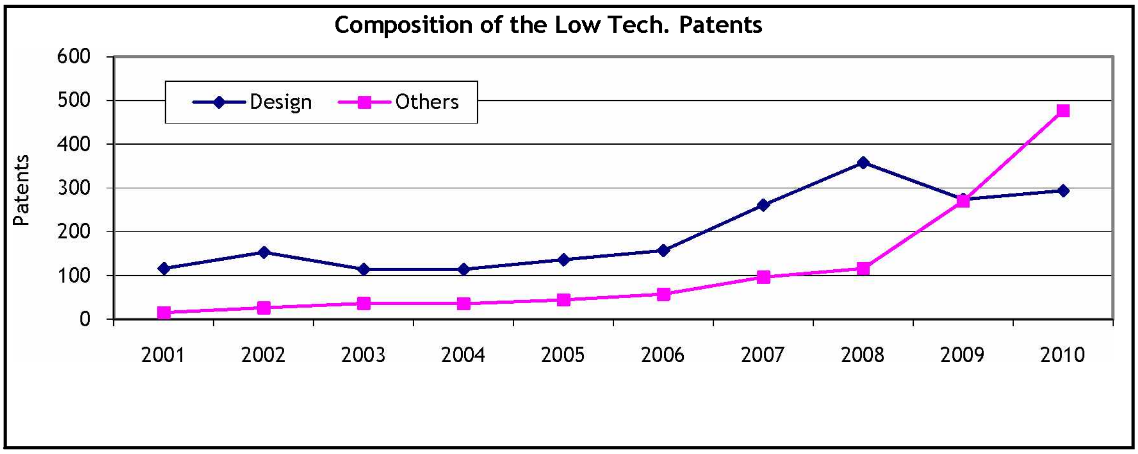
	High %	Medium %	Low %	
2001	22 (11.8)	33 (17.7)	131 (70.4)	186
2002	32 (11.3)	72 (25.4)	179 (63.3)	283
2003	34 (12.1)	98 (34.8)	150 (53.2)	282
2004	68 (21.9)	94 (30.2)	149 (47.9)	311
2005	57 (15.0)	142 (37.5)	180 (47.5)	379
2006	86 (17.1)	203 (40.4)	214 (42.5)	503
2007	108 (13.5)	335 (41.9)	357 (44.6)	800
2008	118 (10.1)	579 (49.4)	474 (40.5)	1171
2009	123 (8.7)	747 (52.8)	544 (38.5)	1414
2010	242 (10.3)	1337 (56.9)	771 (32.8)	2350
	890 (11.6)	3640 (47.4)	3149 (41.0)	7679



Over 63% of the low technology patents taken by Chinese are ornamental designs (Table 15), and the rest are minor modifications of other commonly used products. Out of these, the design patents on office supplies, artists' and teachers' materials make up (25.38%), lighting fixtures (20.93%), tools and hardware (10%), recording, communication & retrieval equipment (8.3%), electricity; electrical systems (6.5%), medical and laboratory equipment (5.81%), transportation, furnishings (3.48%), Machines (2.9%) make up most of the others. The remaining patents are in the nature of crayon sharpener, template for cover design, jar openers, vacuum cleaners, additives, inhalers, combing devices, etc.

+Table 15 Low technology patents

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Design patents	116 (88.5)	153 (85.5)	114 (76.0)	114 (76.5)	136 (75.6)	157 (73.4)	261 (73.1)	358 (75.5)	274 (50.4)	294 (38.1)	1977 (62.8)
Others	15 (11.5)	26 (14.5)	36 (24.0)	35 (23.5)	44 (24.4)	57 (26.6)	96 (26.9)	116 (24.5)	270 (49.6)	477 (61.9)	1172 (37.2)
Total	131	179	150	149	180	214	357	474	544	771	3149



The innovator collaboration is more, and seems to be on a rise (50% in 2010) (Table 16), even among the low tech patents in China, and 14% of them for the period were completely outsourced to foreign inventors. The foreign collaboration of local inventors is also on a rise and this stood at 14% of the low technology patents for 2001-2010 period. Foreign collaboration is more often hands on ways of technology transfer used by China. Also, Chinese seem to work in teams and the same has benefited them in fructifying more innovations.

Table 16   Inventor Collaboration on Technology Levels

	Low			Medium			High		
	Collab	Single	Total	Collab	Single	Total	Collab	Single	Total
2001	21 (16.0)	110 (84.0)	131	18 (54.5)	15 (45.5)	33	17 (77.3)	5 (22.7)	22
2002	35 (19.6)	144 (80.4)	179	49 (68.1)	23 (31.9)	72	26 (81.3)	6 (18.8)	32
2003	37 (24.7)	113 (75.3)	150	53 (54.1)	45 (45.9)	98	27 (79.4)	7 (20.6)	34
2004	33 (22.1)	116 (77.9)	149	62 (66.0)	32 (34.0)	94	57 (83.8)	11 (16.2)	68
2005	23 (12.8)	157 (87.2)	180	86 (60.6)	56 (39.4)	142	47 (82.5)	10 (17.5)	57
2006	55 (25.7)	159 (74.3)	214	150 (73.9)	53 (26.1)	203	73 (84.9)	14 (16.3)	86

2007	86 (24.1)	271 (75.9)	357	264 (78.8)	71 (21.2)	335	84 (77.8)	24 (22.2)	108
2008	189 (39.9)	285 (60.1)	474	419 (72.4)	160 (27.6)	579	97 (82.2)	21 (17.8)	118
2009	286 (52.6)	258 (47.4)	544	539 (72.2)	208 (27.8)	747	100 (81.3)	23 (18.7)	123
2010	387 (50.2)	384 (49.8)	771	979 (73.2)	358 (26.8)	1337	207 (85.5)	35 (14.5)	242
	1152 (36.6)	1997 (63.4)	3149	2619 (72.0)	1021 (28.0)	3640	734 (82.5)	156 (17.5)	890

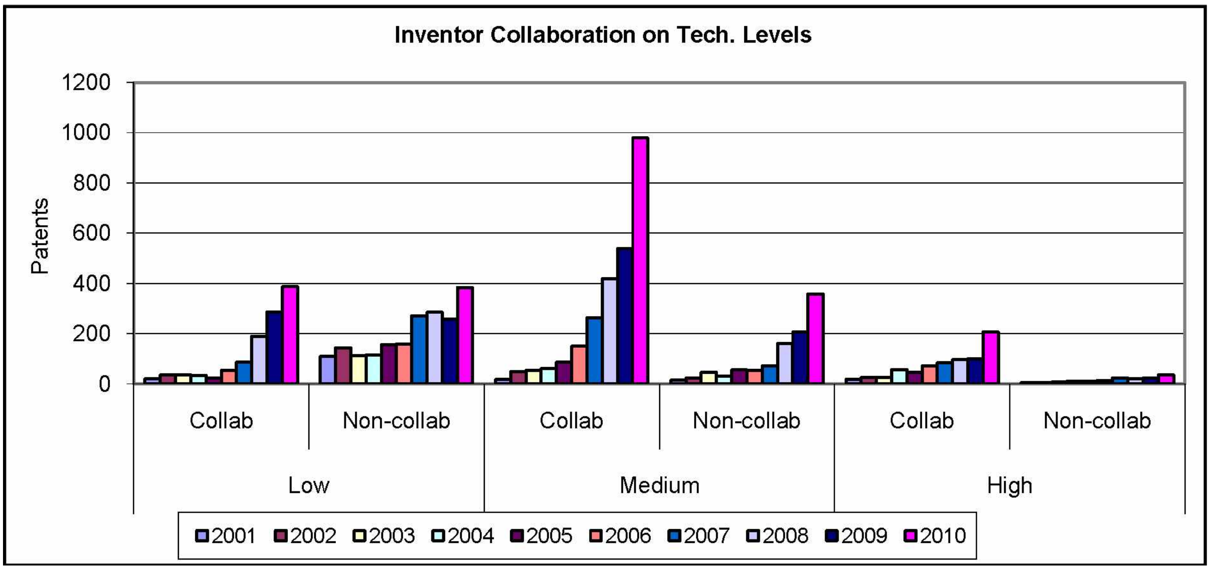
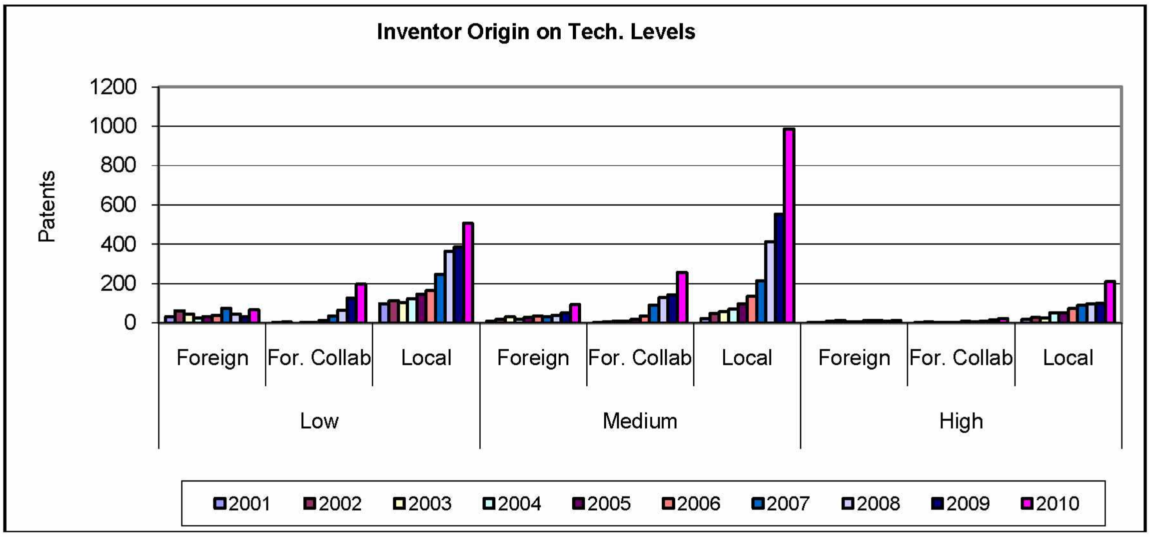


Table 17 Inventor Origin on Technology Levels												
	Low				Medium				High			
	Foreign %	For. Collab %	Local %	Total	Foreign %	For. Collab %	Local %	Total	Foreign %	For. Collab %	Local %	Total
2001	31 (23.7)	3 (2.3)	97 (74.0)	131	10 (30.3)	3 (9.1)	20 (60.6)	33	2 (9.1)	2 (9.1)	18 (81.8)	22
2002	62 (34.6)	4 (2.2)	113 (63.1)	179	18 (25.0)	5 (6.9)	49 (68.1)	72	1 (3.1)	4 (12.5)	27 (84.4)	32
2003	46 (30.7)	0 (0.0)	104 (69.3)	150	30 (30.6)	10 (10.2)	58 (59.2)	98	8 (23.5)	1 (2.9)	25 (73.5)	34
2004	25 (16.8)	1 (0.7)	123 (82.6)	149	17 (18.1)	7 (7.4)	70 (74.5)	94	13 (19.1)	3 (4.4)	52 (76.5)	68
2005	31 (17.2)	3 (1.7)	146 (81.1)	180	28 (19.7)	19 (13.4)	95 (66.9)	142	5 (8.8)	2 (3.5)	50 (87.7)	57
2006	38 (17.8)	12 (5.6)	164 (76.6)	214	34 (16.7)	34 (16.7)	135 (66.5)	203	6 (7.0)	7 (8.1)	73 (84.9)	86
2007	75 (21.0)	35 (9.8)	247 (69.2)	357	31 (9.3)	91 (27.2)	213 (63.6)	335	12 (11.1)	6 (5.6)	90 (83.3)	108

2008	45 (9.5)	64 (13.5)	365 (77.0)	474	37 (6.4)	129 (22.3)	413 (71.3)	579	13 (11.0)	9 (7.6)	96 (81.4)	118
2009	32 (5.9)	127 (23.3)	385 (70.8)	544	51 (6.8)	143 (19.1)	553 (74.0)	747	8 (6.5)	15 (12.2)	100 (81.3)	123
2010	68 (8.8)	197 (25.6)	506 (65.6)	771	93 (7.0)	257 (19.2)	987 (73.8)	1337	11 (4.5)	22 (9.1)	209 (86.4)	242
	453 (14.4)	446 (14.2)	2250 (71.5)	3149	349 (9.6)	698 (19.2)	2593 (71.2)	3640	79 (8.9)	71 (8.0)	740 (83.1)	890



Among the medium technology patents also Chinese inventors tend to collaborate. The trend shows a gradual increase in collaboration over the years going along with the increase in number of patents. In 2010, nearly 29% of these patents were a result of collaboration with the foreign inventors or exclusively by the foreign inventors themselves (Table 17). The corresponding figures for the decade also stand around the same. China has registered a sudden growth in patents of this group during the post 2006 period. This is also an outcome of increasing foreign collaboration in innovation in this category.

Interestingly figure on foreign collaboration is considerably less in high technology patents, and is 8% of the total patents obtained for the entire decade.

Local inventorship is relatively the highest in high technology patents at 83% of the total. Complete end-to-end foreign inventorship is noticeable even in high technology patents, though in actual numbers it is much less compared to low or medium technology patents (Table 17).

On the whole more low technology patents assigned to China during 2001-2010 had exclusive foreign inventors, followed by medium and high technology patents, in that order. Inventors are largely drawn from Taiwan, the US, and the UK. Chinese foreign collaboration, which is a trend noticed more recently, has drawn inventors mainly from Taiwan.

China has consistently exercised the technology choice in enhancing their patent count, by depending on the low technology innovations. The country has taken the route of rewarding successful inventors through prize money at various levels. It is reported that inventors are also rewarded with better housing, permanent resident status in cities, apart from monetary incentives at different levels.

Assignee Distribution on Patent Technology Levels

It is interesting to examine who owns the patents across various technology levels. The description below presents such an analysis.

Industry

High Technologies: Greater proportion of high technology patents have come from the industry sector during the decade. Among the patents within this category are over two dozen on nanotechnology, lab based R&D in organic and inorganic chemistry, including those relating to petroleum crude processing, separation, purification, etc. Over two-dozen patents fall under biotechnology, including those on polypeptides, protein structures, etc. These patents also include ones on drugs, biosensors and also several on semiconductors.

+Table 18 - Technology levels across major assignee types

Tech Level	Industry	Research Institutes	Universities	Others
Low	3040 (88.47)	17 (0.49)	283 (8.24)	96 (2.79)
Medium	3270 (83.72)	143 (3.66)	403 (10.32)	90 (2.30)
High	610 (72.71)	171 (20.38)	24 (2.86)	34 (4.05)

[Patent figures do not tally with other corresponding tables as some patents have more than one assignee falling in different categories.]

Medium Technologies: A wide variety of patents fall under this category, including those on electrical and mechanical systems, several instruments such as watch winding machine, voltage detecting equipment, USB port tester, etc. Several patents on methods of manufacturing thin film magnetic head, device for testing circuits, switching between high / low voltage, circuit for AC / DC converter, over 200 method and systems relating to one or the other tasks, like those for focusing images in a camera, validating printed circuit boards, quite a few on heat sink mechanism, exercise machine, electric tooth brush, satellite antenna, sharpener, etc. Most of these are improvements or different ways of accomplishing the said functions.

Low Technologies: Forty-one percent of the patents granted to China could be classified as low technology, and of these industry makes up 88%. Also, 63% of the low technology patents are design patents and almost all of these are ornamental designs. These designs include a large number of those on lamps, lampshades, light and candleholder etc. Pen and the related accessories (discussed elsewhere) has as many as 221 **patents**, highlighter (21), cosmetic case (33), computer cover (17), mounting apparatus (28), automotive wheel (27), chair (37) are some of the other ornamental designs of the products patented. These also include patents on egg slicer, bottle opener, condiment shaker, exit sign, garbage bin, ice cream scoop, nail clipper, salad grater, screwdriver box, snack box, toilet cover and even telescope, in varying numbers.

Research institutions

High Technology: Most prominent category of patents in this group are those dealing with organic and inorganic chemistry, including ones on cracking, alkalization, aromatization of petroleum products, etc. A large number of patents also deal with formation of metal complexes, organo-metallic compounds, metal halides, crystal growth metallurgy, hydrocarbon synthesis, polymerization, nano-crystallization etc. There are also a few patents on the pharmaceuticals and drugs. All these patents are outcome of research based studies.

Medium Technologies: Patents granted to China grouped under this head largely deal with -

- ✓ Communication signal processing, antenna equipment for transmission, allocation of channels, signal spreading, data transmission via various communication protocols.
- ✓ Ore extraction, forming processes and other processes in industrial chemistry.
- ✓ Mechanical and electro-mechanical devices.

Universities

High Technology: High technology patents by universities in China can be broadly classed into genetics/ pharmaceuticals, and electronics / communication. These include over two-dozen patents on nanotechnology, mainly those on method for manufacturing nanotube and other nanomaterials. Biotechnology patents including those on DNA encoding, protein binding, genetically modified plants, synthesis and hybridization, etc. There are also a few on drugs and pharmaceuticals, specifically dealing with SARS. Noticeable in this group of patents are also those dealing with neurological diseases, cancer cure and prosthetic devices.

Medium Technologies: Among the medium technologies patented are data transmission, signal processing, noise reduction, coaxial cable design, mobile technologies, electronic lighter, equipment relating to measuring chemical properties, electrical currents, high temperature, elastic properties, pressure gauge, etc. There are a number of patents relating to optical devices such as optical sensors, multiple use of lenses, LEDs, and tools for illuminating crystal structures, etc. There are also a few product patents such as radiation equipment, ion-pumping sources. The patents, though emanating from University science departments, do not focus on patentable aspects in basic sciences.

The low technology patents from both research institutions and universities are fewer in number.

Subject classification based on USPC

The analysis also explored the patents based on the USPTO classification (USPC) to understand the subject spread. Chinese patents for the years studied fell under more than 359 distinct main classes of the US patent classification (Table 19). Of these 31 were design classes and the rest were in utility section. These numbers are an indicator of the spread of innovation across a wide variety of topics. Some of these classes, among those patented by China, include: electrical system and devices (375) multiplex communication (225), textiles including fiber preparation and cloth finishing, bleaching and dyeing (503), heat exchange(58), transportation (72), buckles, buttons, clasps (121), drugs (67), textile ironing and smoothing and such others. The patents are mainly consumer products, and the innovations are mostly product improvements and not radical technological breakthroughs.

+Table 19 - **Distribution on USPC Main Classes**

No of Patents	No of Unique Patent classes
> 200	3
150-200	3
100-150	7
50-100	27
40-49	15
30-39	19
20-29	33
10-19	48
9	9
8	5
7	11
6	22
5	17
4	18
3	29
2	39
1	54

Broad Areas of Invention by China

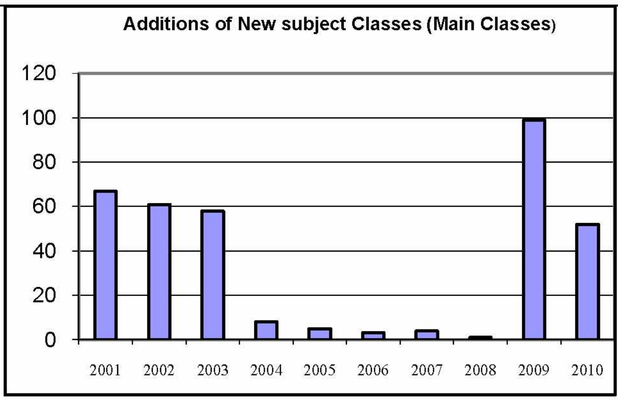
Electricity (US pat subject classes 361, 439, D26, 362,324)	803
Office systems	127
Drugs etc	102
Chemistry (Physical)	101
Textiles	503
Furnishings	73
Multiplex communication	351

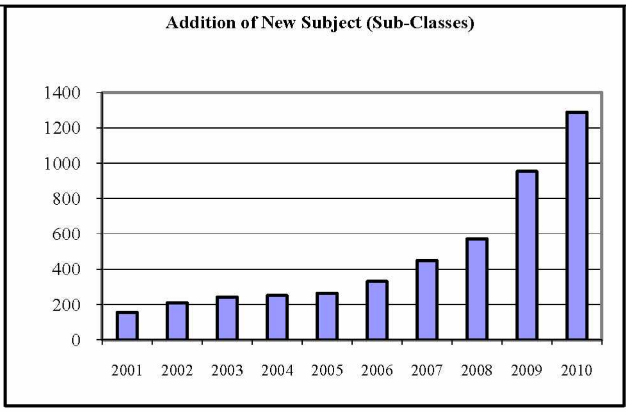
This data were also examined to know about the possible skewness in the innovation on particular subject classss. Thirteen subject classes have more than 100 patents each, indicating the patent clusters.

Analysis was extended to examine whether the subject scope of the Chinese patents are growing over the years through new additions to main classes and sub-classes (Table 20). We could see that the main classes are growing at a CAGR of 18.24% and the new sub-classes at a CAGR of 40.63%. Over the 2001-2010 decade the country has not only registered a patent growth, but also widened the subject scope continuously in a remarkable way.

Table 20 Additions of Distinct Patent Subject Classes

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	CAGR
New Main Classes	67	61	58	8	5	3	4	1	99	52	358	18.24%
New Sub-classes	156	210	243	252	264	331	449	572	954	1289	4720	40.63%





Distinct Assignees who have obtained the US Patents:

Distribution of assignees and the corresponding number of patents obtained by them are presented in Table 21. The data reveal that there are 13 assignees in China with over 100 patents during the period under analysis. Two of these Honhai Precision Industries (1231) and Hong Fu Jin Precision Co. (1004) have over one thousand US patents each. This is to show that it is not a few who dominate innovation in China. Otherwise R&D activity is distributed widely with quite a few small patent holders and a smattering of large ones.

+Table 21 - Distribution on distinct assignees

Patents	Assignees
>100	13
90-99	1
80-89	1
70-79	2
60-69	3
50-59	1
40-49	5
30-39	8
20-29	19
10--19	39
6--9	73
3--5	265
2	309
1	1340

It is also interesting to note that the new assignees being added to patent pool are growing at a CAGR of 32.79% over the decade (Table 22). The year on year increase of the new assignees has ranged from 98% in 2005 to 149% in 2010. There has been a continuous growth of new enterprises in an innovation mode.

Table 22 Addition of new assignees

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
No of new Assignees	122	134	146	150	147	202	237	266	271	404	2079
Year on Year growth		109.84	108.96	102.74	98.00	137.41	117.33	112.24	101.88	149.08	

CAGR: 32.79%

Table 23 Royalty & licence fee payments (US $ million)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Outgoing	1,938	3,114	3,548	4,497	5,321	6,634	8,192	10,319	11,065	13,040
Incoming	110	133	107	236	157	205	343	571	429	830

Source: http://data.worldbank.org/indicator/BM.GSR.ROYL.CD/countries

China has been a large technology importer as reflected in the royalty and license fee payments. Accrual of license fees - a function of technology agreements - is less than 10% of what it imports or pays for. It could be inferred that China is in a 'learning phase' and is making considerable investments in acquiring and updating the technologies. Current (or cumulated) innovations are offsetting the imbalance only to a small extent, as reflected in the statistics (Table 23).

Summary

In essence China's efforts and relative success in patenting in the USPTO can be summarized as follows:

- Solo inventors *to begin with and* collaborative teams in the later stages of the decade.
- Exclusive foreign inventions
- Foreign collaboration - Institutions & inventors
- Dominance of industrial patenting
- Medium and Low tech patents
- Increased R&D investment
- Gradual expansion to new areas of technology
- Focusing on universities for innovations
- Launch of a host of targeted programmes, including handpick and nurture schemes
- Focus on university for hi-tech research. Initiation of university science parks
- Host of incentives *to Chinese national and foreign companies, including for patenting innovations and grant of the same in the patent offices*
- Facilitating Incubators for promising technology ventures. Functioning of International incubators
- State Technology Parks
- Scores of Economic and Technology Development Zones
- Policy thrust for innovation - MNC and R&D Labs in China
- Focus of activities in MLP of 2006
- Groundswell of inventors / assignees, and also,
- Appropriation of IPR out of turn in some cases.

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Soft Innovations: A Case of Chinese Design Patents on Pens

Introduction:

Soft innovation encompasses innovation in or based on the arts, but it may also occur beyond the boundaries of the arts. Soft innovations include publishing a new book, writing, and producing a movie, developing a new advertisement campaign, design of a new range of products, etc. Writers such as Marzal and Esparza [4] and Tether[9] have explored the concept of soft innovation in the context of new products.

Soft innovations are improvements that primarily impacts upon aesthetics or intellectual appeal rather than functional performance in the context of products. These innovations could either be purely aesthetic appeal or could also bring in functional improvements.

OECD [5] defines product innovation as "The introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specification components and materials, incorporated software, user friendliness or other functional characteristics". According to OECD new products are goods and services that differ significantly in their characteristics or intended uses from those previously produced. Although design is an integral part of the development and implementation of product innovation, design changes are not seen as involving a significant change. Definitions of the OSLO [5] and FRASCATI manuals [2] also do not adequately encompass, or sufficiently emphasize soft innovation activities. Thus, to be termed a product innovation by these definitions, any change must involve either newness or significance as indicated by the impact on the product's functional or performance characteristics.

Nonetheless, the presence and the impact of soft innovations cannot be undermined. Recognizing this Bianchi and Bartolotti (1996) define what they call 'formal innovation' as innovation that changes product form without any necessary changes in product function and production methods. They consider that the new form 'exalts the aesthetic or symbolic content of the product'. Swan et al [8] confirm that importance of aesthetics (as compared to functional aspects) in product demand. They cite evidence on the importance of visual or aesthetic design in consumer choice. Marzal and Esparza [4] argue that there are industries that experience aesthetic innovation which occur when novelty is conferred in a product in terms of visual attributes. This can be compared with the new functions that are often considered to be conferred by technological change. As a result of aesthetic innovation a product can be perceived as being radically different and can displace earlier products.

In the context it is appropriate to consider two recognized types of product differentiations, viz, vertical and horizontal [10]. The two products are vertically differentiated if, at a given price, all buyers prefer one rather than the other. In such a case the two goods can be objectively ranked in terms of quality, like first or second-class travel. They are horizontally differentiated if at a given price some consumers prefer one and the other product(S) preferred by others. In this case, the variants cannot be ranked objectively in terms of quality, but only subjectively. In this differentiation one product is not better than the other, but some prefer one to the other.

Patent strategies:

Patents are obtained by firms / organizations to protect their innovation and commercially exploit the same. Firms device their own strategies to achieve this larger objective.

One or more 'broad' patents can achieve exclusivity on a technology. It could also be done with a number of 'narrow' ones. A 'broad patent' is a subjective description of a patent which typically has claim language which exclude others. [3]

Narrow patent is typically used to describe a patent that has claim language which excludes others from a more specific piece of a technology area. They exclude others from only a few embodiments of an invention. Narrow patents tend to be shorter in length and very specific in application. While they may introduce new concepts, typically they build on and extend previously patented inventions. Because of the specificity it is not uncommon for narrow patents to have only a few claims. Number of narrow patents would provide a maze. Firms use narrow patents to induce competitors to cross license their patents. This way both can share the market. This approach is characterized as 'patent flooding'. Patent flooding can happen with soft patents

In practice, exclusivity in a technology area is achieved by developing a portfolio of patents, some broad and some narrow, which effectively restrict the options competitors have in a technology area. This could be effected by obtaining a series of patents in a technology area with each patent excluded by a specific aspect of the technology. This strategy severely restricts the competitors' manipulability with the product. This kind of blanketing has two difficulties. It calls for a great deal of resources, and the natural development of a commercial enterprise is seldom as planned or coordinated as one might design.

An alternative strategy, which assumes that the researchers of the first company are just as aggressive as their competitors, is the wall strategy. In the 'wall strategy' the first company assumes that competitors will eventually bypass some of the patents they obtain, and the true value for the patent is the time delay caused in circumventing the patent wall that is put up.

Objectives:

This analysis examines the patent strategy adopted by China in increasing their market shore of pen. Pens are used universally for writing. Technology content of the product long exists and at best could be improved marginally.

Methodology:

This analysis is based on the US patents obtained by entities in China and other leading pen exporting countries such as Japan, Germany, Taiwan and India. The patents data were obtained from the USPTO database for the years 2000-2010. The patents on pen were segregated into two categories, namely design and utility patents. Subject categorization of these innovations was confined to the main patent class as indicated in the patent document. The data on market share and exports of pens were obtained from the secondary sources. Data were grouped into three varying time periods to observe the trends.

Discussion:

Pen is a tool used for writing or drawing with a colored fluid. There are different types of pens such as the reed pen, quill pen, metal nib pen, fountain pen, ballpoint pen, etc. The history of patents on pens started with a patent on the principle of working of a ballpoint pen. An 1888 patent owned by John J. Loud for a product to mark on leather forms the basis of a working ballpoint pen. Though this patent was never commercially exploited, it was a watershed moment for pen technology. In 1938 Hungarian journalist named Laszlo Biro invented the first ballpoint pen based on this principle. In June 1943, Biro and his brother took out a new patent from the European Patent Office and made the first commercial model called Biro Pens.

With universal use of pens certainly one design will not fit writing ease of all scripts apart from individual preferences in design. Innovation thrust in this field currently isn't as much on the working principles of a pen as is on the design and ergonomics of it. Majority of patents on pens are design patents rather than utility ones.

It is interesting to take a panoramic view of the US patents obtained by the major exporters of pens.

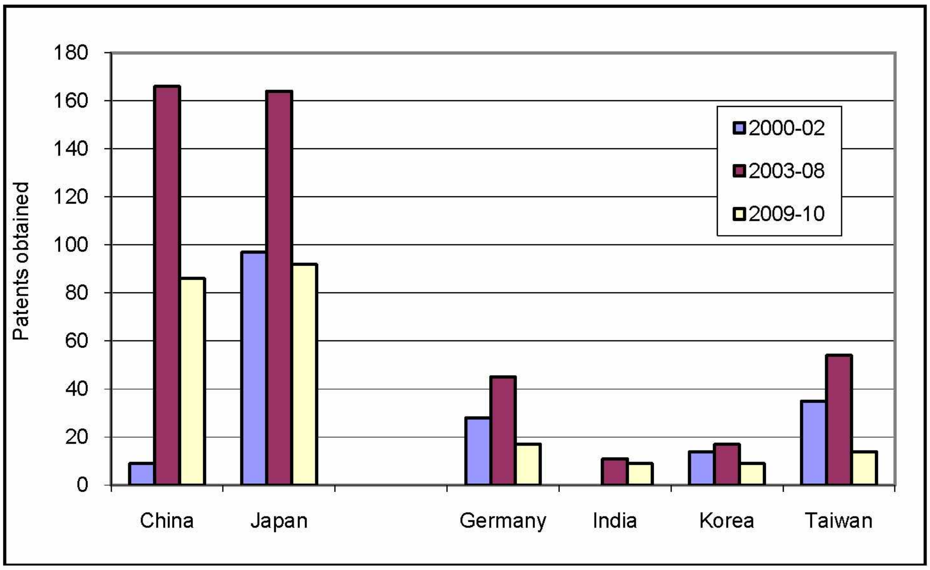
Table 1: Patents on pens obtained in the USPTO by select counties

	2000-02		2003-08		2009-10	
	Design patents	Total	Design patents	Total	Design patents	Total
Japan	41 (42.27%)	97 (100.00%)	97 (59.15%)	164 (100.00%)	50 (54.35%)	92 (100.00%)
China	8 (88.89%)	9 (100.00%)	112 (67.47%)	166 (100.00%)	82 (95.35%)	86 (100.00%)
Taiwan	5 (14.29%)	35 (100.00%)	16 (29.63%)	54 (100.00%)	3 (21.43%)	14 (100.00%)
Korea	13 (92.86%)	14 (100.00%)	14 (82.35%)	17 (100.00%)	2 (22.22%)	9 (100.00%)
Germany	6 (21.43%)	28 (100.00%)	43 (95.56%)	45 (100.00%)	15 (88.24%)	17 (100.00%)
India	0 (0.00%)	0 (100.00%)	11 (100.00%)	11 (100.00%)	2 (22.22%)	9 (100.00%)
World	219 (43.71%)	501 (100.00%)	626 (59.85%)	1046 (100.00%)	218 (68.34%)	319 (100.00%)

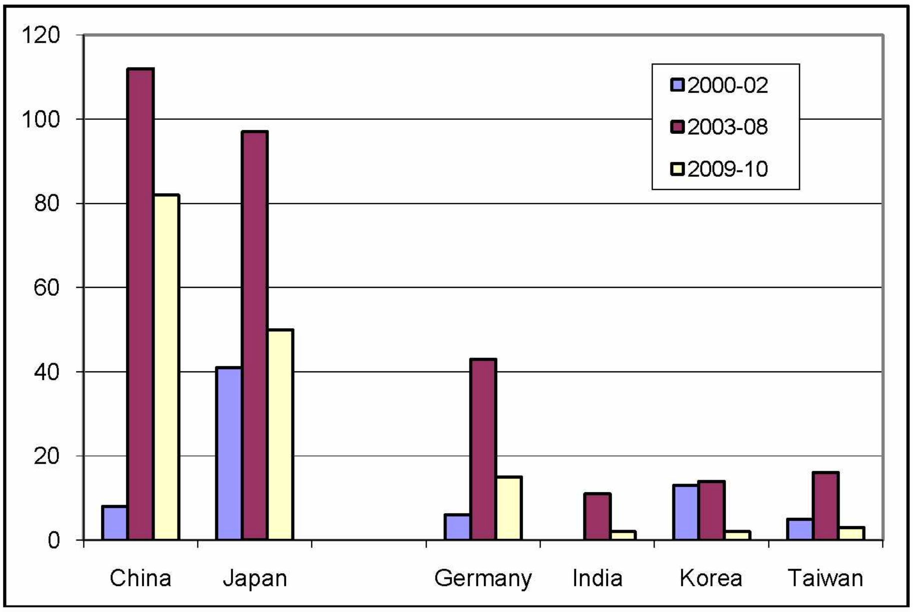
(Figures in brackets are % share of the total for the years in the context)

Source: Parker, Philip M: (2006); Parker, Philip M: (2011)

US Patents on Pens obtained by Select Countries



US Design Patents on Pens obtained in the USPTO by Select Countries



In the three time periods chosen for analysis, namely 2001-02, 2003-08, and 2009-10, it could be seen that China's patent share has increased considerably. Though the total patents granted were more or less the same for Japan and China during 2003-08 and 2009-10 time intervals, the difference stands out in the design patents obtained during the period. Design patents made up 67% of the total during the 2003-08 period and over 95% during the 2009-10. It is also interesting to notice the relative decline in innovation on the product by Germany, Korea and Taiwan and other active players in the export market for pens. Japan, the main competitor to China, has more utility patents on the technology. It is interesting to examine how these patents have affected their relative market share in the trade as such.

Table 2: World Exports of Pens

	2005	2010
Asia's share in global exports [% share]	50.54	59.36
Europe	37.17	29.77
Country share in world exports		
China [$ '000]	717,599 (19.92)	1,347,906 (32.91)
Japan [$ '000]	666,587 (18.50)	655,388 (16.00)
Germany [$ '000]	512,758 (14.23)	570,680 (13.93)
France [$ '000]	238,241 (6.61)	285,042 (6.96)
Asia's pen export market		
China [$ '000]	717,599 (39.41)	1,347,906 (58.44)
Japan [$ '000]	666,587 (36.61)	655,388 (26.96)
India [$ '000]	59,879 (3.29)	94,677 (3.89)
Taiwan [$ '000]	159,353 (8.75)	90,304 (3.71)
World Imports of Pens		
USA [$ '000]	932,358 (25.88)	1,181,176 (28.84)
France [$ '000]	211,046 (5.86)	336,605 (8.22)
Germany [$ '000]	226,893 (6.30)	267,431 (6.53)
Italy [$ '000]	140,138 (3.89)	212,872 (5.20)
USA Imports		
China [$ '000]	260,862 (27.98)	501,651 (42.47)
Japan [$ '000]	265,191 (28.98)	266,387 (22.55)
India [$ '000]	18,155 (1.95)	38,252 (3.24)

Source: Parker, Philip M: (2006); Parker, Philip M: (2011)
Figures in brackets show the % of the total

Currently global pen export market is worth $4 billion and is relatively small compared to other products. Of this Asia contributes nearly 60 percent. China supplies nearly 33% of the world exports valued at about $1.35 billion, closely followed by Japan and Germany. India figures 8th in the world order and has pen exports worth $95 million.

On the top of the list, among the countries that import pens, is the US, followed by France, Germany, and Italy. The US imports 29% of the world's total, followed by France (8%), Germany (6%) and Italy (5%).

Within Asia, China's pen exports accounted for 55% of the total, followed by Japan (27%), India (4%) and Taiwan (4%). These four countries make up over 90% of the pen exports from Asia.

China exports 37% of its pens to the US in 2010. Its total exports amount to US $ 501million. India on the other hand directs 40% of its total pen exports to the US with an export value of US$ 38 million. Also, interestingly, 42% of the US imports of pen come from China, followed by 22% from Japan and 12% from Mexico.

China has almost doubled its world export share in the last five years, from $700 million to $1.35 billion; its world share raising from 39.41% to 32.91%. During the same period China's export to the US has almost doubled in the 2006-2010 period from 260 million to 501 million.

There has been considerable increase in the share of India as well, which went up from US $60 million to US $94 million. During the same period the country's exports to the US have increased from US $18 million to US $38 million. Currently Indian exports make up 3.24% of the US imports of pens.

There has been considerable decline in the exports of pens to the US from Mexico, Taiwan, Germany, Italy and the UK. The shift as is seen from the data is towards China.

It is interesting to understand the patenting strategy of China in the context. China has used the soft innovation route to attain this growth. Because of the design or soft patents in almost all US Patent sub-classes [Table 3]. China could obtain considerable exclusivity on the product market. In effect, Chinese firms erected a wall through patenting various designs. This came in as an additional factor. Chinese pens were available in various designs, apart from the cost advantage the product enjoyed. The soft innovation strategy also provided for horizontal product differentiation.

The following table lists the details of Chinese patents relating to pen as grouped by the US subject Classification manual in the patent award process.

Table 3 Distribution of Chinese pen patents on USPC sub-classes

Sub Class	Description	No. of patents
35	Equipment for writing and fine arts	1
36	Plural or combined	8
43	Provision for cap over writing tip only	18
44	With suspension ring or loop	13
45	Elongated	1
46	Having Flared or enlarged top	8
47	With surface texture or pattern	14
48	Lateral striation	47
49	Longitudinal striation	26

50	Diagonal striation	49
51	Substantially circular or oval in cross section	48
54	Element or attachment	2
55	Nib stylus or grip	20
56	Clip	28
57	Top or cover for marking instrument	4

Source: Data computed from USPTO database

Clearly, China dominates the scene as far as patents on pens are concerned. Nearly a half of all the patents filed on pens with the USPTO in the year 2008 were from china, and within the country from one company, namely Beifa Group.

Beifa

Beifa Group is a high-tech joint venture specialized in R&D, production and sales of writing instruments as well as stationery in China. With registered capital of US$ 10.05 million, Beifa group currently has a total asset of RMB 450 million. [http://www.beifa.com/en/aboutus.php]

Beifa Group was established in 1994, started as a pens and stationery trade company. In 2000, Beifa Group invested USD 15 million and built the world's largest plant in writing instrument industry.

The company has become China’s largest exporter of writing instrument and stationery with total export exceeding US$100 Million. Beifa Group has more than 600 products of writing instruments, including gel ink pens, stick and retractable ballpoint pens, roller pens, markers & highlighters, mechanical pencil, and multi-functional pens.

The company claims to invest more than 5% of the annual sales volume in R&D, and ranks highest among similar Chinese companies. The company is named as State Level High-Tech Enterprise, having obtained more than 750 patents and inventions worldwide.

Beifa takes up nearly the whole pie when it comes to Chinese patents on pens in the US. The company was set up in 1994, but it was after the year 2000 when it set up a USD 15 million writing instrument plant did the patents start coming. The number of patents from this company has also shown a significant increase with 68 patents in 2008 [Table 4]

Table 4 **Patents Granted to Beifa Group by the USPTO**

Year	Beifa	Others	Total
2010	41 (100.00)	0	41
2009	39 (97.5)	1 (2.5)	40
2008	68 (98.6)	1 (1.4)	69
2007	20 (74.1)	7 25.9)	27

2006	2 (100.0)	0 (0.0)	2
2005	17 (85.0)	3 (15.0)	20
2004	12 (85.7)	2 (14.3)	14
2003	0 (0.0)	2 (100.0)	2
2002-2002	6 (75.0)	2 (25.0)	8
1990-99	0 (0)	0 (0)	0

Source: Data computed from USPTO database
Figures in brackets show the % of the total

Beifa's patents are mainly ornamental designs. With this exclusivity of products in the US, the company has the potential to set and alter the market trend in writing instruments. Considering these design are products of aesthetic imagination and not technological innovations the company can always pitch in more patent applications as and when required. It is interesting to note that one inventor figures in 88 of the 115 patents of the company and two other inventors figure in five patents each during the 2003-08 period. Nine other inventors figure in the remaining patents. Thus, soft innovation can turn the table in global perspective on select products.

Conclusion

The power of soft innovation in establishing market domination is often underestimated. In several counties, including India, designs are excluded in the patent process. However, for a set of products, particularly consumer products, soft innovations could be decisive factors in market domination. China seems to have made an effective use of these innovations.

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Typical design patents obtained by China

D19-35 Equipment for writing and fine arts

Equipment for writing and fine arts are pen patents developed primarily for aesthetics and/or concept rather than utility.

A patent design is shown below as an example.

Fig.1.

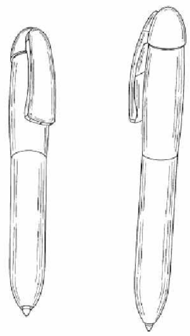


Fig.2.

D19-36 : Plural or combined

Pens that have an added functionality integrated into the design.

Fig.1.

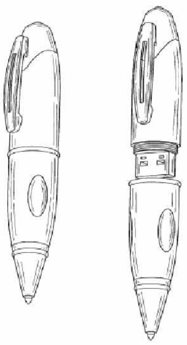


Fig.2.

A USB flash drive combined with a pen.

D19-43

Provision for cap over writing tip only.

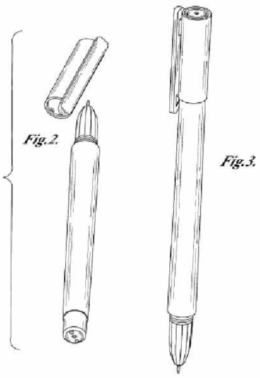


Fig.2. Fig.3.

D19-44

Pens with provision for a string by use of a suspension ring or loop which facilitates in easy carrying of the pen.

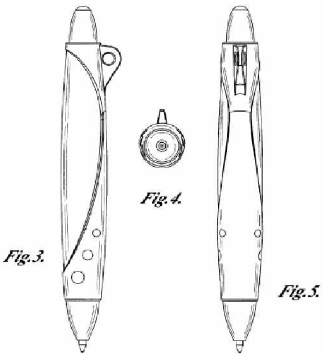
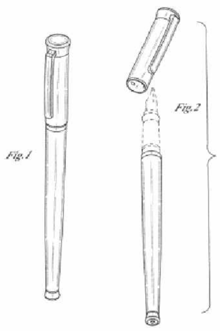


Fig.3. Fig.4. Fig.5.

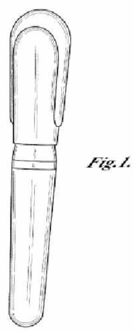
D19-45

Pens with an elongated body.



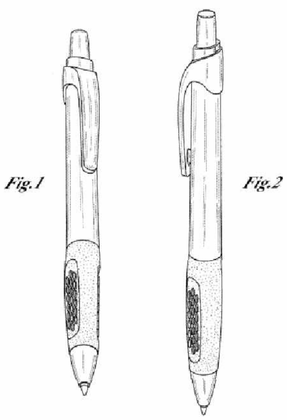
D19-46

Pens having a flared or enlarged top aimed at aesthetic improvement.



D19-47

Pens having a special surface texture or pattern.



D19-48

Pens with lateral striation, i.e. series of ridges, furrows or linear marks.

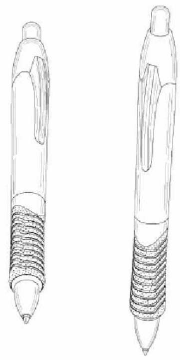


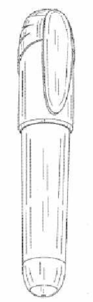
Fig.1. *Fig.2.*

D19-49

Pens with longitudinal striation, i.e. series of ridges, furrows or linear marks

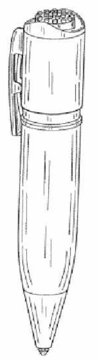
D19-50

Pens with diagonal striation, i.e. series of ridges, furrows or linear marks



D19-51

Pens having a substantially circular or oval cross section.

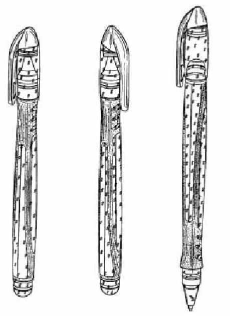


D19-54

Pens having an additional element or attachment.

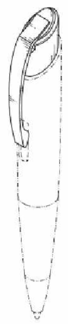
D19-55

Pens having modified nib, stylus or grip.



D19-56

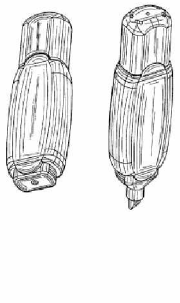
Pens having a clip.



D19-57

Pens having a top cover for the marking instrument.

Fig. 1. *Fig. 2.*



Heat Sink Technology Patents – Chinese Case

Introduction

China is a late comer to the world of IPR. This case analysis examines the patents obtained by the country in one of the sub-classes on US patent classification, viz., 370/641 - Thermal Conduction of electronic equipment. The analysis attempts to see the relative position of China vis-à-vis the others who have patented under this class. It also examines various associated variables to understand the China's strategy in acquiring the IPR.

Thermal conduction refers to the transfer of thermal energy from an object having differing temperature. For thermal energy to be transferred using conduction there should be no movement of the object as a whole. Thermal energy always moves from that of higher concentration to lower concentration--that is, from hot to cold. Therefore, if one part of an object is hot, the heat will transfer via thermal conduction to the cooler part of that object. Thermal conduction will also take place if two different objects of varying temperatures are touching each other.

The particles—such as atoms and molecules—of an object with high thermal energy will move faster than that of an object with low thermal energy. When the particles are heated, they can either move around or bump into one another, thus transferring energy. In case of many solids, the particles vibrate faster, causing the surrounding particles to vibrate. When thermal energy is transferred, the faster moving particles will slow down, thus becoming cooler, and the slower moving particles will move faster, thus becoming warmer. This will continue until the object reaches thermal equilibrium.

Thermal conductivity of materials play a significant role in the cooling of electronics equipment. From the die where the heat is generated to the cabinet where the electronics are housed, conduction heat transfer, and subsequently, thermal conductivity are the integral components of the overall thermal management process.

The path of heat from the die to the outside environment is a complicated process. In the past, several devices could operate without an external cooling device. In these devices, the conduction resistance from the die to the board needed to be optimized. As the primary heat transfer path was into the PCB. As the power levels increased, heat transfer solely into the board became inadequate. much of the heat is now dissipated directly into the environment through the top surface of the component.

In the electronics industry the constant push for smaller size and faster speeds has considerably reduced the scale of many components. This transition now continues from macro to micro scale and calls for new thinking. Thermal conductivity is affected by changes in thickness and orientation; in addition, temperature also has an effect on the overall magnitude. [http://qats.com/cms/2011/10/21/thermal-conductivity-what-is-it-and-why-you-should-care/]

There are many different methods of assembling heat sinks into electronic devices for the purpose of extracting heat from the processing chips during use. A good heat sink attachment needs to:

1. Provide a constant even pressure between the bottom of the heat sink and the heat source.
2. The heat sink must be removable for servicing of the electronics being cooled.
3. Maximize board space by using as little board area for attachment as possible.
4. Minimize stresses in the PC board which are induced by the fastening system itself.
5. Provide compliance in all directions in the event of a shock loading, such as a drop.
6. Minimize space needed on heat sink for fastening device.

Heat sinks are generally soldered with hooks to the board adjacent to the heat source. A bent wire spring is then clipped across the hooks and over the heat sink to hold it in place (Figure A). Others use a plastic bracket to clip onto the heat source, to which a spring is then clipped (Figure B). These methods are fine if the heat sink is not too heavy since the force that can be applied this way is limited to the strength of the PC board, or the plastic clip.

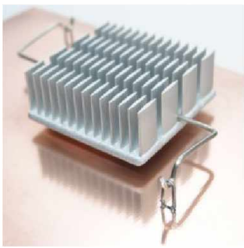


Figure A

Figure B

Heavier heat sinks that require greater force to hold them in place need to consider board stresses that will be induced by the attachment method. Bending stresses induced into the circuit board can cause costly fracturing of electrical traces, and even failure of components, or their connections to the board. To handle heavier heat sinks, fasteners with springs that control the load applied are frequently used.

Methodology

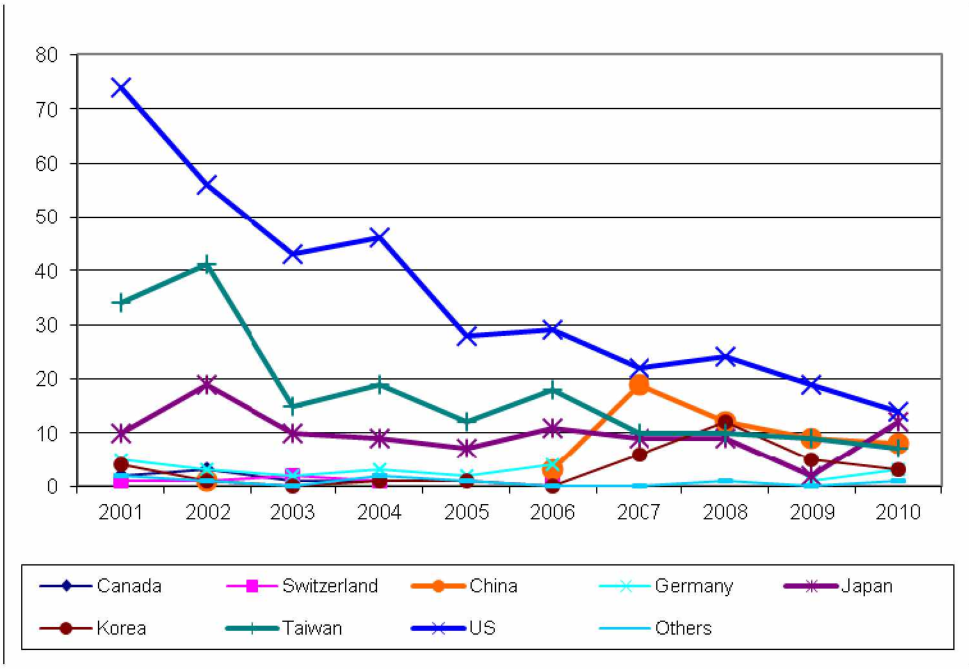
For the purpose of this analysis the USPTO database was searched for the entire set of patents obtained by the countries during 2001-2010 period under the sub-class. The growth of patents and the countries associated with them over the period were tracked. The patents were analysed to group them into different categories such as - technology per se, manufacturing method, components of the main system, tools associated with the product and method, to understand the nuances of the novel element in patens. Top four countries with relatively more number of patents in the sub-class were taken up for more detailed analysis. Chinese patents on the sub-class were analyzed for assignee, inventor collaboration, and the type of innovation. The licensing status of the patents were also examined to check whether the technology was traded to others.

Data Analysis

The patents obtained on heat sinks have both technology and design elements. The following analysis presents distribution of patents across countries that have obtained patents in the US on the technology. As the associated technologies, viz., ICs, semiconductors, were initially developed by the companies located in the US and close on the heels by Japan, and some of the European countries, the initial patents on heat sinks were obtained by them. Taiwan and Korea were also early innovators in this technology, as these East Asian countries were assembling / manufacturing the compatible personal computers and such equipment. The technology, as has been mentioned earlier, matured around the beginning of the year 2000s. Year-wise / country-wise distribution of the patents shows (Table 1) a declining trend in the patens for almost all the major players in the technology.

Table 1 Growth of US Patents on Heatsink (US Patent Subject Class 370/641)

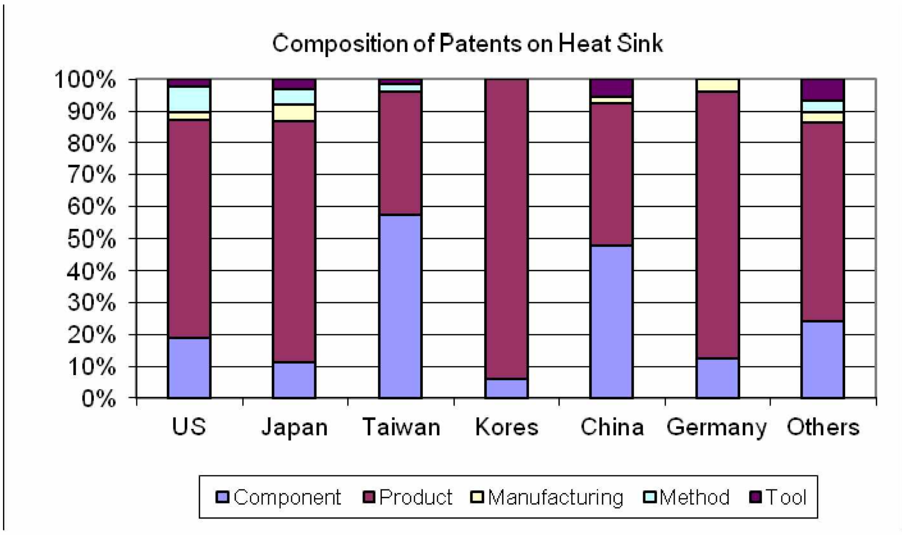
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Canada (5)	2	3	1	1	1					
Switzerland(4)	1	1	2	1		1				
China (4)		1				3	19	12	9	8
Germany(9)	5	3	2	3	2	4			1	3
Japan(46)	10	19	10	9	7	11	9	9	2	12
Korea (5)	4	1	0	1	1	0	6	12	5	3
Taiwan (58)	34	41	15	19	12	18	10	10	9	7
US (116)	74	56	43	46	28	29	22	24	19	14
Others(11)	2	1	0	2	1	0		1		1
Figures in bracket are no. of unique assignees in the country										

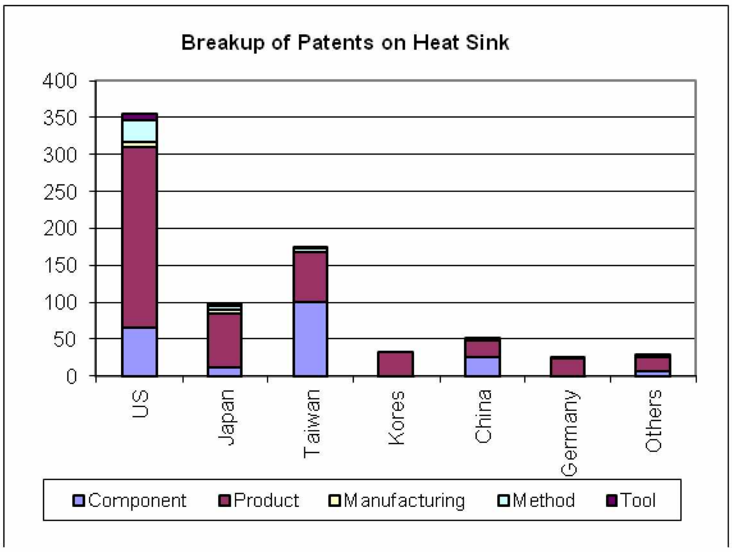


An interesting trend also could be seen where the patents obtained for heat sink innovation was compartmentalized into patents on sub-components such as clip / fasteners etc.

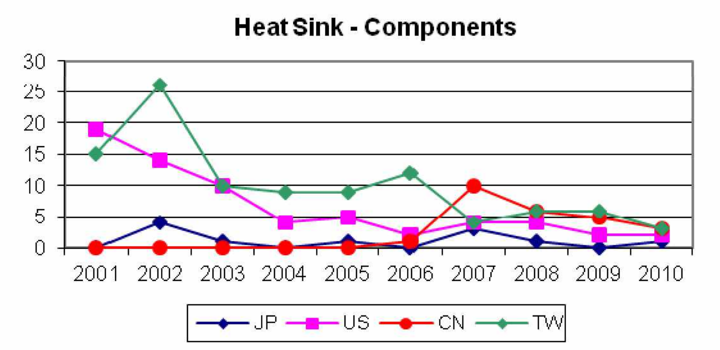
Table 2 Classification of heat sink patents on technology component

	Sub-compo nent	Technology *per se*	Manu-facturing process	Method	Tool
US	66	243	8	30	8
Japan	11	74	5	5	3
Taiwan	100	68	0	4	3
Korea	2	31	0	0	0
China	28	19	2	0	3
Germany	3	20	1	0	0
Others	7	18	1	1	2





It could be seen that the US, Japan and Taiwan are the leaders in this technology. The US has several patents on the product per se. Taiwan's strength is in the sub-component level, which includes improvements in product features other than the main technology. China is a more recent entrant to this technology. As could be seen in Table 3 patent yield in this technology is on the decline for all the players.



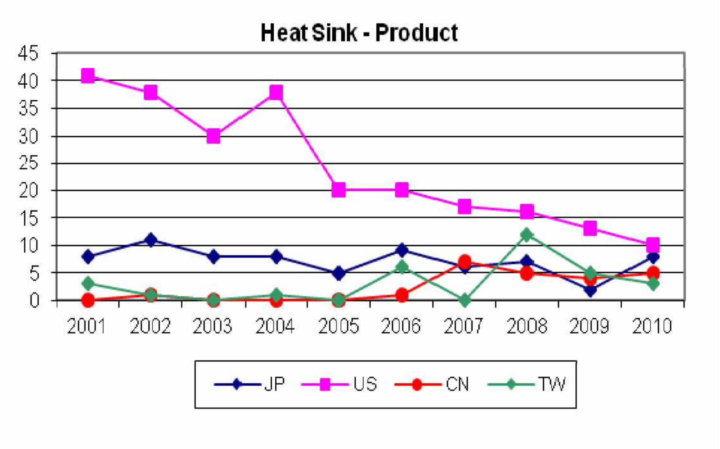


Table 3 Classification of heat sink patents

component		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	JP	0	4	1	0	1	0	3	1	0	1
	US	19	14	10	4	5	2	4	4	2	2
	CN	0	0	0	0	0	1	10	6	5	3
	TW	15	26	10	9	9	12	4	6	6	3
Technology		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	JP	8	11	8	8	5	9	6	7	2	8
	US	41	38	30	38	20	20	17	16	13	10
	CN	0	1	0	0	0	1	7	5	4	5
	TW	3	1	0	1	0	6	0	12	5	3

Major firms in the technology

47	Fu Zhun Precision Ind. (Shenzhen) Co., Ltd. (Shenzhen, CN), Foxcon Technology Co., Ltd. (Tu-Cheng, TW)	CN;TW
41	International Business Machines Corporation (Armonk, NY)	US
33	Hewlett Packard Company (Palo Alto, CA)	US
28	Samsung Electro-Mechanics Co., Ltd. (Kyungki-Do, KR)	KR
14	Fujitsu Limited (JP)	JP
11	Tyco Electronics Corporation (Berwyn, PA)	US
11	Micron Technology, Inc. (Boise, ID)	US
10	Denso Corporation (Kariya, JP)	JP

Closer reading of the claims also indicate that the countries like Japan and the US moved on to higher level of technology to accomplish the same results with the use of coolant [US Patent no. 6845012] and nanotech solutions [US Patent no. 6891724]. This indicates that any further patents on the old technology could be termed as secondary innovation. Patents as an outcome of the secondary innovation could be to obtain the cost advantage in manufacturing, as this would reduce royalty payments. This could well be the case with Taiwan and more so with China, which continued to file for patents on the technology with minor improvements, or what is termed as secondary innovations. Chinese patents in this sub-class were analysed to understand the nature of innovation.

Secondary innovation takes place usually in latecomer firms in developing countries. By definition a latecomer firm is one which meets the four conditions:

A late entrant to the industry
Lacks in resources: technology and market
Focused on catch-up as its primary goal
Some initial competitive advantage such as development costs. [1]

n contrast to the traditional technological learning model, the secondary innovation model emphasizes the very important interrelations and interactions between acquired technologies, local technological environment and the domestic market environment. These interrelations and interactions can be termed as “understanding”. Based on these understanding (Characteristics) the patents can be classified into categories/stages of secondary innovation as shown in table.

Table 4

Stages	**Duplicative Imitation**	**Creative Imitation**	**Exploitative Innovation**	**Explorative Innovation**
Nature	Basic Assimilation	Structural Understanding	Functional Understanding	Conceptual Understanding
Focus	Operation	Localization	Differentiation	Value Innovation

Foreign technology acquisition is the start of the secondary innovation process and the most important thing in the Duplicative Imitation stage is to master the operation technology. Through importing technical know-how, blueprints, equipment, production manuals and technicians, production capability is formed and functional performance is achieved. The localization process of foreign acquired technologies in the creative imitation stage is named “structural understanding“ which refers to the interaction between the foreign imported technology and the endogenous technological capability. As high level design capability is formed in the exploitative innovation stage, the localized technologies are improved, diversified and applied to different market segments. A *functional understanding* is said to be established as the interaction between localized technologies and the domestic user requirements emerges. Conceptual understanding refers to the interaction between the emerging foreign technology and new product concept, which is a key route to reach the explorative innovation stage. It requires high-level R&D, advanced production capability and marketing capability.

Duplicative Imitation	**Creative Imitation**
Basic assimilation of imported technology. The Main foci of the innovation will be mastering the technology from an operational point of view through adapting the patented methods to the market	Structural Understanding of the imported technology and localizing the technology with endogenous technological capability. This is developing technology for the market, improving efficiency by understanding the structure of the imported technology
Exploitative Innovation	**Explorative Innovation**
Functional Understanding of the patents and application of the technology concepts in developing technology for different market segments with similar functioning as that of the imported technology.	Use of imported technology for development of new product concepts via understanding the concepts involved in the imported technology and applying the concepts in developing indigenous technology for various market segments.

In the light of this understanding patents obtained by China were studied in detail.

Analysis of the patents obtained by China vis-à-vis the IPR already claimed in the technology [Table 5] shows that most of these patents could be categorized as exploitative innovation.

Table 5 Distribution of Chinese patents on invention categories

Duplicative Imitation	**Creative Imitation**
-	21 *Some e.gs* 7375964 Memory module assembly including a clamp for mounting heat sinks thereon 7443679 dissipating device having a fin also functioning as a fan holder 7667970 Heat sink assembly for multiple electronic components 7692927 Shielding and heat dissipation device 7843696 Heat sink assembly
Exploitative Innovation	**Explorative Innovation**
26 *Some e.gs* 7164583 Mounting device for heat sink 7180743 Fastener for heat sink 7203066 Heat sink assembly incorporating spring clip 7262969 Heat sink clip assembly 7272007 Locking device for heat sink	

Careful reading of the patent claims show that Chinese innovations in heat sinks fall into either exploitative innovation (26) or Creative imitation (21). The companies have not been able to build of the technology to bring in any newer elements. The patents are mainly improvements through better fixing / retention mechanisms - in essence fine tuning at the sub-component level. Some of them are also in the nature of creative imitation, wherein the patented technology has added to the technical finish of the components as a whole as in the case of heat sinks for multiple electronic components [7667970] or in the case of Heat sink assembly [7843696]. The heat sink contact includes use of thermal grease in the dissipation process.

The analysis also shows that patents obtained for sub-components like clips are important only in the production context. It could also be noted that clips [14 patents] fasteners [7] patented in the context are also important as it is crucial to keep the heat sink in place. It is also relevant in the context of increasing miniaturization of electronic devices like laptops, tablets, etc. The miniaturization has also brought in the issue of heat sink orientation to get the maximum heat dissipation.

Further analysis also shows that most of these patents are obtained after 2006 and are initially outcome of the collaboration with Taiwan. After the initial phase Chinese inventors have picked up the threads and have developed technologies without Taiwanese collaboration. This is an interesting trend, in that Taiwanese companies which obtained the patents on this technology during the first half of the decade collaborated with the Chinese company after 2006. The inventions were collaborative during 2007 and 2008. After this phase Chinese have taken up the technology development themselves [Table 6 and 7]. This could be summarized as collaboration as well as invention skill transfer.

Table 6 Collaboration in Heat sink patents

	Collaborative	Non-collaborative
Assignee	50	2
Inventor	30	22

Table 7 Inventor collaboration Trend in Heat sink patents

	China collab with Taiwan	China	Total
2001			
2002		1	1
2003			
2004			
2005			
2006	3		3
2007	16	3	19
2008	7	5	12
2009	2	7	9
2010	2	6	8
	30	22	52

In this secondary innovation process, China has learnt the technology through collaboration. The country has patented improvements on the existing base technology. In the process they have not only acquired the patent right but have also got the innovation skill transfer on this technology. Fu Zhun Precision Ind. (Shenzhen) Co., Ltd. from China and Foxcon Technology Co., Ltd. from Taiwan are the main collaborators in this process.

Thus, unlike Israel in the context of medical device patents where the innovations were plugging the gaps in the current technologies, China's patents on thermal conduction could be seen as a process of learning the game and obtaining cost advantage to the extent possible. This is particularly so, as none of the 52 patents has been licensed as technology transfer to any other company.

Reference:

Xiaobo Wu, et al (2009) : **Secondary innovation:** The path of catch-up with 'made in China'China Economic Journal, V. (1) February, 93-104

List of China's patents in 370/641 class (2001-2010)

6469895	Integrated circuit mounting structure including a switching power supply	A semiconductor packaging structure comprising a hybrid IC package having at least one IC chip mounted therein is disclosed. The semiconductor packaging structure includes a DC-DC switching power supply mounted within the hybrid IC package that is electri	Smith; David Anthony (Sai Kung, HK), Stewart; Neal G. (Sai Kung, HK)	Astec International Limited (Hong Kong, HK)	361/704 ; 257/691; 257/713; 257/723; 257/724; 257/E23.099; 361/718; 361/722	2002	361/704
7692927	Shielding and heat dissipation device	Discloses herein is a shielding and heat dissipation device comprising a conductive bracket (1) provided on a PCB around a shielded heat-generating electronic component, and electrically connected to a conductive layer of the PCB; a heat sink (2), which i	Jin; Linfang (Shenzhen, CN), Zhou; Liechun (Shenzhen, CN)	Huawei Technologies Co., Ltd. (Shenzhen, CN)	361/704 ; 165/80.3; 174/16.1; 257/712; 361/719; 361/818	2010	361/704
7116556	Heat sink mounting apparatus	A mounting apparatus (1) includes a locking pin (10) and an operation member (20) attaching to the locking pin. Resilient prongs (13) are formed at a first end of the locking pin. A detent (16) is formed at a periphery of the locking pin. The operation me	Lee; Hsieh-Kun (Tu-Cheng, TW), Chen; Chun-Chi (Tu-Cheng, TW), Zhao; Liang-Hui (Shenzhen, CN)	Fu Zhun Precision Industry Co., Ltd. (Shenzhen, CN), Foxconn Technology Co., Ltd. (Taipei Hsien, TW)	361/704 ; 165/185; 165/80.3; 24/453; 24/458; 257/718; 257/719; 257/727; 257/E23.086; 361/719	2006	361/704
7126824	Heat dissipation device assembly incorporati ng	A heat dissipation device assembly includes a heat sink (20) placed on an electronic component (52) which is mounted on a printed circuit board (PCB) (50) and including a pair of shoulders (23) on	Lee; Hsieh Kun (Tu-Chen, TW), Xia; Wanlin (Shenzhen, CN), Feng; Jin Song (Shenzhen, CN)	Fu Zhun Precision Industrial (Shenzhen) Co., Ltd. (Shenzhen, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, TW)	361/704 ; 165/122; 165/185; 165/80.3; 174/16.1; 174/16.3; 257/706; 257/712;	2006	361/704

	retention member	opposite sides thereof, a pressing part (30) including a p			257/718; 257/E23.086; 257/E23.099; 361/695; 361/719		
7142426	Heat dissipating device and method for manufacturing it	A heat dissipating device includes a heat sink forming a pressing portion thereon and a clip. The heat sink includes a hollow dissipating member and a column-shaped core, and the clip includes an integrally formed body defining a round hole therein. The p	Wang; Gen-Cai (Shenzhen, CN), Zhao; Di-Qiong (Shenzhen, CN), Fang; Yi-Chyng (Tu-Cheng, TW)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Guangdong Province, CN), Foxconn Technology Co., Ltd. (TW)	361/704 ; 165/80.3; 248/510; 257/717; 257/727; 257/E23.086; 257/E23.103; 361/703; 361/710	2006	361/704
7164583	Mounting device for heat sink	A mounting device (10) for mounting a heat sink (20) to a circuit board (40), includes a locking member (16) extending through the heat sink and including a through hole (162) and barbs (172) formed in one end portion thereof for engaging with the circuit	Lee; Hsieh Kun (Tu-Chen, TW), Xia; Wan-Lin (Shenzhen, CN), Liu; He-Ben (Shenzhen, CN)	Fu Zhun Precision Ind. (Shenzhen) Co., Ltd. (Shenzhen, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, TW)	361/704 ; 165/80.3; 174/16.3; 257/718; 257/719; 257/E23.086; 257/E23.099; 361/695; 361/719	2007	361/704
7180743	Fastener for heat sink	A fastener for a heat sink of the present invention includes a length-variable operating member (10), a piston member (20), an embracing member (30), a resilient member (40) and a post (58) extending from a printed circuit board (50). The piston member is	Chen; Chun-Chi (Tu-Cheng, TW), Zhou; Shi-Wen (Shenzhen, CN), Lee; Hsieh-Kun (Tu-Cheng, TW)	Fu Zhun Precision Industry (Shenzhen) Co., Ltd. (CN), Hon Hai Precision Industry Co., Ltd. (TW)	361/704 ; 165/185; 165/80.3; 257/718; 257/719; 257/727; 257/E23.086; 361/709; 361/710; 361/719; 411/41; 411/45	2007	361/704
7180744	Heat sink mounting device	A mounting device for a heat sink (200) includes a pair of pivot members (10), two joining members (30), and two pairs of spring members (20). Each pivot member includes a clipping portion (11) for clasping the electric unit (300). The joining members piv	Chen; Chun-Chi (Tu-Cheng, TW), Wu; Yi-Qiang (ShenZhen, CN), Feng; Cheng-Bin (ShenZhen, CN)	Fu Zhun Precision Industry (Shenzhen) Co., Ltd. (CN), Hon Hai Precision Industry Co., Ltd. (TW)	361/704 ; 165/80.3; 24/489; 24/520; 257/718; 257/719; 257/E23.086; 361/719	2007	361/704
7190588	Heat-dissipating fin assembly for heat sink	A heat-dissipating fin assembly (1) includes a plurality of individual fin plates (12) arranged side by side. Each fin plate includes a main body (14). First and second flanges (16, 18) extend perpendicularly from opposite edges of the main body of each f	Lee; Hsieh-Kun (Tu-Cheng, TW), Xia; Wan-Lin (Shen-Zhen, CN), Chen; Bao-Chun (Shen-Zhen, CN), Li; Neng-Bin (Shen-Zhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, TW)	361/704 ; 165/185; 165/78; 165/80.3; 257/E23.103; 361/703; 361/709; 361/710	2007	361/704
7203066	Heat sink assembly incorporating spring clip	A heat sink assembly includes a heat sink (20) and a pair of clips (10) attached on opposite sides of the heat sink for securing the heat sink to an electronic component (40). The heat sink includes a base (22) and a plurality of fins (24). A pair of prot	Lee; Hsieh Kun (Tu-Chen, TW), Lee; Dongyun (Shenzhen, CN), Zhang; Zhijie (Shenzhen, CN), Shi; Hong Bo (Shenzhen, CN)	Fu Zhun Precision Ind. (Shenzhen) Co., Ltd. (Shenzhen, CN), Foxcon Technology Co., Ltd. (Tu-Cheng, TW)	361/704 ; 165/80.3; 174/16.3; 257/E23.086	2007	361/704
7218520	Retainer for heat sink	A retainer includes a retention module surrounding a heat sink and two clip members for cooperating with the retention module to retain the heat sink. Each	Li; Dong-Yun (Shenzhen, CN), Shi; Hong-Bo (Shenzhen, CN), Li; Min (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen City, Guangdong Province, CN), Foxconn	361/704 ; 165/185; 165/80.3; 174/16.3; 24/458; 248/510; 257/718; 257/727;	2007	361/704

		clip member includes a strap resting on the heat sink and a pair of legs located at opposite ends o		Technology Co., Ltd. (Tu-Cheng City, Taipei Hsien, TW)	257/E23.086; 257/E23.099; 361/710; 361/719		
7218522	Heat dissipating device	A heat dissipating device includes a heat sink and a protecting device attached to the heat sink. The heat sink includes a plurality of individual fins in assembly. The protecting device is made from plastic. The protecting device includes a lath resting	Chen; Chun-Chi (Tu-Cheng, TW), Zhou; Shi-Wen (Shenzhen, CN), Fu; Meng (Shenzhen, CN), Liang; Chi (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/80.3; 257/706; 257/722; 257/E23.103; 257/E23.194; 361/703; 361/709; 361/710	2007	361/704
7230828	Heat dissipation device	A heat dissipation device (30) includes a heat dissipation member (31), a positioning member (33) and a mating member (34). The heat dissipation member includes a fin set (311) and a post (312) in the fin set. The post extends through the positioning memb	Lee; Hsieh Kun (Tu-Chen, TW), Lu; Cui Jun (Shenzhen, CN), Sun; MingXian (Shenzhen, CN)	Fu Zhun Precision Ind. (Shenzhen) Co., Ltd. (Shenzhen, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, TW)	361/704 ; 165/80.3; 257/719; 257/E23.084; 257/E23.099; 361/719	2007	361/704
7239518	Universal locking device for heat sink	A locking device includes a flat plate for contacting with a heat-generating electronic component, a plurality of fins mounted on the flat plate, four locking feet and four fasteners. The flat plate includes two locking portions at opposite sides thereof.	Yang; Bo-Yong (Shenzhen, CN), Wung; Shin-Hsuu (Tu-Cheng, TW), Chen; Chun-Chi (Tu-Cheng, TW)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/80.3; 174/16.1; 257/718; 257/E23.084	2007	361/704
7254028	Heat dissipating device with back plate for electronic assembly	An electronic assembly includes a PCB (20), a socket (22) mounted on the PCB, a CPU (24) connected with the socket, a heat sink (10) in thermal contact with the CPU, a foldable back plate (30) attached to an underside of the PCB and a base plane (40) form	Lee; Hsieh-Kun (Tu-Cheng, TW), Chen; Chun-Chi (Tu-Cheng, TW), Wung; Shin-Hsuu (Tu-Cheng, TW), Huang; Yu (Shenzhen, CN)	Fu Zhun Precision Industry (Shenzhen) Co., Ltd. (Bao'an District, Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/80.3; 174/16.3; 257/718; 257/719; 257/E23.086; 361/719	2007	361/704
7262969	Heat sink clip assembly	A heat sink clip assembly is for attaching a heat sink (10) to a motherboard (60). The motherboard and the heat sink each respectively define through apertures (52) and through holes (16) therein. The heat sink clip assembly includes four sleeves (46), fo	Lee; Hsieh-Kun (Tu-Cheng, TW), Lu; Cui-Jun (Shenzhen, CN), Chen; Yong-Dong (Shenzhen, CN)	Fu Zhun Precision Industry (Shenzhen) Co., Ltd. (Bao'an District, Shenzhen, Quangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/185; 165/80.3; 257/718; 257/719; 257/E23.084; 361/710; 361/719	2007	361/704
7269016	Heat dissipating device	A heat dissipating device includes a heat sink and a clip attached on the heat sink. The heat sink includes a solid trunk and a plurality of fins extending radially outwardly from a circumference of the trunk. A rectangular extension portion is formed at	Wang; Jin-Liang (Shenzhen, CN), Wang; Gen-Cai (Shenzhen, CN), Zhou; Wei-Guo (Shenzhen, CN)	Fu Zhun Precision Industry (Shenzhen) Co., Ltd. (Bao'an District, Shenzhen City, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng City, Taipei Hsien, TW)	361/704 ; 165/80.3; 257/707; 257/E23.086; 257/E23.099; 361/709; 361/710	2007	361/704

7272007	Locking device for heat sink	A locking device (10) for securing a heat sink to an electronic device includes a rectangular main frame (20), four first fasteners (30) respectively pivotably attached to four corners of the main frame and two second fasteners (40) pivotably attached to	Lee; Hsieh-Kun (Tu-Cheng, TW), Lai; Cheng-Tien (Tu-Cheng, TW), Zhou; Zhi-Yong (Shenzhen, CN), Wang; Bo-Tao (Shenzhen, CN)	Fu zhun Precision Industry (Shenzhen) Co., Ltd. (Bao'and District, Shenzhen, Quangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/185; 165/80.3; 257/719; 257/E23.084; 257/E23.088; 257/E23.099; 257/E23.103; 361/710; 361/719	2007	361/704
7277288	Heat sink assembly with retention module and clip	A heat sink assembly of the present invention includes a printed circuit board (10), a retention module (20), four pins (30), a heat sink (40) and a clip (50). The printed circuit board (10) has an electronic package (100) mounted thereon. The retention m	Lee; Hsieh Kun (Tu-Chen, TW), Xia; WanLin (Shenzhen, CN), Wang; Gen-Cai (Shenzhen, CN), Li; Tao (Shenzhen, CN)	Fu Zhun Precision Ind. (Shenzhen) Co., Ltd. (Shenzhen, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, TW)	361/704 ; 257/E23.086; 361/709; 361/710; 361/719	2007	361/704
7283361	Heat dissipation device	A heat dissipation device includes a heat sink, a retention module and a clip having two clipping portions for securing the heat sink to the retention module. The heat sink includes a base for contacting with a heat generating electronic device. The base	Lee; Hsieh-Kun (Tu-Cheng, TW), Xia; Wan-Lin (Shenzhen, CN), Chen; Bao-Chun (Shenzhen, CN)	Fu Zhun Precision industry (Shenzhen) Co., Ltd. (Shenzhen, Quangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 24/458; 24/513; 257/719; 257/E23.086	2007	361/704
7283362	Heat dissipation device having a locking device	A heat dissipation device includes a retention module, a heat sink, a locking plate and a clip rotatably connecting with the retention module. The retention module includes an opening in a center thereof. The heat sink includes a heat conducting body and	Lin; Yu-Chen (Guangdong, CN), Chen; Feng (Guangdong, CN)	Hong Fu Jin Precision Industry (Shen Zhen) Co., Ltd. (Longhua Town, Bao an District, Shenzhen, Guangdong Province, CN), Hon Hai Precision Industry Co., Ltd. (Tu-Chung, Taipei Hsien, TW)	361/704 ; 257/E23.086	2007	361/704
7286362	Heat dissipating apparatus	A heat dissipating apparatus includes a retention module (20) forming clipping portions (26) thereon, a heat sink (10) mounted to the retention module, and a clip (30) engaged with the retention module and the heat sink. The clip includes a resilient clip	Yu; Fang-Xiang (Shen-Zhen, CN), Hsieh; Yin-Jong (Tu-Cheng, TW), Lin; Shu-Ho (Tu-Cheng, TW), Chou; Da-Chang (Tu-Cheng, TW)	Fu Zhun Precision Industry (Shenzhen) Co., Ltd. (Bao'an District, Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/80.3; 174/16.3; 257/E23.086; 361/709	2007	361/704
7292442	Heat sink clip and assembly	A heat sink clip and an assembly incorporating such clip are provide. The heat sink clip comprises: a body, an actuating member and a movable fastener. The body has a securing portion formed at one end thereof. The actuating member has a hinge portion the	Yu; Fang-Xiang (Shenzhen, CN), Lin; Yeu-Lih (Tu Cheng, TW), Yang; Ming (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen City, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng City, Taipei Hsien, TW)	361/704 ; 165/121; 165/185; 165/80.3; 174/16.3; 248/510; 257/E23.086; 361/697; 361/703; 361/801	2007	361/704
7292443	Heat sink mounting assembly	A heat sink mounting assembly includes a retention module having a bottom and a pair of posts extending from the bottom. A heat sink is located on the bottom of the retention module. A clip spans across the heat	Lai; Cheng-Tien (Tu-Cheng, TW), Lu; Cui-Jun (Shenzhen, CN), Liu; Song-Shui (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng,	361/704 ; 16/223; 16/371; 165/121; 165/185; 165/76; 165/80.3; 174/16.3; 248/510; 254/104; 257/712; 257/718;	2007	361/704

		sink and includes a clamping member having		Taipei Hsien, TW)	257/719; 257/E23.086; 257/E23.099; 361/719; 361/801		
7342791	Locking device for heat sink	A locking device for securing a heat sink to a heat generating electronic device includes a retaining member attached to the heat sink and a plurality of fasteners positioned to the retaining member. The retaining member includes a frame and a plurality o	Lee; Hsieh-Kun (Tu-Cheng, TW), Lu; Cui-Jun (Shenzhen, CN), Cao; Ling-Bo (Shenzhen, CN)	Fu Zhun Precision Industry (Shenzhen) Co., Ltd. (Bao'an District, Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/185; 165/80.3; 257/718; 257/719; 257/E23.084; 361/710; 361/719	2008	361/704
7345879	Heat dissipation device	A heat dissipation device includes a primary heat sink (10) contacting a central processing unit and a secondary heat sink (20) attached on heat-generating electronic components adjacent the central processing unit. The primary heat sink includes a base (	Chen; Chun-Chi (Tu Cheng, TW), Zhou; Shi-Wen (Shenzhen, CN), Fu; Meng (Shenzhen, CN), Zheng; Dong-Bo (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/185; 165/80.3; 257/712; 257/E23.099; 361/707; 361/709	2008	361/704
7365983	Grease protecting apparatus for heat sink	A grease protecting apparatus (10) includes a heat sink (12) defining a plurality of receiving cavities (124) therein, a layer of grease (16) spread on a surface (122) of the heat sink, and a grease cover (14) attached to the surface of the heat sink for	Huang; Shu-Liang (Guangdong, CN), Lin; Yeu-Lih (Guangdong, CN), Huang; Ai-Min (Guangdong, CN), Yang; Ming (Guangdong, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Longhua Town, Bao'an District, Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/185; 165/80.2; 165/80.3; 257/719; 257/E23.087; 361/690; 361/707; 361/708; 361/710	2008	361/704
7375964	Memory module assembly including a clamp for mounting heat sinks thereon	A memory module assembly includes a pair of heat-dissipation plates (10), a printed circuit board (20) sandwiched between the heat-dissipation plates (10), and four clamps (30) for securing the heat-dissipation plates (10) onto opposite sides of the print	Lai; Cheng-Tien (Tu-Cheng, TW), Zhou; Zhi-Yong (Shenzhen, CN), Ding; Qiao-Li (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 257/707; 257/719; 257/E23.103; 361/715; 361/719	2008	361/704
7375965	Clip and heat dissipation assembly using the same	A heat dissipation assembly comprises a mounting seat, a heat sink and a clip for fastening the heat sink in the mounting seat. The mounting seat defines an opening and is provided with a first and second protrusions. The heat sink is accommodated in the	Xia; Wan-Lin (Shenzhen, CN), Li; Tao (Shenzhen, CN), Tian; Wei-Qiang (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/80.3; 174/16.3; 24/457; 257/719; 257/E23.086; 361/719	2008	361/704
7391615	Clip for heat sink	A clip includes a body with opposite first and second legs, a movable fastener, an actuating member and a sliding axle. The movable fastener has a retaining hole defined therein for engaging with a retention module and an elongated slot above the retainin	Fu; Meng (Shenzhen, CN), Zhou; Shi-Wen (Shenzhen, CN), Chen; Chun-Chi (Tu-Cheng, TW)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/185; 165/80.3; 24/505; 24/510; 257/718; 257/719; 257/727	2008	361/704
7397663	Clip for heat dissipation device	A clip includes a body, an actuating member, a first hook plate and a second hook plate. The body includes a supporting	Chen; Chun-Chi (Tu-Cheng, TW), Zhou; Shi-Wen (Shenzhen, CN), Chen; Guo	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong	361/704 ; 165/80.3; 257/718; 257/719; 257/727;	2008	361/704

		portion and a pair of spaced arms extending from opposite sides of the supporting portion. The actuating member includes a cam supporte	(Shenzhen, CN), Wu; Zhan (Shenzhen, CN)	Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/695; 361/697		
7414847	Heat dissipation device	A heat dissipation device includes a retention module surrounding a heat-generating component therein and a heat sink secured in the retention module. The retention module has a plurality of sidewalls. The heat sink includes a base positioned in the reten	Xia; Wan-Lin (Shenzhen, CN), Li; Tao (Shenzhen, CN), Tian; Wei-Qiang (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/80.3; 257/718; 257/719; 257/721; 257/727; 257/E23.086; 361/719	2008	361/704
7414848	Heat dissipation device	A heat dissipation device includes a base and two heat sinks formed by aluminum extrusion and located on the base. Each heat sink includes a heat conducting portion. The two heat sinks include a plurality of first fins extending inwardly from first faces	Zhou; Shi-Wen (Shenzhen, CN), Liu; Peng (Shenzhen, CN), Chen; Chun-Chi (Taipei Hsien, TW)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/104.33; 165/185; 174/15.2; 174/16.3; 361/700; 361/703; 361/709; 361/710	2008	361/704
7443679	Heat dissipating device having a fin also functioning as a fan holder	A heat dissipating device for cooling a heat-generating electronic device, includes a heat sink assembly (10) and a fan (20) mounted to a side of the heat sink assembly. The heat sink assembly includes a heat spreader (12), a plurality of fins (14), and h	Li; Wei (Shenzhen, CN), Wu; Yi-Qiang (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/104.33; 165/185; 165/80.3; 257/E23.084; 257/E23.088; 257/E23.099; 361/695; 361/697; 361/700	2008	361/704
7443680	Heat dissipation apparatus for heat producing device	A heat dissipating apparatus for dissipating heat generated by heat producing device, includes a base, a fin set and an axial fan. The base is secured on the heat producing device. The fin set comprises a plurality of fins arranged on the base; the fins a	Peng; Xue-Wen (Shenzhen, CN), Chen; Rui-Hua (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., lts. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/104.33; 165/185; 165/80.3; 257/E23.099; 361/695; 361/697; 361/700; 361/709	2008	361/704
7457122	Memory module assembly including a clip for mounting a heat sink thereon	A memory module assembly includes a printed circuit board (10) having a heat-generating electronic component (14) thereon, and first and second heat-dissipation plates (20), (30) attached on opposite sides of the printed circuit board. The first heat-diss	Lai; Cheng-Tien (Tu-Cheng, TW), Zhou; Zhi-Yong (Shenzhen, CN), Ding; Qiao-Li (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 257/707; 257/719; 257/E23.086; 257/E23.103; 361/715; 361/719	2008	361/704
7480144	Heat dissipation device	A heat dissipation device includes a retention module (40) and a heat sink (10) both mounted on the printed circuit board (50). The retention module forms a pair of opposite fixture blocks (44) thereon. The heat sink received in the retention module has p	Li; Dong-Yun (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/104.33; 165/104.34; 165/121; 165/80.3; 257/E23.086; 361/695; 361/697; 361/719	2009	361/704
7495917	Heat dissipation device	A heat dissipation device includes a retention module (60), a heat sink (10), a fan bracket (50), a fan (70) mounted on the fan bracket, and a pair of	Li; Dong-Yun (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN),	361/704 ; 165/185; 165/80.3; 257/718; 257/719; 257/727;	2009	361/704

		wire clips (30) cooperating with the fan bracket and the retention module to secure the heat sink to a h		Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/695; 361/703		
7515419	Locking device for heat sink	A locking device used for locking a heat sink to an electronic device, includes two clips each having a clamping portion. The clamping portion of each has a first pressing portion, a second pressing portion spaced from and in alignment with the first pres	Li; Dong-Yun (Shenzhen, CN), Li; Min (Shenzhen, CN), Yang; Hong-Cheng (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/80.3; 24/458; 361/709	2009	361/704
7564687	Heat dissipation device having a fixing base	A heat dissipation device includes a heat sink and a fixing base for securing the heat sink to a heat-generating device. The heat sink includes a base and a pair of flanges formed on two opposite sides of the base. The fixing base includes a pair of side	Liu; Jie (Shenzhen, CN), Shuai; Chun-Jiang (Shenzhen, CN), Feng; Jin-Song (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/185; 165/80.3; 257/718; 257/719; 257/727; 361/719	2009	361/704
7564688	Heat dissipation assembly	A heat dissipation assembly for dissipating heat generated by an electronic component includes a heat sink contacting the electronic component, a pair of retaining members fixed on two lateral sides of a top portion of the heat sink, a pair of arms pivota	Li; Min (Shenzhen, CN), Ma; Wu-Jiang (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/80.3; 174/16.3; 257/718; 361/719	2009	361/704
7564689	Clip for heat sink	A clip (100) includes a body (10), a handle (30) and a movable fastener (20). The body has a first end terminating in a supporting portion (16) and a second end terminating in a latching leg (14). The handle has a cam portion (32) supported on the support	Guo; Qing-Lei (Shenzhen, CN), Zhu; Shou-Li (Shenzhen, CN), Yang; Ming (Shenzhen, CN), Tong; Jun (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/185; 165/80.3; 24/459; 248/505; 248/510; 257/718; 257/719; 361/719	2009	361/704
7576987	Clip for heat dissipation device	A clip includes a body with a first end and a second end, an actuating member pivotally coupled to the second end of the body via a pivot, and a movable fastener pivotally coupled to the actuating member at a location apart from and above the pivot. The b	Lai; Cheng-Tien (Tu-Cheng, TW), Zhou; Zhi-Yong (Shenzhen, CN), Hu; Jian (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/185; 165/80.3; 174/16.3; 257/718; 257/719; 361/719	2009	361/704
7636241	Heat dissipating device	A heat dissipating device includes a heat sink, and a block. The heat sink includes a base and a plurality of fins formed on the base. A bottom portion of the base defines a first groove. The block defines a second groove in one surface of the block. The	Liu; Chang-Chun (Shenzhen, CN), Gan; Xiao-Lin (Shenzhen, CN), Ho; Yu-Kuang (Taipei Hsien, TW)	Hong Fu Jin Precision Industry (ShenZhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Hon Hai Precision Industry Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/185; 165/80.2; 257/707; 257/712; 257/718; 257/719; 361/707	2009	361/704
7639501	Heat sink assembly having a clip	A heat sink assembly includes a heat sink and a clip. The heat sink includes a base and a plurality of fins extending upwardly from a top surface of the base. The	Wang; Yi-Can (Shenzhen, CN), Lu; Cui-Jun (Shenzhen, CN), Wang; Xin-Jian (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn	361/704 ; 165/80.3; 361/710; 361/715; 361/719	2009	361/704

		clip includes a pressing body, two bending portions slantwise to the pressing body and exten		Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)			
7663884	Heat dissipation device	A heat dissipation device attached to a top surface of an electronic device mounted on a printed circuit board, includes a heat sink and a retainer securing the heat sink onto the electronic device. The retainer includes a frame, a plurality of baffle wal	Min; Xu-Xin (Shenzhen, CN), Fu; Meng (Shenzhen, CN), Chen; Chun-Chi (Taipei Hsien, TW)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/80.2; 165/80.3; 257/719; 361/719	2010	361/704
7667970	Heat sink assembly for multiple electronic components	A heat sink assembly for removing heat from two heat generating-components mounted on a printed circuit board, includes a first heat sink, a second heat sink, a plurality of poles each having a head at a top end and a double-layer spring. The first heat s	Ma; Wu-Jiang (Shenzhen, CN), Li; Min (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704	2010	361/704
7724525	Heat sink clip and assembly	A clip includes a body, a moveable fastener and an actuating member. The body includes a pressing part, a flat portion and a latching leg. The movable fastener includes a connecting portion, a pivot axis connected at a top end of the connecting portion an	Zha; Xin-Xiang (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/80.3; 24/457; 24/459; 257/718; 257/719; 257/727	2010	361/704
7746643	Heat sink assembly with a locking device	A heat sink assembly includes a heat sink having a first shoulder and a second shoulder, and a locking device having a retention module, a first clip and a second clip. The first clip has two extension portions engaging with the retention module and a pre	Li; Hao (Shenzhen, CN), Long; Jun (Shenzhen, CN), Li; Tao (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/185; 165/80.3; 174/16.3; 24/458; 24/459; 248/510; 257/719; 361/709; 361/719	2010	361/704
7764503	Heat dissipation device	A securing device includes a securing member defining a securing hole, and a fastener. The fastener includes a spring, and a bolt having a main portion, a bottom fixing portion, and a top head portion. The securing hole includes an inner portion and an ou	Zha; Xin-Xiang (Shenzhen, CN)	Fu Zhun Precision Industry (ShenZhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/121; 165/185; 165/80.3; 174/16.3; 257/718; 257/719; 361/679.47; 361/679.54; 361/695; 361/700; 361/710	2010	361/704
7796390	Fastener and heat sink assembly having the same	A heat sink assembly is mounted on a printed circuit board to dissipate heat generated by an electronic component. The heat sink assembly includes a heat sink and a plurality of fasteners fixing the heat sink to the printed circuit board. The fastener inc	Cao; Lei (Shenzhen, CN), Li; Min (Shenzhen, CN)	Fu Zhun Precision Industry (Shen Zhen) Co., Ltd. (Shenzhen, Guangdong Province, CN), Foxconn Technology Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)	361/704 ; 165/80.3; 257/718; 257/719; 361/719	2010	361/704
7843696	Heat sink assembly	A heat sink assembly includes a heat sink main body and a contact member attached to a base of the heat sink main body. The contact	Yeh; Chin-Wen (Taipei Hsien, TW), Peng; Zhi-Jian (Shenzhen, CN), Lin; Zhen-Neng (Shenzhen,	Hong Fu Jin Precision Industry (ShenZhen) Co., Ltd. (Shenzhen, Guangdong Province, CN),	361/704 ; 165/185; 165/80.3; 257/707; 257/718; 257/719; 361/719	2010	361/704

		member includes a container with thermal grease contained therein and a movable cover movably attached to the container. Th	CN)	Hon Hai Precision Industry Co., Ltd. (Tu-Cheng, Taipei Hsien, TW)				

Israel

Israel's S&T tradition predates the formation of the country in 1948. Israel is 100th smallest country with eight million population. Much of today's population has come through migration, initially from parts of Western Europe, and more recently from the Eastern Europe. The country has been war torn and security has been a great concern. Country's population has grown from a little over a million in 1949 to eight million in 2010.

The natural resource availability in the country is low with its desert climate. The economy has characterized in intermittent phases by heavy defense investment and high levels of inflation. Israel today is an OECD country and has greater economic stability and growth. Successive governments of the country have chosen to focus their efforts in select sectors.

"The country has the highest ratio of university degree holders to the population in the world, produces more papers per capita; and has one of the highest per capita rates of patents filed." Israel is also cited to lead the world in the number of scientists and technicians in the workforce proportionately to the population, with 145 per 10,000 as opposed to 85 in the US, 70 in Japan. Relative size of Israeli Universities' patenting activity far exceeds that of higher education sectors in other countries. The country has registered tremendous progress in agriculture, medical instrumentation, telecommunication, software and the like.[1]

The Government in 1949 reconstituted the Scientific Council, which coordinated research under the British Mandate. A decade later, the Council was replaced by the National Council for Research and Development, a body consisting of leading scientists, engineers, industrialists, chief scientists of government ministries and other prominent figures, who advise the government on science policy and priorities.

Israel's S&T achievement is not an outcome of master plan. It has evolved step by step, over the decades. At every stage the government capitalized on the previous achievements and unleashed the next set of facilitating measures.[2,3,4]

Israel's innovation economy:

Israel's innovation economy is a consequence of careful and measured responses to market developments and coincidence in terms of fresh inflow of immigrants and hostile environment which makes innovation indispensible.

Innovation economy typically calls for economic incentives, availability of financial capital, technical manpower and access to information. Effective government intervention is a must to facilitate these factors.

In 1968, a committee of scientists and the government noted that due to the country's lack of natural resources S&T should play an important role in the economic development. Office of the Chief Scientist (OCS) was created in 1969 in the Ministry of Industry, Trade & Labour to foster new R&D with an emphasis of industrial innovation. High concentration of skilled engineers and scientists were appropriate to think of science-based economy through financial support for commercial R&D. [2,5]

Under the leadership of OCS, Yitzhak Yaakov, the OCS gave direct grant-based support for R&D within private firms by soliciting proposals for such marketable technology development. Yaakov encouraged MNCs to perform R&D by changing the tax status of science-based firms to 'approved factory' to provide favorable tax treatment. This facilitated the growth of R&D expenditure several folds.

Arms embargo on Israel at the time of war by France forced the country to direct is resources towards technological R&D in military sector. Technology adoptions and improvisation that the military technology demands, and successive wave of internees in the military service created a talent pool with hands-on-experience and trained skills.

R&D grants from the OCS increased in the 1980s, creating new economic incentives to innovate, which in turn led to new technologies in many sectors. Israel's companies were also encouraged to develop. Grants from the government for R&D created new technologies with commercial potential. New financial vehicles were created. These include direct R&D investment partnership negotiation through grant programmes and venture capital funds which facilitated new technology startup companies

Israel government followed these external conditions with proper economic incentives and R&D funding from the OCS.

Government support to R&D schemes:

Direct grant program

This is a large R&D support program. Under this program the firms submit a grant proposal for a specific R&D project and the proposal is examined by a research committee. The grants generally cover up to 50% of the R&D budget, requiring the firms to contribute the rest. The projects are expected to be executed by applicant firms and the products are to be manufactured in Israel.

Incubator programs

Immigration from former Soviet Union was at its peak in 1991. Many of those immigrants were highly skilled, yet without the knowledge of western commercial culture. In response, the OCS launched the incubators program in 1991 to create support organizations for entrepreneurs so that they could develop innovative technological ideas and businesses around them.

Incubators help entrepreneurs at the earliest stage of development by providing guidance on -

1. Determining validity/applicability of ideas;
2. Drawing up R&D Plan and organizing an R&D team;
3. Raising capital;
4. Preparing a marketing plan.

Between 1991-2010, 24 incubators across the country graduated over 1,300 projects. Of these 57% managed to attract additional investments.

Magnet

OCS established the Magnet program in 1993 to encourage the cooperation of individual firms and academic institutions to perform generic, pre-competitive research on new technologies. MAGNET program encourages industry-academy collaboration in R&D. The grant prefers industry consortia, though individual companies are also qualified for the grant. There are currently several such consortia spanning a wide range of technologies, including communications, micro-electronics, biotechnology and energy.

Magnet program operates in four main tracks:

- Consortium - which is an R&D channel for generic technology. Generally extends from three to six years.
- Association -which caters to distribution and implementation of the technology
- Magneton - which is a technology transfer channel and the maximum duration is two years.
- Nofar - which caters to converting ideas from basic to applied research.

The government has also enacted laws to encourage industrial investment in R&D through tax exemptions, loans and discounts in different stages of the industrial life-cycle. These loans apply across the industries/projects. Equal benefits are handed out to all who apply and meet the basic criteria. This is intended to let the market forces dictate what R&D would be pursued for commercialization.[5] This policy is cited as the key factor for the development of Israel's high-tech, as it created competitive advantage in R&D intensive ICT, communication hardware, and medical devices.

OCS also encourages International Joint cooperation on R&D through bi-national industrial R&D foundation (initially with the US in 1977) which provides conditional grants. This program is extended by the launch of Israeli Industry Centre for R&D which oversees all inter - and bi- national cooperation agreements. Under this, the international companies are extended certain tax incentives to open and operate centres in Israel.

Education

There are eight universities and several dozen colleges in Israel, which are recognized and academically supervised by the Council for Higher Education in Israel.

The primary difference between a university and a college in Israel is that only a university can confer doctorate degrees, and therefore tends to be more research-oriented than the teaching-oriented like colleges.

Venture Capital

Emergence of a robust and effective venture capital policy is one of the main reasons for Israel's innovation economy. Emergence of venture capital in Israel was not a market led phenomenon. It was a concerted effort of policy makers to bridge the funding gap for startups. Target incentives have facilitated experienced venture capital agents and foreign capital to Israel. This led to the emergence of thousands of high tech startups.

Several problems such as Soviet immigration, unemployment due to restructuring of the defense industry, funding/talent gap prompted the government to shift its innovation policy - from strictly R&D promotion to a mixed prescription of R&D promotion plus growth stage support for startups. The effort was designed to create employment for the large pool of scientists/engineers and improve the Israeli industrial landscape through infusion of foreign capital and expertise.

Venture Capital policy was thought of to overcome the limitations of the grants programs in supporting companies after the development phase. The government started an insurance company called Inbal that guaranteed venture capital funds up to 70% of assets. Four venture capital funds were created and structured as publicly traded companies. This did not have the intended effect of building a venture capital industry.

Yozma scheme - initiated in 1993 - intended to build a self sustaining venture capital industry; attracting foreign venture capital firms as partners; and promoting exportable technologies in Israel.[5]

Yozma - fund of venture capital funds - gave seed capital to 10 new private, Israel venture capital funds. Each of these funds was to attract a foreign partner and one Israel bank partner and operate as a venture capital with limited partnership. In 1997 in a buyout by the five of the eight venture capital funds, Yozma venture fund was privatized.

Yozma successfully leveraged $100m of government capital into $250m of investment for 200 start-ups. More venture capital funds came up with this experience. Global companies like IBN, CISCO, Intel invested in Israel VCs as also foreign VC funds set up Israel specific funds, which led to spawning of many technologies and ventures. The proportion of startups receiving funding rose up to two-thirds in 1993 and as such ventures increased it settled down to 40-50% during the late 1990s. Thus, a cluster of high tech companies emerged alongside a responsive VC industry.

Israel has witnessed a cultural change as it moved towards market based economy. This is reflected even in the S&T ventures. Social norms now stress individualism, materialism and independence. The entrepreneur has become Israel's new hero. Israel's story is characterized by a long-term effort by the government to create a 'science economy' through support of R&D. [6]

In essence, major milestones for Israel are as follows:

- State support for R&D;
- Development of human capital;
- Development of IPR;
- Financial reforms and market liberalization;
- Venture capital policy;
- Cultural changes favouring new entrepreneurship.

Table 1 **Key economic figures for Israel**

GDP (PPP) Estimates; US$ billion at purchasing power parity										
Values	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Israel	130.39	154.63	149.20	160.86	162.10	175.95	190.38	202.10	206.7	217.84
GDP (PPP) per capita US$ per capita at purchasing power parity										
Israel	20059.38	23322.18	22136.34	23414.42	23189.67	24722.01	26281.52	27414.74	27442.56	28298.66

Source: https://www.worldcompetitiveness.com/OnLine/App/Index.htm

Currently Israel has OCS in the Ministries of Agriculture, Communications, Defense, National Infrastructure, Health and Industry & Trade in order to promote and encourage science-based high-tech industries. Each chief scientist acts as advisor to the minister on matters of industrial R&D and implements government and ministerial decisions in this area. The chief scientist is also responsible for providing financial aid to worthy R&D projects, as well as guidance and training to new enterprises and funding for industrial and technological incubators.

OCS of the Israel's Ministry of Industry, Trade and Labor is responsible for implementing the government's policy of encouraging and supporting industrial R&D in Israel. The OCS annually supports hundreds of projects from incipient concepts within a pre-seed framework followed by support of incubator and start-up companies through autonomous industrial R&D enterprises. The support is directed toward the development of novel products based on new and innovative technologies throughout the industry - well established as well as new companies - and in both the high-tech and traditional sectors. This support also extends to a broad range of cooperative ventures with foreign commercial entities.

Support to industrial competitive R&D programs operate with varying criteria, such as

R&D program period (at least one year);

Project outcome (lead to a new industrial process or a significant improvement in an existing industrial process); and

Extent of funding (partial support of the estimated R&D ranging from 20% to 50% of the estimated cost).

The Office runs several innovative international programs, including those that facilitate participation of Israeli companies in international bilateral or multilateral cooperation programs for industrial R&D. The Office also facilitates joint industrial development of advanced technologies in many advanced technologies and Israeli industrial companies seeking international cooperation.

Several innovative Government schemes to facilitate domestic R&D include:

✓ Supporting the formation of consortia made up of industrial companies and academic institutions, in order to jointly develop generic, pre competitive technologies with grants are up to 66% of the approved budget for industry and up to 80% for the academic institution. [Magnet Consortium]

- ✓ Support for R&D programs carried out by research institutes according to criteria, and provision of grants up to 90% of approved budget.
- ✓ Encouragement to companies investing heavily in R&D to invest a significant percentage of funds in long-term generic R&D, with grants up to 50% of the approved budget.
- ✓ Establishment of R&D centers in universities.
- ✓ Support to technological entrepreneurship and innovation at pre-seed stage. Under this scheme the OCS assist individual inventors and startup companies during earliest stages of projects, including evaluation of technological and financial feasibility, preparation of patent proposal for submission to authorities, construction of prototype, preparation of business plan, establishing contact with the appropriate industry representatives as well as attracting investors.
- ✓ Supporting R&D projects of Israeli companies by offering conditional grants of up to 50% of the approved R&D expenditure. If the project is commercially successful, the company shall be under the obligation to repay the grant by royalty payments.
- ✓ Program for incubators that give fledgling entrepreneurs an opportunity to develop their innovative technological ideas and set up new businesses in order to commercialize them.

The Ministry of Industry, Trade and labor also runs international support programs with bi-national funds enabling a joint R&D programme with a foreign counterpart. Such funds are earmarked for Australia, Britain, Canada, Korea, Singapore, and the USA.

The Israeli Directorate for the Framework Program provides assistance to Israeli companies and research organizations that wish to implement R&D programs with the European business and science communities.

Global Enterprise R&D Cooperation Framework encourages cooperation in industrial R&D between Israel and multi-national companies. This program shares the high risks and costs inherent in hi-tech development with the partnering companies. Joint R&D projects between MNCs and Israeli companies, authorized by the OCS, could be entitled to financial assistance of 50% of the Israeli company's R&D approved costs. Direct investments in joint R&D project with Israeli companies will be credited with 150 percent of the value of such investment for "Buy-Back" liabilities.

Table 2 **Key R&D Expenditure Figures**

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total expenditure on R&D Percentage of GDP									
4.76	4.56	4.27	4.28	4.41	4.48	4.81	4.75	4.44	4.41
Total expenditure on R&D per capita US$									
8715	777.34	7543	7907	846.72	919.67	1115.70	1304.21	1156.27	1242.77
Business expenditure on R&D US$ millions									
4318.19	3919.29	3783.13	4111.13	4599.53	5110.66	6521.58	7662.50	6912.79	7635.0
Total R&D personnel in business per capita full-time work equivalent (FTE 000)									
39.14	40.23	38.86	39.27	435	46.53	539	51.62	49.35	-
Business exp on R&D as % of GDP									
3.63	3.47	3.18	3.24	3.43	3.50	3.88	3.79	3.54	3.52
Total expenditure on R&D (US $ million)									
5661.84	5153.78	5082.13	5427.80	5918.60	6545.30	8082.12	9614.60	8682.41	9566.84

Source: https://www.worldcompetitiveness.com/OnLine/App/Index.htm

Israel scores high on both China and India in GDP per capita (PPP). It is over four times that of China and nine times that of India on this measure, indicating the relative economic success. Israel has registered a growth on this measure over the last several years. The size of the overall economy is not as much as that of China or India.

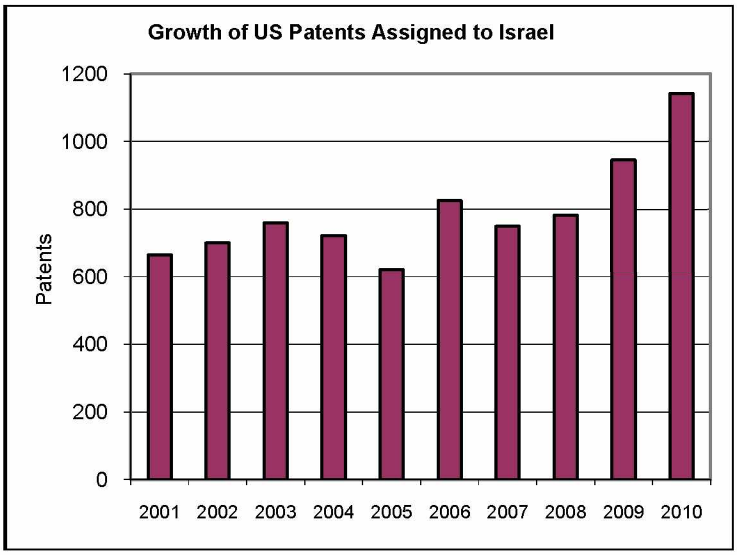
Israel's total expenditure on R&D as a proportion to GDP and per capita expenditure on R&D is way ahead of India and China. However, considering that Israel's population is small, R&D investment do not add up to big numbers. This is reflected in the business expenditure on R&D, wherein China has seven-times higher figure. Israel has six more R&D personnel for every 1000 people compared to China, and over a hundred times more than that of India.

US patents assigned to Israel - Overall growth:

Israel has been holding steady in the US patents growth during the 2001-2008 and has registered a rapid growth during 2009-2010 period. Considering that Israel is a much smaller country, the number of patents obtained is high. In fact, a longitudinal view of the total patents assigned to Israel (over the previous years) shows that the number has been growing over the last several years and from 2001 onwards it has ranged from 600 to 1142 annually, reaching a high of 1142 in 2010. This work to a CAGR of 28.11%

Table 3 **US Patents growth**

2001	665
2002	701
2003	760
2004	722
2005	621
2006	825
2007	750
2008	783
2009	947
2010	1142
Total	7916



Assignee Affiliation

The data show a distinct trend of industry dominating the patenting activity in Israel. Industrial sector obtained nearly 86% of the total patents granted by the USPTO to the country during 2001-2010 period considered for the analysis [Table 4]. Universities and research institutions also have relatively high number of patents considering that the country has only seven universities and around 50 research institutions. On the whole the trends reflect a high degree of awareness of the importance of innovation, new technology development, and patenting by various sectors.

In all there were 2,400 distinct assignees in Israel during 2001-2010 who had obtained the US patents. The patents obtained by them range from one to 293 during the period. A large majority have only one patent to their credit during the period. Yeda Research and Development Company Ltd. the commercial arm of the Weizmann Institute of Science, stands at the top of the list with 293 patents during the ten-year period under consideration. Yessum Research Development Co., a commercial arm of the Hebrew University of Jerusalem stands first among the universities with 223 patents during the same years. Teva Pharmacaetical Industries Ltd. with 275 patents stands first within the industries list.

The other major assignees in Israel are as follows:

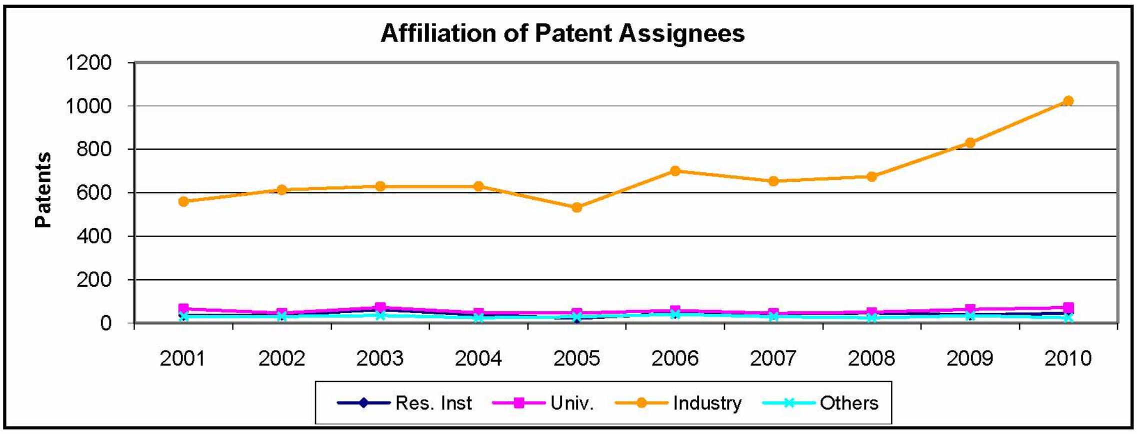
293 Yeda Reaearch and Development Co., Ltd. (Rehovot, IL)
275 Teva Pharmacaetical Industries Ltd. (Petach-Tikva, IL)
223 Yessum Research Development Co. of the Hebrew University of Jerusalem (Jerusalem, IL)
124 Applied Materials Israel Limited (Rehovot, IL)
116 Marvell Israel Ltd.
114 Saifon Semiconductors Ltd. (Netanya, IL)
112 Technion Research & Development Co., Ltd. (Haifa, IL)A
112 Ramat at Tel Aviv University Ltd. (Ramat-Aviv, IL)A
106 Iscar Ltd. (IL)
102 Sandisk IL Ltd (Kfar Saba, IL)
87 ECI Telecom Ltd (Petach Tikva, IL)

85 Given Imaging LTD (Yoqneam Ilite, IL)
78 Danziger - "Dan" Flower Farm (Moshav Mishmar Hashiva, IL)

There are 37 more entities with 20 or more patents during the period under research

Table 4 **Distribution of Assignees on Affiliation**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Res. Inst %	36 (5.4)	37 (5.3)	62 (8.2)	38 (5.3)	22 (3.5)	45 (5.5)	42 (5.6)	47 (6.0)	37 (3.9)	45 (3.9)	411 (5.2)
University %	65 (9.8)	46 (6.6)	72 (9.5)	47 (6.5)	46 (7.4)	58 (7.0)	45 (6.0)	50 (6.4)	63 (6.7)	71 (6.2)	563 (7.1)
Industry %	560 (84.2)	614 (87.6)	630 (82.9)	630 (87.3)	533 (85.8)	701 (85.0)	654 (87.2)	675 (86.2)	831 (87.8)	1024 (89.7)	6852 (86.6)
Others %	31 (4.7)	31 (4.4)	35 (4.6)	25 (3.5)	29 (4.7)	40 (4.8)	30 (4.0)	25 (3.2)	34 (3.6)	25 (2.2)	305 (3.9)
Total	665	701	760	722	621	825	750	783	947	1142	7916



Innovation in Israel's industrial sector is way ahead of India, and the growth has held out steadily over the years. In Israel, universities and research institutions have also carved a niche for themselves in innovation. Both universities and research institutions have annexed business arms to the parent organizations to deal with the IPR and technology transfer issues.

Assignee collaboration

As a rule Israeli patents are mostly inventions by single entities and collaboration in R&D of two or more entities is a relatively minor affair, both in actual numbers and as a proportion to the total. Only three per cent of the industries are joint assignees of the patents with either other firms or academic entities. This could be a result of highly specialized nature of product / process invented. The two sectors operate independently in the R&D game. This could also be due to competitive environment prevailing in the country. Collaboration at the firm level is presented in Table 6. The trend of sparse collaboration is same for industries as well.

Table 5 Collaboration among assignees

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Non-collaborative	636 (95.6)	672 (95.9)	709 (93.3)	688 (95.3)	603 (97.1)	801 (97.1)	716 (95.5)	748 (95.5)	915 (96.6)	1092 (95.6)	7580 (95.8)
Collaborative	29 (4.4)	29 (4.1)	51 (6.7)	34 (4.7)	18 (2.9)	24 (2.9)	34 (4.5)	35 (4.5)	32 (3.4)	50 (4.4)	336 (4.2)
Total	665	701	760	722	621	825	750	783	947	1142	7916

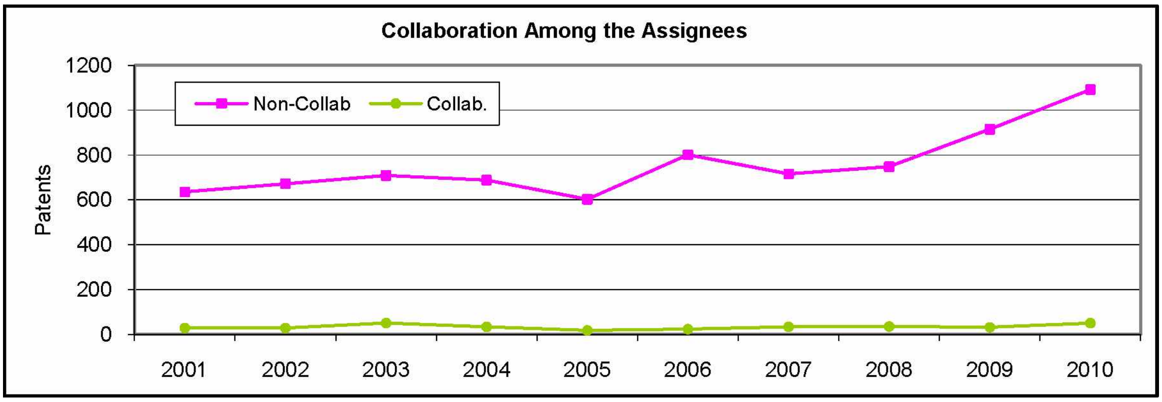


Table 6 - **Distribution of Assignees on Firm Level Collaboration**

	Industry (non-collab) %	Inter Industry (collab) %	Industry-Res. Inst (collab) %	Industry-Univ. (collab) %	Total
2001	539 (96.4)	4 (0.7)	7 (1.3)	9 (1.6)	559
2002	592 (97.4)	4 (0.7)	7 (1.2)	5 (0.8)	608
2003	605 (96.3)	9 (1.4)	6 (1.0)	8 (1.3)	628
2004	614 (97.9)	9 (1.4)	1 (0.2)	3 (0.5)	627
2005	525 (98.9)	4 (0.8)	1 (0.2)	1 (0.2)	531

2006	683 (98.1)	4 (0.6)	5 (0.7)	4 (0.6)	696
2007	635 (97.4)	5 (0.8)	6 (0.9)	6 (0.9)	652
2008	651 (96.9)	17 (2.5)	1 (0.1)	3 (0.4)	672
2009	808 (97.5)	15 (1.8)	2 (0.2)	4 (0.5)	829
2010	981 (96.2)	25 (2.5)	6 (0.6)	8 (0.8)	1020
Total	6633 (97.2)	96 (1.4)	42 (0.6)	51 (0.7)	6822

International Collaboration

Israel's non-collaborative feature in R&D at the firm level seems to hold good for foreign collaboration also (Table 7). A few collaborations noticed are mostly with firms in the USA. Israel has considerable MNC R&D presence. However, all the patents obtained by those firms may not figure in the present list, as they are not necessarily assigned to Israel.

Table 7 Distribution of Assignees – Foreign collaboration

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Foreign Collab	10	8	25	16	7	9	14	9	17	30	145
% of total Patents	1.5	1.1	3.3	2.2	1.1	1.1	1.9	1.1	1.8	2.6	1.8

Distribution of assignees collaboration to academic bodies

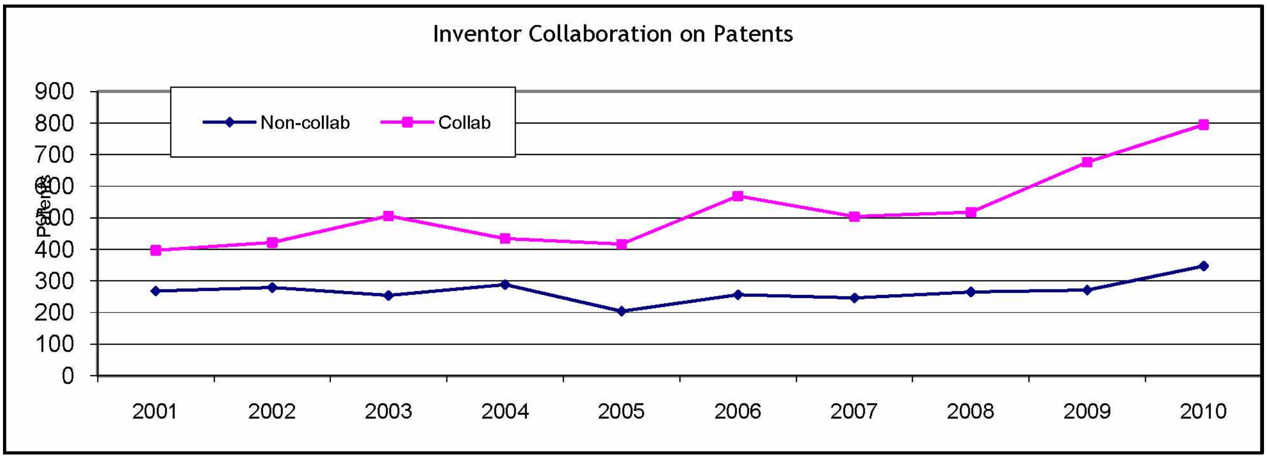
	Res. Inst. Total	Ind-Res. Inst [collab]	Res. Inst [Non-collab]	Res. Inst [collab]	Res. Inst-Univ. [collab]	Univ. Total	Ind-Univ. [collab]	Univ [non-collab]
2001	36	7	22	1	7	65	9	44
2002	37	7	21	1	7	46	5	33
2003	62	6	38	1	13	72	8	44
2004	38	1	23	3	11	47	3	31
2005	22	1	15	1	5	46	1	38
2006	45	5	37	0	3	58	4	49
2007	42	6	27	3	6	45	6	33
2008	47	1	42	1	3	50	3	39
2009	37	2	23	4	5	63	4	47
2010	45	6	33	1	5	71	8	55
	411	42	281	16	65	563	51	413

Inventor Collaboration

It is interesting to see the collaboration among the inventors who have worked for the technology that resulted in the patents (Table 8).

Table 8 - Inventor Collaboration

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Non-Collaborative %	268 (40.3)	279 (39.8)	254 (33.4)	288 (39.9)	204 (32.9)	256 (31.0)	246 (32.8)	265 (33.8)	271 (28.6)	347 (30.4)	2678 (33.8)
Collaborative %	397 (59.7)	422 (60.2)	506 (66.6)	434 (60.1)	417 (67.1)	569 (69.0)	504 (67.2)	518 (66.2)	676 (71.4)	795 (69.6)	5238 (66.2)
Total	665	701	760	722	621	825	750	783	947	1142	7916



One-third of the Israeli patents are technologies developed by sole inventors. These include most of the plant patents, design patents, medical instruments and electronic gadgets, security devices, etc. However, considerable share (66.2%) of their innovation is based on teamwork. The proportion of sole inventor and team based invention seems to have stabilized over the years. Such collaborations are with team size of 2 to 5 inventors, and only a much smaller proportion have larger teams. Mostly these teams are of two or three inventors (Table 9).

Table 9 **Distribution of inventors**

No of Inventors	Patents	% of the Total
1	2678	33.83
2	2188	27.64
3	1455	18.38
4	839	10.60
5	431	5.44
6>	336	4.24

An interesting piece of data that comes along with this is the number of distinct inventors. As could be discerned from the pool of patents examined, Israel had 9,475 successful inventors for the period (Table 10). A large proportion of inventors hold only one or two patent (or part thereof) rights. The minor inventor share is as high as

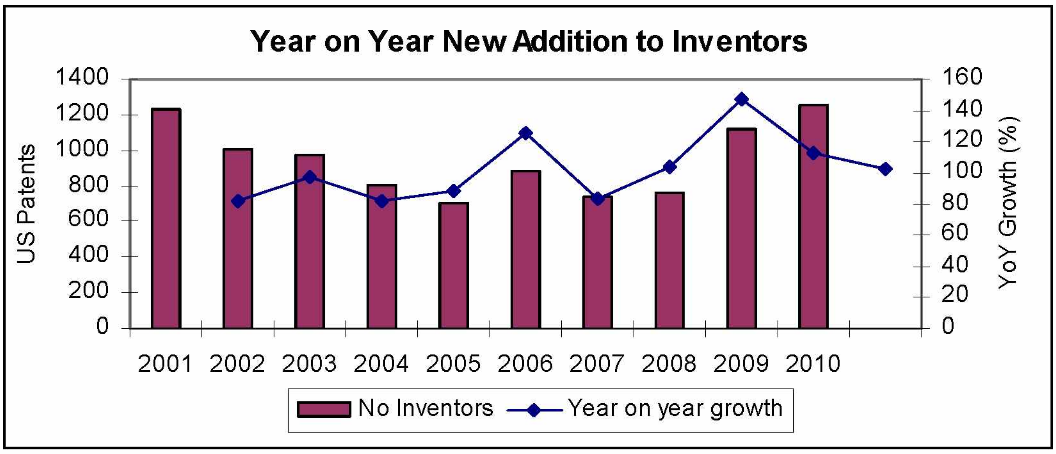
84% in Israel. This indicates that invention activity is not skewed towards a few big players. Many of these could be new patent holders and given due assistance they could be more productive on this front. The per capita patents work out to be 0.84 per inventor in Israel.

Israel has a relatively large inventor base. Country has also maintained a steady growth by adding new inventors to this stock on year on year basis. The country registered a CAGR of 22.68% new inventors during the decade (Table 10). There were around 800 to 1,000 new inventor additions from the country appearing on the US Patent scene every year during the period.

Table 10 Inventor Growth

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010		
Now Inventor s	1227	1005	975	803	705	887	734	764	1120	1255		9475
Year on year growth (%)		81.91	97.01	82.36	87.8	125.82	82.75	104.09	146.6	112.05	102.26	

CAGR 22.68%

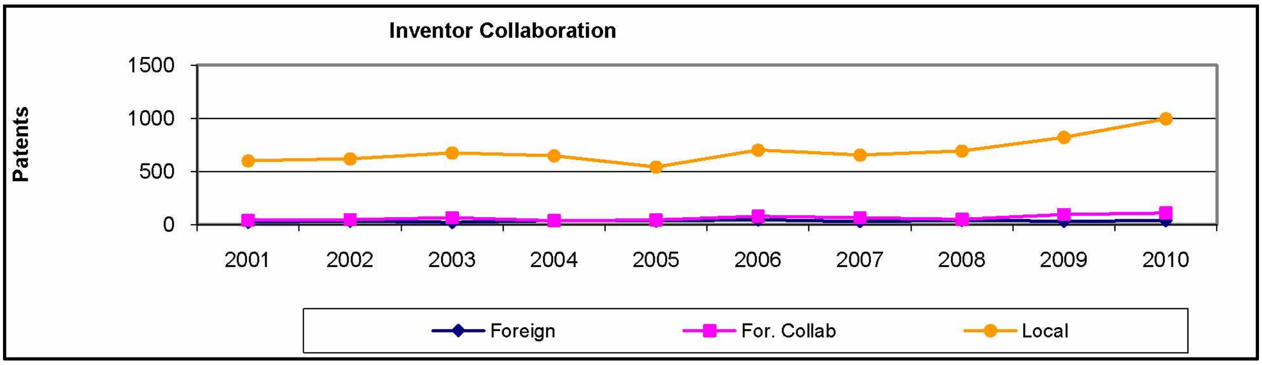


Outsourced Innovations

Nearly 90% of the Israeli patents emanate from the local inventors, working singly or in team with other local inventors (Table 10). Over the ten-year period only 4% of the total (335) patents assigned to Israel were exclusively the products of non-Israeli inventors, and 635 more (8%) were outcome of foreign collaboration. Together they make up about 12 per cent of the total.

Table 11 **Distribution on inventor Collaboration**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Foreign Inventor %	23 (3.5)	35 (5.0)	21 (2.8)	37 (5.1)	35 (5.6)	45 (5.5)	29 (3.9)	41 (5.2)	31 (3.3)	38 (3.3)	335 (4.2)
Foreign Collaboration %	42 (6.3)	47 (6.7)	65 (8.6)	37 (5.1)	44 (7.1)	79 (9.6)	66 (8.8)	50 (6.4)	96 (10.1)	109 (9.5)	635 (8.0)
Local %	600 (90.2)	619 (88.3)	674 (88.7)	648 (89.8)	542 (87.3)	701 (85.0)	655 (87.3)	692 (88.4)	820 (86.6)	995 (87.1)	6946 (87.7)
Total	665	701	760	722	621	825	750	783	947	1142	7916

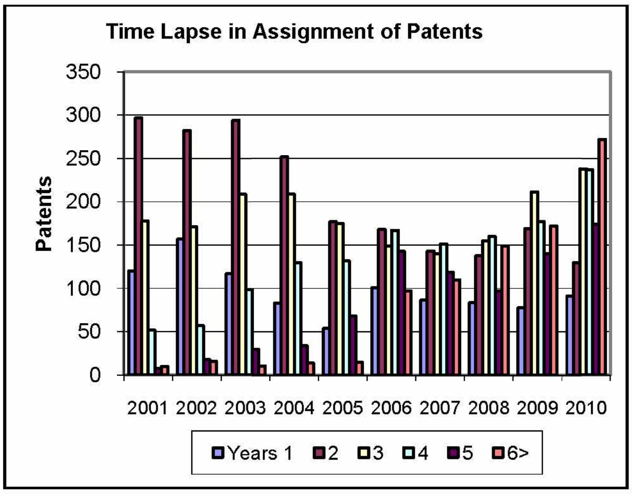


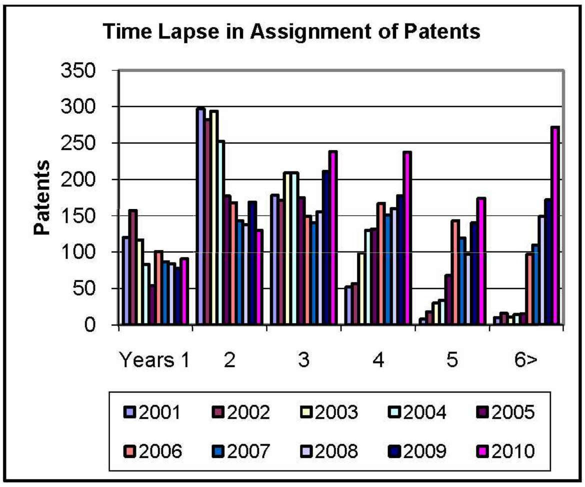
How soon were the patents assigned?

On an average US patents filed by Israel taken four years to be granted the rights. Over 40% of them take more than four years for the process (Table 12). This proportion has more or less remained the same over the years. This duration is also an indication of the patent quality, as patents embodying more recent technologies call for thorough evaluation before being granted the rights.

Table 12 **Time Duration in Obtaining US Patents**

	Years 1	2	3	4	5	6>	
2001	120	297	178	52	8	10	665
2002	157	282	171	57	18	16	701
2003	117	294	209	99	30	11	760
2004	83	252	209	130	34	14	722
2005	54	177	175	132	68	15	621
2006	101	168	149	167	143	97	825
2007	87	143	140	151	119	110	750
2008	84	138	155	160	97	149	783
2009	78	169	211	177	140	172	947
2010	91	130	238	237	174	272	1142
	972	2050	1835	1362	831	866	7916



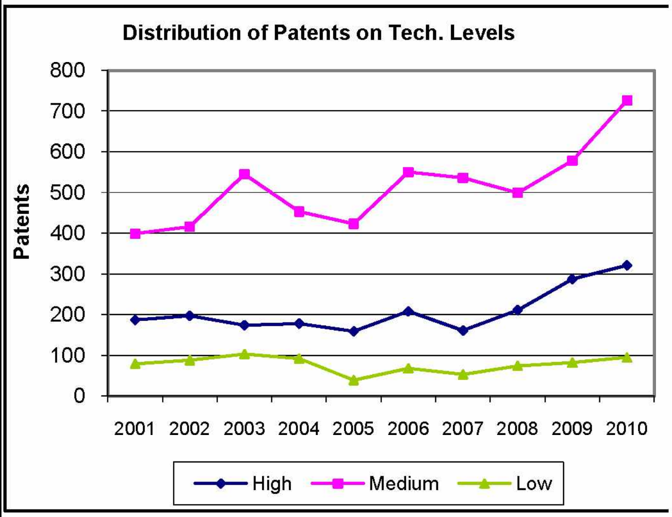


Technology level of patents

Low technology patents form a small proportion with less than 10% of the total US patents granted to Israel. Two-thirds of the total could be grouped as medium technologies and nearly one-fourth of them belong to high technologies (Table 13).

Table 13 **Distribution of patents on Technology Levels**

	High %	Medium %	Low %	
2001	187 (28.1)	399 (60.0)	79 (11.9)	665
2002	197 (28.1)	416 (59.3)	88 (12.6)	701
2003	174 (22.9)	545 (71.7)	103 (13.6)	760
2004	178 (24.7)	453 (62.7)	92 (12.7)	722
2005	159 (25.6)	423 (68.1)	39 (6.3)	621
2006	208 (25.2)	550 (66.7)	68 (8.2)	825
2007	161 (21.5)	536 (71.5)	53 (7.1)	750
2008	211 (26.9)	499 (63.7)	74 (9.5)	783
2009	287 (30.3)	578 (61.0)	82 (8.7)	947
2010	321 (28.1)	726 (63.6)	95 (8.3)	1142
	2083 (26.3)	5125 (64.7)	773 (9.8)	7916



The low technology patents include products such as combination locks, bracelet, faucet, bed, key chain etc. Medium technology patents include those relating to software procedures, plants - mainly cultivars - cryptographic methods, engineering and electrical equipment make up two-thirds of the total. The rest make up high technology category. Israel high technology patents are larger in number compared to India and China. These fall under medical equipment, biotechnology, pharmaceutical, semi-conductor devices, and others. There is relatively a slower growth that could be noticed in the number of patents obtained in this category. Higher growth in patents could be noticed in medium technologies.

Israel is not only holding steady with the number of patents obtained in the USPTO, but has also retained a consistent distribution on the technology levels. Israel has a high proportion of medium technology patents. It is also higher in absolute terms compared to India in high tech patents. The actual difference in the patent performance lies in medium and low technologies.

Israel is at a higher plane in innovation activities and it seems to be the result of growth registered in the previous decades. The following are some of the typical high technology patents from the universities and research institutions:

Tumor necrosis factor alpha (TNF-.alpha.) inhibiting pharmaceuticals. [2003] 6545041
Post-natal administration of activity-dependent neurotrophic factor-derived polypeptides for enhancing learning and memory [2008] 7427598
Jasmonate derivative compounds, pharmaceuticals compounds and methods of use thereof [2008] 7425651
Anti-cancer therapeutic compounds.[2007] 7285536
Veto cells effective in preventing graft rejection and devoid of graft versus host potential. [2007] 7270810
Thermoanaerobacter brockii alcohol dehydrogenase promoter for expression of heterologous proteins [2007] 7264946
IFN receptor 1 binding proteins, DNA encoding them, and methods of modulating cellular response to interferons [2007] 7264945
Method and apparatus for multivariable analysis of biological measurements [2007] 7225172
Interleukin-18 binding proteins, their preparation and use [2007] 7220717
Avidin derivatives and uses thereof [2007] 7217575
IL6RIL6 chimera for the treatment of neurodegenerative diseases . 2007] 7201896
Spinal prostheses [2009] 7537613
Formation of substances by mechanical breaking of carbon-carbon chains molecules 2009 7541503
Letrozole production process [2009] 7538230
Inserting anterior and posterior spinal prostheses [2010] 7736369
Hydrogel functionalized with a polymerizable moiety and their uses as biosensors or bioreactors [2010] 7737240

Medium technologies make up a sizeable portion of the Israeli patent portfolio. Industries have the most of this category patents. These are the improvements in embedded software, improvements in the devices, plants, electronic equipment and the like. Typical Medium technology patents from the industry sector are listed below:

Mask programmable read-only memory (ROM) cell 6809948
General purpose interpreter and database for accessing enterprise servers over an internet protocol network 6807549
Data quality assurance [2004] 6804778
Encoding semi-structured data for efficient search and browsing [2004] 6804677
Pet and spect systems with attenuation correction [2004] 6803580
Three-phase transformer [2004] 6792666
Mobile collect call system and method [2004] 6792261

Expandable orthopedic device [2004] 6783530
Broadcast protocol for local area networks [2004] 6781953
Buffer switch having descriptor cache and method thereof [2005] 6941392
Method for the treatment of bedsores using electrical impulses [2005] 6941173
Modem channel sharing based on frequency division [2006] 7151794
Breath test apparatus and methods [2003] 6656127
Wavefront method for designing optical elements [2003] 6655803
Method and apparatus for optimizing inkjet fluid drop-on-demand of an inkjet printing head [2003] 6655795
Soil disinfecting device [2003] 6655082

Israel also has 388 design patents (Table 14). These include several ornamental designs of the products such as office supplies, pens and such accessories. Firm level collaboration in patenting is consistently low and is visible only with those categorized as high technologies. Even here they just make up only around 10 % of the total.

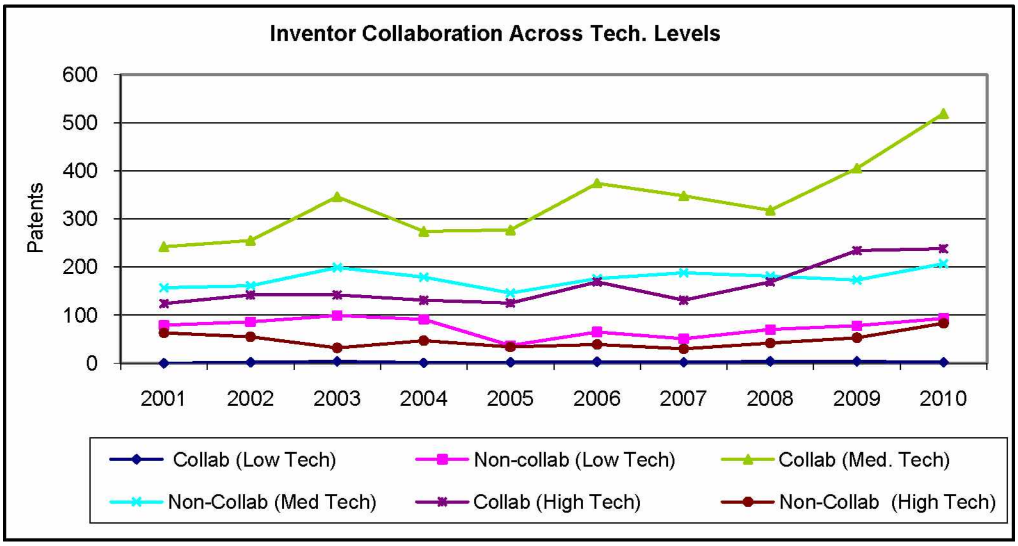
Inventor collaboration is relatively less in low technology patents of Israel, which works out to be approximately 40% overall. Collaboration of inventors is nearly 77% in high technology patents (Table 15). This distribution is more or less consistent over the period of analysis. A small proportion of the patents in all levels have exclusive non-Israeli inventors (Table 16). It totals to 216 in medium technology and 83 in high technology. The foreign collaboration in inventions at different levels is limited and is to the tune of 6.8% (350) in medium technology and 12.6% (282) in high technology for the entire decade.

Table 14 **Distribution of Low Tech patents**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Design Patents %	28 (35.4)	39 (44.3)	23 (22.3)	32 (34.8)	23 (59.0)	33 (48.5)	36 (67.9)	58 (78.4)	57 (69.5)	59 (62.1)	388 (50.2)
Others %	51 (64.6)	49 (55.7)	80 (77.7)	60 (65.2)	16 (41.0)	35 (51.5)	17 (32.1)	16 (21.6)	25 (30.5)	36 (37.9)	385 (49.8)
Total	79	88	103	92	39	68	53	74	82	95	773

Table 15 **Inventor Collaboration on Across Technology Level Categorization**

	Low			Medium			High		
	Collab %	Non-Collab %	Total	Collab	Non-Collab %	Total	Collab %	Non-Collab %	Total
2001	0 (0.0)	79 (100)	79	242 (60.7)	157 (39.3)	399	124 (66.3)	63 (33.7)	187
2002	2 (2.3)	86 (97.7)	88	255 (61.3)	161 (38.7)	416	142 (72.1)	55 (27.9)	197
2003	4 (3.9)	99 (96.1)	103	346 (63.5)	199 (36.5)	545	142 (81.6)	32 (18.4)	174
2004	1 (1.1)	91 (98.9)	92	274 (60.5)	179 (39.5)	453	131 (73.6)	47 (26.4)	178
2005	2 (5.1)	37 (94.9)	39	277 (65.5)	146 (34.5)	423	125 (78.6)	34 (21.4)	159
2006	3 (4.4)	65 (95.6)	68	374 (68.0)	176 (32.0)	550	169 (81.3)	39 (18.8)	208
2007	2 (3.8)	51 (96.2)	53	348 (64.9)	188 (35.1)	536	131 (81.4)	30 (18.6)	161
2008	4 (5.4)	70 (94.6)	74	318 (63.7)	181 (36.3)	499	169 (80.1)	42 (19.9)	211
2009	4 (4.9)	78 (95.1)	82	405 (70.1)	173 (29.9)	578	234 (81.5)	53 (18.5)	287
2010	2 (2.1)	93 (97.9)	95	519 (71.5)	207 (28.5)	726	238 (74.1)	83 (25.9)	321
	24 (3.1)	749 (96.9)	773	3358 (65.5)	1767 (34.5)	5125	1605 (77.1)	478 (22.9)	2083



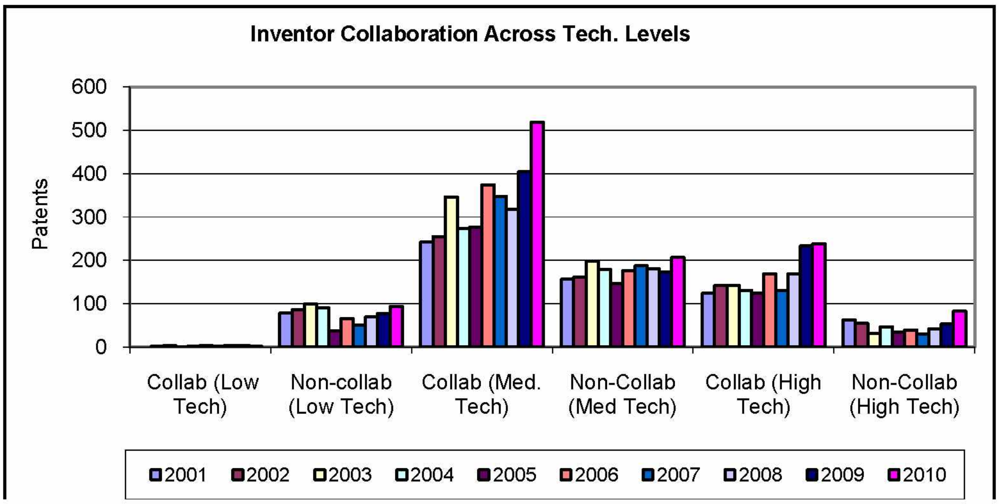
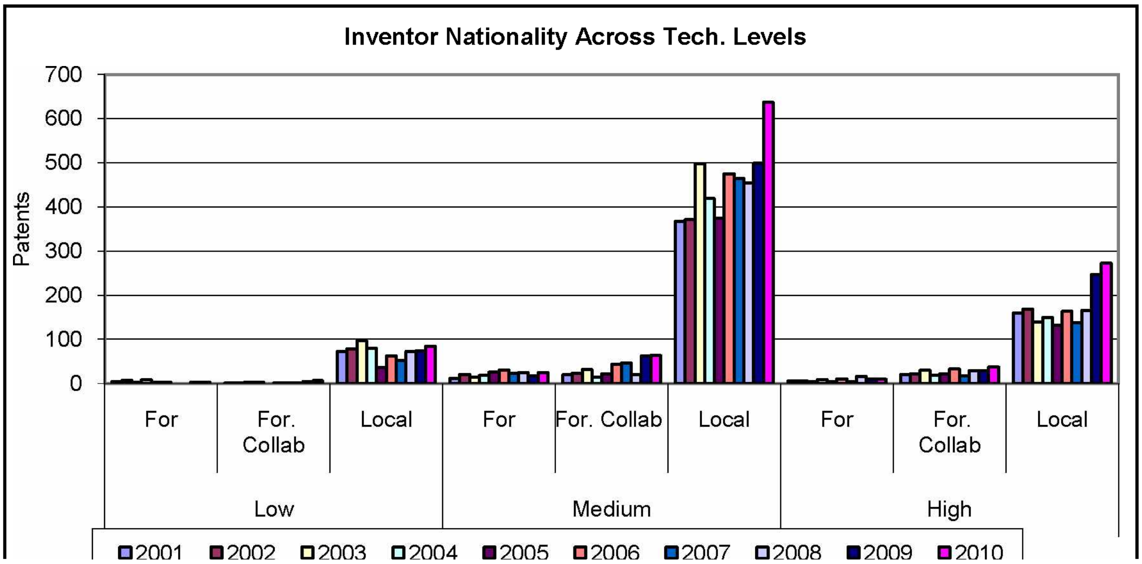


Table 16 Inventor Nationality												
	Low				Medium				High			
	Foreign %	Foreign Collab %	Local %	Total	Foreign %	Foreign Collab %	Local %	Total	Foreign %	Foreign Collab %	Local %	Total
2001	5 (6.3)	1 (1.3)	73 (92.4)	79	12 (3.0)	20 (5.0)	367 (92.0)	399	6 (3.2)	21 (11.2)	160 (85.6)	187
2002	8 (9.1)	1 (1.1)	79 (89.8)	88	21 (5.0)	24 (5.8)	371 (89.2)	416	6 (3.0)	22 (11.2)	169 (85.8)	197
2003	3 (2.9)	3 (2.9)	97 (94.2)	103	15 (2.8)	32 (5.9)	498 (91.4)	545	4 (2.3)	31 (17.8)	139 (79.9)	174
2004	9 (9.8)	3 (3.3)	80 (87.0)	92	19 (4.2)	15 (3.3)	419 (92.5)	453	9 (5.1)	19 (10.7)	150 (84.3)	178
2005	3 (7.7)	0 (0)	36 (92.3)	39	27 (6.4)	22 (5.2)	374 (88.4)	423	5 (3.1)	22 (13.8)	132 (83.0)	159
2006	3 (4.4)	2 (2.9)	63 (92.6)	68	31 (5.6)	44 (8.0)	475 (86.4)	550	11 (5.3)	33 (15.9)	164 (78.8)	208
2007	0 (0)	1 (1.9)	52 (98.1)	53	24 (4.5)	47 (8.8)	465 86.8)	536	5 (3.1)	18 (11.2)	138 (85.7)	161
2008	0 (0)	1 (1.4)	73 (98.6)	74	25 (5.0)	20 (4.0)	454 (91.0)	499	16 (7.6)	29 (13.7)	166 (78.7)	211
2009	3 (3.7)	5 (6.1)	74 (90.2)	82	17 (2.9)	62 (10.7)	499 (86.3)	578	11 (3.8)	29 (10.1)	247 (86.1)	287
2010	3 (3.2)	7 (7.4)	85 (89.5)	95	25 (3.4)	64 (8.8)	637 (87.7)	726	10 (3.1)	38 (11.8)	273 (85.0)	321
	37 (4.8)	24 (3.1)	712 (92.1)	773	216 (4.2)	350 (6.8)	4559 (89.0)	5125	83 (4.0)	262 (12.6)	1738 (83.4)	2083



Thus, Israel's low and medium technology is mostly homegrown and depends very less on foreign collaboration with 90% of the patents being local in all aspects. Israel's foreign collaboration is more in patents categorized as high technologies compared to other groups, with 17% of them coming from foreign inventors, either as exclusively responsible for invention or collaborated with local R&D personnel for the same.

Israel's inventors have clearly earmarked sectors like software, medical instrumentation, and agriculture, among others, for major innovation activities. They seem to have made the best of available technical manpower, considering Israel is a small country with smaller population base.

Israel has shown different ways of enhancing innovation. They have consistently exercised the technology option. Israel has vigorously administered the government grants for R&D, and even encouraged MNC collaboration in R&D through official grants.

Patents across assignee affiliation

Israel has only seven universities and around 50 research institutions. Most of these public research bodies focus on agriculture or pure sciences which the industry may not be keen to pursue.

Both Universities and research institutions in Israel have patented inventions greater proportion of which classify as high technology (Table 17). They mainly fall in the discipline of biotechnology, chemical sciences, drugs and pharmaceuticals or medical science. The inventions are lab based research and are in the cutting edge disciplines of science and technology.

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Table 17 **Distribution of Patents Across Assignee Affiliation**

	Industry	Res. Inst	Univ.	Others
Low	703 (92.99)	2 (0.26)	2 (0.26)	49
Medium	4660 (90.49)	111 (2.16)	185 (3.59)	194
High	1489 (66.92)	298 (13.39)	376 (16.90)	62

Most of the medium technology patents and whatever that could be categorized as low technology patents have been taken by the industrial sector in the country. They are in the area of software, embedded software/ electronics, and plant patents.

The high tech patents from the industry are in the domain of pharmaceuticals, drug discovery, medical instrumentation, semi-conductor devices, and some nanotechnologies. Israel's patents fall under more number of sub-classes in the US patent classification system, however, most of these sub-classes comes from fewer main classes. This indicates the focus of the R&D development in Israel and at the same time, the expanse of the research within these selected areas for research and technology development.

Subject Classification of Patents

The analysis also explored the patents based on the USPTO subject classification to understand the subject spread. Generally a string of subject class numbers are assigned to patents, the first among them being the prominent one highlighted. Based on the criterion of prominent subject category Israel's patents could be categorized under 217 main classes of USPTO classification (Table 18). The major categories listed below make up one-third of the patents (Table 19).

Distribution of patents in 217 main classes and 4372 sub-classes reflects a span of invention spreading over a wide variety of products and processes. Six of these have over 200 patents which are unique to the subject class. This reflects specialization and clustering of R&D on the subject. The focal areas of Israeli patents during the decade were drugs, electrical computers / data processing, chemistry, medical equipment, multiplex communication and others (Table 19).

Table 18 **Distribution of patents on USPC main classes**

Patents	No of distinct USPC main classes
> 200	6
150-200	2
100-150	8
50-100	23
40-49	9
30-39	20
20-29	30
10-19	36
9	8
8	14
7	15
6	15
5	18
4	24
3	29
2	37
1	57

Table 19 - **Major areas of innovation by Israel**

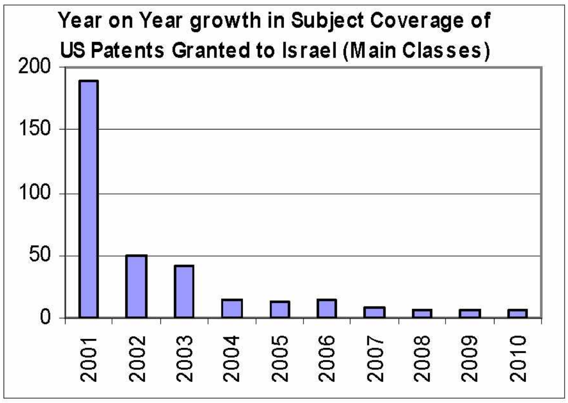
Drugs (US Patent Subject Class 414,514)	629
Electrical Computers & Data/Digital Processing (709)	148
Chemistry	217
Medical Equipment (600 to 607, 228)	368
Multiplex communications (370)	372
Radiant energy (250)	225
Bio-chemistry (435)	217
Optics: measuring and testing (356)	174
Image analysis (382)	174

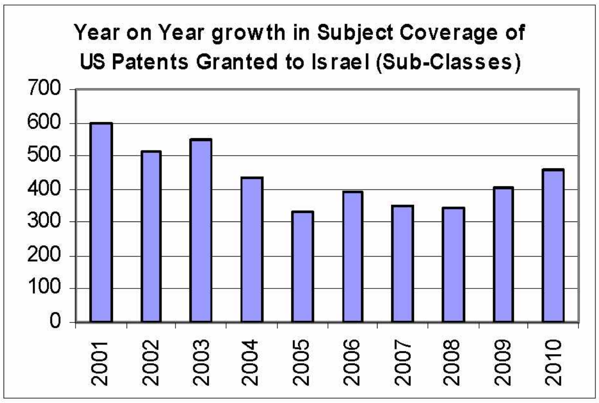
Subjectwise Growth of Patents

Data were analyzed to examine the growth of the subject base over the period. Expansion in the main classes over the period was slow with a CAGR of 6.39%. Addition of new sub-classes on the other hand has been vigorous. The CAGR of the sub-classes has been 22.07% over the decade (Table 20). The patent activity has been to look out for new focus and niche areas within the main classes already specialized in.

Table 20 Growth of Subject Patents

Year	Main Classes	Sub-classes
2001	189	595
2002	50	513
2003	42	550
2004	14	434
2005	13	334
2006	15	393
2007	8	349
2008	7	341
2009	6	402
2010	7	461
CAGR	6.39%	22.01%





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Unique Assignees

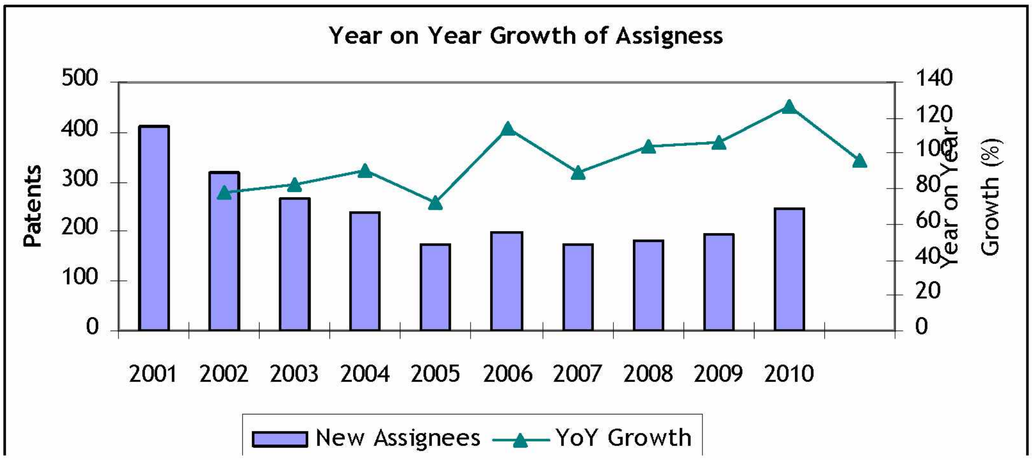
Distribution on assignees (Table 21) and the corresponding number of patents bring out that Israel has more distinct assignees, compared to other countries examined in the study. The difference is particularly noticeable in the category of those who have obtained single patent during the decade. This is to show that it is not a few who dominate the innovation in Israel. The activity is distributed widely from quite a few small patent holders to a few large ones.

Table 21 Distribution of Patents on Assignees

Distinct Assignees	US Patents
10	>100
1	90-99
2	80-89
2	70-79
2	60-69
4	50-59
6	40-49
6	30-39
18	20-29
73	10--19
123	6--9
270	3--5
327	2
1556	1

Table 22 Growth of New Assignees

Year_	New Assignees	YoY Growth
2001	411	
2002	320	77.86
2003	265	82.81
2004	239	90.19
2005	172	71.97
2006	196	113.95
2007	175	89.29
2008	182	104.00
2009	194	106.59
2010	246	126.80
		95.94
	2,400	
CAGR	19.30%	



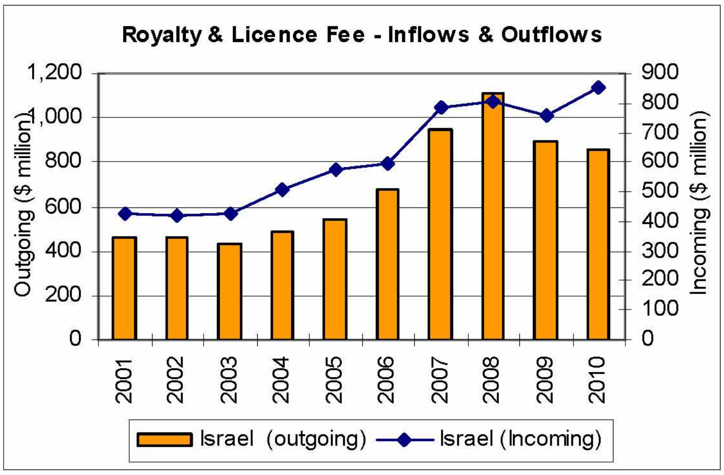
Israel has on the whole 2,400 unique assignees during the decade. There are 10 entities with over 100 patents and on the bottom end 1,556 entities with one patent each during the decade.

There is also continuous new addition to these entities on an annual basis, with a CAGR of 19.30%. There has been a continuous flow of new assignees. This is an impact of available R&D grants and incubator programmes which encourage entrepreneurs to the IPR mode (Table 22).

Royalty & Licence fee Payment

Table 23 Inflows & Outflows of Royalty and Licence fees

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
(outgoing) $ million	460	462	433	491	542	681	948	1,107	897	860
(Incoming) $ million	425	420	425	505	574	593	785	804	761	849



As we know, patents are essentially new technologies. They need to be harnessed for their monitory worth, where possible, at the earliest. As the individual licensing and the earnings on patents are hard to come by, the study examined the overall inflows and outflows of royalty and license feel for the 2001-10 period. Outgoing royalties indicate the new technologies sourced on payment, where as the incoming earnings indicate the local technologies transferred for a gain. The trend (Table 23) reflects an overall balance on this count. This trade balance is significant as, on technology terms the give and take are the same. Israel is not adversely dependent on foreign countries for technology.

Israel's is a case of optimum utilization of technological manpower and invention capacity. The country's invention footprint is widespread, purposive and based on, what seems to be, imaginative use of R&D grants from the government.

Summary

In essence, Israel's efforts in innovation and patenting could be summarized as follows:

- Giving pride of place Office of Chief Scientists
- Direct grant to industries, including to collaborate with MNCs
- Encouragement to Industry + academy collaboration in pre-competitive research through grants
- Variety of incubator programmes
- Bi-national R&D collaboration
- Venture capital through publicly managed funds
- Patents driven by solo inventors
- Extensive government funding as grants
- High per capita investment on R&D
- Focus on select niche areas -
    - Plants, drugs & pharmaceuticals, software, communication, medical instruments etc.
- Benchmark performance on other OECD countries

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Medical Devices Patents of Israel – A Case study

Israel has been seeking to explore new areas of innovation. Over the years Israel has obtained US patents dealing with 217 major and 4,372 specific subject categories, as per the US patent subject manual. In the past decade Israel has sought to move into innovation in medical devices in a significant manner. The growth of US patents obtained in this areas has been steady, though modest in number compared to the leaders in this technology. Medical patents are classed under numbers 128, 600, 604, 606, 607, and 623. Israel manufactures 0.29% of the world share of medical equipment. The country's share of medical equipment in terms of US Patents is a little more than one percent of the total. Israel is a late comer to this area of specialization (Table 1).

The official information from the Israel reveals that the country's medical equipment manufacturing has a turnover of $ 1.2 billion, which is a fraction of the world output. However, growth in number of patents obtained and also the range of specific topics covered indicate the Israel's strategy to equip themselves for the activity. There are over 600 [http://www.matimop.org.il/database.aspx?text=&keys=&address=&tech=0&app=38] business enterprises in Israel devoted to this activity. The largest sub-sector of the medical device industry is therapeutic devices. The remaining sub-sectors include diagnostic, monitoring, medical equipment, imaging and drug delivery. The leading medical product offerings of Israeli companies include cardiology, oncology, neurology, neurodegenerative disease, ophthalmology and orthopedic. Major markets for the medical devices industry are: 48% export to North America, 31% to the EU, and 17% to Asia.
[http://www.investinisrael.gov.il/NR/exeres/56EBCC44-CB88-4102-B791-BAC6C4C0604B.htm]

Among the oft cited Israeli products/ achievements in this sector include, a new engineered substance called Gelrin or 'bone glue' was developed at the Haifa Technion-Israel Institute of Technology. Gelrin fuses biological and synthetic substances at the molecular level and speeds bone and cartilage repair by stimulating tissue development. Breakthrough in cardiac regenerative medicine by discovering a biological pacemaker made from embryonic stem cells is another noteworthy example.

The Wide Beam Reconstruction Technology creates a stack of images that are transferred to a workstation where physicians can review a 3D model. Israel has also contributed to novel products such as WristClinic - a compact all-in-one wireless remote medical monitoring system for telemedicine and homecare applications.

As new entrant to the innovation which the focus, Israel could at best fill in the gaps that exist in the technology areas which has already been 'patent walled'. The Table 2 shows that on all the sub-topics identified Israel has only a miniscule of patents in the 2001-2010 period.

Table 1 US Patents on Medical Devices granted to Israel (inclusive of Class nos 601 to 607)

Years	US Patents
1981-85	12
1986-90	12
1991-95	56
1996-00	133
2001-05	268
2006-10	369

Medical device market overview

Medical devices include a wide range of products: including laboratory apparatus; surgical and medical instruments; surgical appliances; dental equipment; prosthetics; medical imaging; wearable medical equipment; special furniture and the like. Medical devices have a wide spread market potential across the countries going with the population size.

Medical device sector is a $190 billion industry. Top 20 companies in the sector, according to one estimate, account for a large proportion of the revenue. Because of the demographic focus in Asia (China and India, in particular, with their sizeable population) and changes in age profile of the population world over, substantial trade on the equipment also happens in other parts of the world.
Table 2

Israel's and the world Share of US Patents (in subjects in which Israel has obtained patents)

	Israel	World
600	366	26056
601	27	986
602	4	792
604	87	8230
606	127	15952
607	77	8420

Complete list is annexed at the end

The US, European Union, and Japan manufacture over 90% of the medical equipment. (Table 26)

Table 3 Medical equipment manufacturers

Countries	**% of the total**
US	56
European Union	30
Japan	10
Others	9

The US and the European Union produce a wide range of medical devices. The sector invests highly on R&D ranging from 10 – 13% of sales in the US and 6% of the sales in Europe. There has been special focus within the medical devices by the countries going with the relative strengths. Japan has traditionally focused on diagnostic imaging and endoscopy. The firms in this activity on the whole invest 6% of their turnover on R&D.

Traditionally innovation in this sector has centered in the countries which manufacture the equipment, though, of late, these activities have spread to other areas.

Due to advances in a wide spectrum of S&T innovation with medical focus has grown tremendously. There are as many as 58,534 US patents granted in the classes such as 600 to 607 during the 2001-10 to various countries.

With the use of semiconductors and advances in imaging technologies, scope for innovation in medical devices has increased. Given the need for sophisticated equipment and dissemination of them through appropriate social policies, innovation per se has become a source of revenue to countries like Singapore, Israel, and a few others.

The top 15 companies have also built a substantial innovation reserve and a corresponding patent wall (Table 4).

Table 4 Patents assigned to leading medical instrumentation firms

Top Medical Device Manufacturers	No. of US patents assigned 2012)
Medtronic	5488
Baxter International	2665
Becton Dickinson & Co	2644
Boston Scientific	2618
Siemens Medical Solutions	1555
B. Braun	1478
Tyco Healthcare	1078
Zimmer Holdings	1038
Smith & Nephew	769
St. Jude Medical	663
Fresenius	480
GE Health	344
3M Healthcare	144
Cardinal Health	64
Hospira	58

Classification of medical devices

Not all medical devices are of the same technical sophistication. Neither have they to go through the same level of regulatory scrutiny before they are accepted for the general use. Global Harmonization Task Force (GHTF) conceived in 1992 is an international effort to achieve greater uniformity between national medical device regulatory systems. This is being done with two aims viz., enhancing patient safety and increasing access to safe, effective and clinically beneficial medical technologies around the world. GHTF has adopted *Principles of Medical Devices Classification in* 2006 http://www.ghtf.org/documents/sg1/SG1-N15-2006-Classification-FINAL.pdf

*The **Global Harmonization Task Force** (**GHTF**) is "a voluntary group of representatives from national medical device regulatory authorities (such as the U.S. Food and Drug Administration (FDA)) and the members of the medical device industry" whose goal is the standardization of medical device regulation across the world. http://www.ghtf.org/index.html*

GHTF has adopted the following harmonized definition of the term medical device: "`Medical device' means any instrument, apparatus, implement, machine, appliance, implant, *in vitro* reagent or calibrator, software, material or other similar or related article -

a) Intended by the manufacturer to be used, alone or in combination, for human beings for one or more of the specific purpose(s) of:

- diagnosis, prevention, monitoring, treatment or alleviation of disease,
- diagnosis, monitoring, treatment, alleviation of or compensation for an injury,
- investigation, replacement, modification, or support of the anatomy or of a physiological process,
- supporting or sustaining life,
- control of conception,
- disinfection of medical devices,
- providing information for medical or diagnostic purposes by means of in vitro examination of specimens derived from the human body; and

b) Which does not achieve its primary intended action in or on the human body by pharmacological, immunological or metabolic means, but which may be assisted in its intended function by such means.

The Principles of Medical Devices Classification, as adopted by GHTF (2006), http://www.ghtf.org/documents/sg1/SG1-N15-2006-Classification-FINAL.pdf takes into consideration the level of technology, and sophistication. Various levels calls for different level of regulatory clearances. These are Low Risk, Low-Moderate Risk, and Moderate-high Risk and High Risk devices, named as Class A; B; C; and D respectively.

Class A Low Risk	Surgical retractors / tongue depressors
Class B Low-moderate Risk	Hypodermic Needles / suction equipment
Class C Moderate-high Risk	Lung ventilator / orthopedic implants
Class D High Risk	Heart Valve / Implantable defibrillator

The current analysis adopted this definition to group the patented medical devices by the Israel.

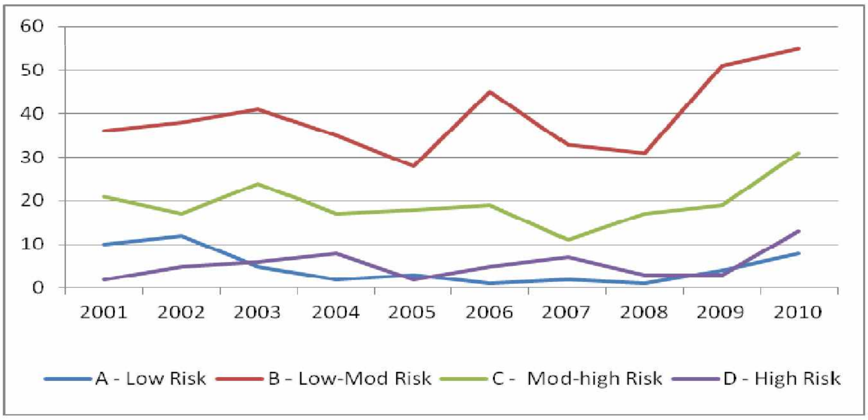
Classification of Israel medical device patents

The current analysis attempts classification of the Israel patents into these categories to examine the country's innovation in this area. The patents were examined thoroughly based on the detailed principles as enlisted by GHTF. These principles consider invasive, non-invasive and active devices.

Classification of the US patents obtained by Israel in the classes 600 to 607 over the 2001- 2010 is presented in Table 5.

Table 5 Growth of patents in different categories

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
A - Low Risk	10	12	5	2	3	1	2	1	4	8
B - Low-Mod Risk	36	38	41	35	28	45	33	31	51	55
C - Mod-high Risk	21	17	24	17	18	19	11	17	19	31
D - High Risk	2	5	6	8	2	5	7	3	3	13



Some of the examples of Israeli patents on the subject from different risk categories are as follows:

Low Risk Devices

Adaptive weight bearing monitoring system for rehabilitation of injuries to the lower extremities
Body and joints massage device
Dual ended hair remover
Umbilical cord clamp and cutter
Needle protector device
Devices for passive motion of joints under traction
Finger-guided suture device
Method and system for system identification of physiological systems
Method, device and kit for obtaining biological samples
Vibrator device with inflatable, alterable accessories
Hair removal system
Method for obtaining a dental occlusion map

Low-Mod Risk

Breath test analyzer
Apparatus and method for cleansing tissue
Self-drilling surgical suture anchor
Forceps useful for intrabody guiding and/or positioning of a medical instrument
Bone measurement device
Physiotherapeutic device
Electrode for muscle stimulation
Sleeve for endoscopic tools
Navigable catheter
Device for muscle stimulation
Insemination device
Non-invasive probe for detecting medical conditions
In vivo imaging device
Physiological stress detector device and system
Orthopedic clamps

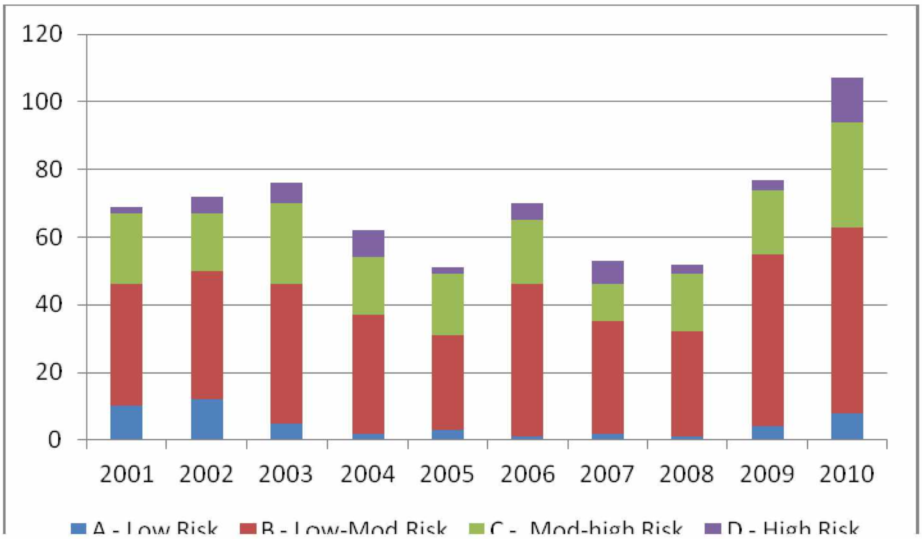
Mod-high Risk

Radiation delivery devices and methods of making same
Cooling apparatus for cutaneous treatment employing a laser and method for operating same
Device for iontophoretic administration of drugs
Set of surgical tools and surgical method for anterior cruciate ligament reconstruction
Fever alarm system
Multiple cryoprobe apparatus and method
Cryosurgical instrument and its accessory system
Nerve-branch-specific action-potential activation, inhibition, and monitoring
Diagnosis, treatment and research of mental disorder
In vivo device and method for collecting oximetry data
Treatment of disorders by unidirectional nerve stimulation
Long-term SPG stimulation therapy for prevention of vascular dementia

High Risk

Apparatus and method for securing a stent on a balloon
Implantable stroke treating device
Method and a device for electro microsurgery in a physiological liquid environment
Method and device for the cancellation of unwanted excitation waves in the heart
Implantable stroke treating device
Spinal prosthesis
Implantable medical device with integrated acoustic transducer
In vivo for improving diastolic ventricular function
Inserting anterior and posterior spinal prostheses
Minimal-heart-rate reduction parasympathetic stimulation
Reduction of heart rate variability by parasympathetic stimulation
Selective nerve fiber stimulation for treating heart conditions

The classification shows that Israel medical device industry has focused on devices dealing with B and C categories. Within these categories the country has more of low-moderate risk devices. Though the country has been able to maintain a steady growth in the numbers, the growth is noticeable in category B devices and relatively less in the high risk type devices which deal with heart and central nervous system.



A cursory look at the figures shows the following trends:

Patents deal both with equipment and methods;
New imaging, radiation and even nanotech is applied in these devices;
The patents cover a wide array of medical problems;
There is no clustering of patents on specific problem;
Innovations are carried out by several organizations.

On the whole analysis shows that Israel has focused on B and C class devices. The features added to these devices are also carefully selected as could be seen from the sub-classes these devices fell into.

Table 6 Israel's Share of US Patents on various Medical Device sub classes 2001-2010

	Israel Share	World Total	
600/1	1	139	RADIOACTIVE SUBSTANCE APPLIED TO BODY FOR THERAPY
600/101	2	206	ENDOSCOPE
600/104	1	241	With tool carried on endoscope or auxillary channel therefore
600/105	1	32	Urogenital resectoscope
600/106	1	101	Having tool moving or stopping means
600/108	1	28	Laser
600/109	8	265	With camera or solid state imager
600/114	6	238	With guide means for body insertion
600/115	3	47	Inflatable cuff or balloon
600/117	2	187	With means for indicating position, depth or condition of endoscope
600/118	1	229	With control or monitoring of endoscope functions
600/121	1	105	With protective sheath
600/123	1	26	For auxiliary channel
600/125	1	31	With locking or retaining means for sheath
600/13	2	84	Electromagnetic coil
600/130	4	114	With particular arrangement of internal elements (e.g., shaft reducing)
600/14	1	48	Pulsating field
600/157	1	26	With window cleaning means
600/158	1	55	With air or water supply means
600/16	2	332	CARDIAC AUGMENTATION (PULSATORS, ETC.)
600/160	6	263	Having imaging and illumination means
600/17	3	102	With condition responsive means

600/173	2	80	View field altering means
600/176	1	56	Having particular distal lens or window
600/180	1	47	With light intensity control
600/181	1	56	With filter, masking, diaphram, or aperture plate
600/196	1	13	Adjustable (e.g., linearly, angularly)
600/197	1	12	Having particular handle structure
600/199	1	26	Illuminating
600/27	1	63	Sensory (e.g., visual, audio, tactile, etc.)
600/29	4	221	BODY INSERTED URINARY OR COLONIC INCONTINENT DEVICE OR TREATMENT (E.G., ARTIFICIAL SPHINCTERS, ETC.)
600/3	1	357	Radioactive substance placed within body (e.g., inhaled, implanted, injected, etc.)
600/30	3	211	Implanted
600/300	9	1438	DIAGNOSTIC TESTING
600/306	1	80	Measurement of skin parameters
600/309	4	231	Measuring or detecting nonradioactive constituent of body liquid by means placed against or in body throughout test
600/310	7	537	Infrared, visible light, or ultraviolet radiation directed on or through body or constituent released therefrom
600/316	3	227	Glucose
600/322	6	323	Determining blood constituent
600/323	1	384	Oxygen saturation, e.g., oximeter
600/324	7	90	And other cardiovascular parameters
600/330	2	34	Separation of ac/dc components in signal
600/335	6	23	Pressurization of body portion performed
600/339	1	20	Inserted in body
600/344	1	154	Mounting structure (e.g., belt, etc.)
600/345	1	258	Electroanalysis
600/349	1	4	Oral fluids
600/35	1	41	Artificial insemination
600/350	1	7	Esophageal or gastrointestinal fluids
600/362	1	27	Absorbent patch for fluid analysis
600/365	1	324	Glucose measurement
600/368	1	31	Physical characteristics of blood
600/37	1		INTERNAL ORGAN SUPPORT OR SLING
600/372	1	214	Structure of body-contacting electrode or electrode inserted in body
600/377	1	58	Electrode implanted in body
600/38	2	167	SEXUAL APPLIANCE
600/386	1	71	Means for attaching electrode to body
600/388	2	31	Garment
600/390	1	42	Belt or strap
600/393	1	156	Plural electrodes carried on single support
600/398	1	42	Testing aqueous humor pressure or related condition
600/40	1	42	Implanted
600/407	17	1113	Detecting nuclear, electromagnetic, or ultrasonic radiation
600/410	4	696	Magnetic resonance imaging or spectroscopy
600/411	3	279	Combined with therapeutic or diverse diagnostic device
600/412C	1	24	Temperature detection
600/414	1	85	Using fiducial marker
600/423	1	104	With means for inserting into a body
600/424	18	531	With means for determining position of a device placed within a body
600/425	1	383	With tomographic imaging obtained from electromagnetic wave
600/427	3	383	Combined with therapeutic or diagnostic device
600/429	1	216	With stereotactic device
600/431	2	284	Detectable material placed in body
600/434	1	115	Catheter guide means
600/435	1	71	Catheter structure
600/437	11	951	Ultrasonic
600/438	7	162	Used as an indicator of another parameter (e.g., temperature, pressure, viscosity)
600/439	12	363	With therapeutic device
600/443	10	716	Anatomic image produced by reflective scanning
600/449	4	97	One-dimensional anatomic display or measurement
600/453	3	119	Doppler effect (e.g., fetal HR monitoring)
600/454	2	166	Blood flow studies
600/458	1	235	Contrast enhancement
600/459	2	516	Structure of transducer or probe assembly
600/466	1	142	Catheter

600/473	1	389	Infrared radiation
600/475	1	67	With comparison means (e.g., ratio of or comparison to a standard)
600/476	5	586	Visible light radiation
600/481	5	303	Cardiovascular
600/483	2	172	Simultaneously detecting cardiovascular condition and diverse body condition
600/484	2	117	Detecting respiratory condition
600/485	5	554	Measuring pressure in heart or blood vessel
600/486	8	167	Testing means inserted in body
600/488	1	53	Pressure transducer structure
600/491	1	8	Hand-supported occluder
600/494	1	107	Pulse-induced pressure fluctuation in occluder generates electric signal
600/495	2	42	Pressure in inflatable occluder automatically raised above systolic pressure
600/500	4	441	Detecting blood vessel pulsation
600/504	1	211	Measuring blood flow in body portion other than heart
600/507	2	32	By detecting volume of body portion
600/509	2	632	Detecting heartbeat electric signal
600/513	2	200	Detecting heartbeat electric signal and diverse cardiovascular characteristic
600/515	1	241	Detecting arrhythmia
600/528	1	138	Detecting heart sound
600/529	6	449	Respiratory
600/532	7	262	Qualitative or quantitative analysis of breath component
600/534	2	112	Detecting body movement attending breathing
600/535	1	13	Capacitor-type transducer
600/538	4	214	Measuring breath flow or lung capacity
600/544	5	357	Detecting brain electric signal
600/545	1	132	With feedback of signal to patient
600/546	3	188	Detecting muscle electrical signal
600/547	17	511	Measuring electrical impedance or conductance of body portion
600/549	6	345	Temperature detection
600/558	2	125	Eye or testing by visual stimulus
600/561	3	178	Measuring fluid pressure in body
600/573	1	325	Liquid collection
600/576	1	127	Manually supported collector with rigid intake tube (e.g., a hollow needle, etc.)
600/578	1	47	Mechanical means for drawing liquid into collection reservoir
600/584	1	158	Indicator
600/585	1	475	Flexible catheter guide
600/587	5	520	Measuring anatomical characteristic or force applied to or exerted by body
600/588	3	31	Gum
600/590	3	43	Mouth, tongue, or jaw
600/592	2	46	Foot
600/593	3	45	Esophagus, stomach, or lower alimentary canal
600/595	1	45	Body movement (e.g., head or hand tremor, motility of limb, etc.)
601/149	1	44	For applying pulsating or sequential pressure
601/150	1	41	Control means for causing pulsation
601/151	3	58	Body member enclosing or encircling
601/152	4	94	Pulsating pressure or sequentially inflatable
601/2	12	352	Ultrasonic
601/26	1	31	With drive means
601/3	1	121	Hyperthermia
601/35	1	121	Pair of legs
601/5	1	87	Means for passive movement of disabled extremity to return natural range of motion
601/7	1	21	With means for attaching diverse devices to vacuum
601/95	1	16	Including a plurality of massaging teeth, projections, or filaments
602/13	1	91	Inflatable
602/19	1	199	Body (e.g., scoliosis brace)
602/41	1	319	BANDAGE STRUCTURE
602/43	1	183	Wound contact surface
604/101.01	1	99	Having plural balloons on conduit
604/103.02	1	37	Delivering fluid or material from external surface of inflated means
604/103.03	1	24	Having means to retain conduit or inflated means in position (e.g., depth control, external seal, etc.)
604/104	1	206	Having means expanding body orifice or canal (e.g., dilator, retaining means, etc.)
604/106	1	32	Expanding arm or finger
604/110	1	546	Having means for preventing reuse of device
604/113	1	176	Having means for cooling or heating body, treating or collected material or device
604/114	1	122	Electric means

604/117	1	72	Having structure for controlling depth of insertion of body piercer
604/122	1	46	Having means for eliminating and/or preventing injection of air into body
604/132	1	80	Material impelled into body by contraction of expanded elastic material reservoir
604/134	2	42	Material impelled by spring
604/135	1	60	Spring drives piston
604/164.01	1	309	Body piercer, obturator rod, or stylet axially movable within body entering conduit while latter is disposed in body
604/165.02	1	34	Having portion cooperating with body entering conduit lumen to provide flow control means
604/17	1	6	Ejector pivoted or swung into operating position
604/173	2	46	Injection or aspiration device having plural body entering conduits
604/174	1	263	Means for securing conduit to body
604/180	1	133	Adhesive securing means
604/19	1	188	MEANS FOR INTRODUCING OR REMOVING MATERIAL FROM BODY FOR THERAPEUTIC PURPOSES (E.G., MEDICATING, IRRIGATING, ASPIRATING, ETC.)
604/198	2	350	Cover or protector for body entering conduit movable axially relative to one another
604/20	17	524	Infrared, visible light, ultraviolet, X-ray or electrical energy applied to body (e.g., iontophoresis, etc.)
604/22	1	547	With means for cutting, scarifying, or vibrating (e.g., ultrasonic, etc.) tissue
604/232	1	101	Material reservoir (e.g., cartridge, etc.) removably mounted in syringe
604/24	1	31	Gas mixed with other material
604/246	3	223	Means for controlling material flow to or from body, or metering a predetermined dose or amount
604/248	1	45	Rotatable type valve
604/249	1	109	Slide or reciprocating valve
604/253	1	14	Having drip sensor
604/265	1	158	With body soluble, antibactericidal or lubricating materials on conduit
604/267	1	12	Mechanical cleaning means
604/272	2	214	Body piercing condit (e.g., needle, etc.)
604/273	1	14	Specific structure for preventing or minimizing inconvenience casued by breakage during insertion of conduit into body
604/29	2	108	Peritoneal dialysis
604/294	1	123	Means for treating eye or surface of ocular cavity
604/30	1	123	Flow control
604/307	1	84	Adhesively attachable to body
604/360	2	83	Containing inhibitor to ammonia or bacteria formation
604/368	1	169	Collagen or gelling material
604/408	1	162	Bag type
604/410	2	113	Plural compartments or bags
604/414	1	91	Mounted on one container and used to pierce another container or closure
604/415	1	131	Container with piercable closure
604/503	1	55	Therapeutic material introduced or removed in response to a sensed body condition
604/510	2	83	With associated advancing or guiding means
604/6.01	1	159	Component of blood removed (i.e., pheresis)
604/6.09	1	274	Filter means
604/65	2	233	Material flow varying means controlled by condition responsive sensor
604/67	1	260	Sensor controls pump, motor, or pressure driven means
604/80	1	30	Gravity feed to body from plural material reservoirs
604/890.1	2	301	CONTROLLED RELEASE THERAPEUTIC DEVICE OR SYSTEM
604/891.1	2	296	Implanted dynamic device or system
604/9	3	296	With flow control means (e.g., check valves, hydrocephalus pumps, etc.)
604/95.04	1	142	Having tensioning means to alter conduit shape
604/99.01	2	51	Having inflation or deflation control means
606/1	3	561	INSTRUMENTS
606/10	1	405	Systems
606/104	2	200	Screw or pin placement or removal means
606/107	2	227	Means for removing, inserting or aiding in the removal or insertion of eye lens material
606/108	5	712	Means for inserting or removing conduit within body
606/120	1	21	Umbilical clamp
606/127	4	149	Means for concretion removal
606/130	4	506	Stereotaxic device
606/131	1	142	Means for removal of skin or material therefrom
606/132	1	20	By means for skin graft preparation (e.g., dermatome)
606/133	2	65	Physical removal of hair or hair plugs from skin
606/139	2	490	Suture, ligature, elastic band or clip applier
606/142	3	208	Clip applier

606/144	2	286	Mechanical suture or ligature applier
606/145C	1	66	Shuttle action by suture passing device
606/15	1	264	With optical fiber
606/151	3	582	Surgical mesh, connector, clip, clamp or band
606/153	3	463	Connector for hollow body organs
606/157	1	194	Occluding clip, clamp, or band
606/159	1	351	Blood vessel, duct or teat cutter, scrapper or abrader
606/166	2	147	Corneal cutter or guide for corneal cutter
606/17	1	129	With beam shaping or redirecting (e.g., lens)
606/170	1	329	Cutter carried on elongated probe-like member
606/185	1	211	Puncturing or piercing
606/191	1	302	Internal pressure applicator (e.g., dilator)
606/192	1	282	Inflatable or expandible by fluid
606/198	1	326	Expanding dilator (e.g., expanding arm, etc.)
606/2.5	2	323	Lithotripsy
606/20	7	169	Cyrogenic application
606/200	7	770	With emboli trap or filter
606/205	1	323	Forceps
606/21	8	223	Internal application
606/213	2	469	Sutureless closure
606/216	3	89	Means to draw opposed sides of incision into apposition
606/219	1	220	Staple fastener
606/22	2	117	With coolant supply
606/23	2	170	Tip or other cooling concentration means
606/232	1	405	Suture retaining means (e.g., buttons)
606/24	1	33	With heating means (e.g., defroster)
606/248	1	56	Spinous process implant
606/249	1	77	Spacer type
606/250	1	106	Including transverse connector for linking longitudinal rods; (e.g., parallel rods)
606/27	1	223	Heat application
606/3	1	172	With particular wavelength
606/32	1	323	Electrical application
606/41	3	1161	Applicators
606/45	2	427	Cutting
606/49	2	455	coagulation
606/5	1	295	Recurving or reshaping of the eye
606/54	1	88	External fixation means
606/57	1	84	Compression or distraction mechanism
606/60	1	209	Internal fixation means
606/62	1	138	Intramedullary fixator
606/63	5	54	Expanding in diameter or length
606/74	1	74	Bone cerclage device
606/75	2	80	Staple or clip
606/85	1	42	Rasp or file
606/86A	1	295	Tool for installing or removing spinal positioner or stabilizer
606/9	10	340	Dermatological
606/99	1	304	Prosthesis insertor or extractor
607/101	4	504	Microwave or RF (high frequency)
607/104	3	304	With fluid supply
607/105	1	391	Internally applied
607/116	1	502	Placed in body
607/118	9	95	Applicator placed around stimulated nerve
607/119	1	250	Heart
607/129	1	65	Patch or epicardial (on heart surface) type
607/138	1	29	Rectum, vagina, or uterus
607/14	1	313	Treating or preventing abnormally high heart rate
607/149	2	89	Treating or preventing abnormally high heart rate
607/152	2	123	Flexible sheet or resilient pad
607/17	1	293	Parameter control in response to sensed physiological load on heart
607/2	8	550	Electrical therapeutic systems
607/27	1	298	Testing or monitoring pacer function
607/3	6	218	Combined with nonelectrical therapy
607/36	1	226	Feature of stimulator housing or encapsulation
607/39	1	45	Stimulating reproductive organ
607/41	1	68	Incontinence control
607/45	4	218	Treating mental or emotional disorder

607/46	2	226	Electrical treatment of pain
607/48	5	147	Directly or indirectly stimulating motor muscles
607/5	2	656	Cardioverting/defibrillating
607/50	3	102	Promoting tissue growth or healing
607/59	2	175	Control signal storage (e.g., programming)
607/60	3	426	Telemetry or communications circuits
607/62	1	109	Output controlled by sensor responsive to body or interface condition
607/63	2	99	Promoting patient safety or comfort
607/67	1	23	Applied for interferential effect in body
607/88	2	505	Light application
607/9	1	820	Heart rate regulating (e.g., pacing)
607/90	1	76	Lamp and casing
607/91	2	89	Surrounding body or body member
607/96	1	386	Thermal applicators

Israel's medical devices R&D is broad based and companies are filling in technology gaps through innovation. Select technologies which are new and where Israel is relatively stronger have been pursued in the innovation process. Among these are imaging technologies on which the country has several patents in the 2001-10 period. Also In this category is more recent specializations, namely methods in cryosurgery and the equipment relating to that. Israel has nearly 1% of the total patents relating to cryosurgery. Examination of these patents on its technology transfer revealed that 24.5% of these (169 out of 690) were, in fact, licensed. The rest remained with the original assignee.

Israel's Innovations in Medical Devices for Cryosurgery

The analysis was extended to examine the patents obtained by Israel on cryosurgery to understand its patenting strategy. The analysis of the Israel's patents in this specialization outnumbers other subcategories. The trend indicates the country is moving towards acquiring skill on this technology.

It was noticed that equipment for cryosurgery is spread on more than one sub-class. The patents for the analysis were retrieved through the subject search, which included both Israel and the rest of the world. The retrieved records for the years 2001-2010 were examined for the enterprise in the activity, collaboration, innovators, etc., in the area.

What is Cryosurgery?

Cryotherapy, a method based on the cytotoxic effects of cold, consists in the therapeutic application of extremely low temperatures to living tissue in order to obtain their destruction. It represents a minimally invasive surgical technique that has expanded in applicability in recent years, in part because of the development of new and improved equipment. Cryosurgery has now a wide range of clinical applications: dermatology, gynecology, urology, neurology, pulmonary medicine, cardiology, oncology and many others. It is also used in veterinary medicine.

Cryosurgery is the application of extreme cold temperature to destroy abnormal or diseased tissue. It is the technique of using extreme rapid cooling to freeze tissues, thereby destroy them. Rapid cooling to temperature below freezing point produces irreversible cell damage and cell death occurs at -20 to -90 degree Celsius. Freezing produces white areas of necrosis. It is applied in the treatment of malignancies, vascular tumors and aggressive tumors. http://www.societyofcryosurgery.org/science/basic-science-link-to-cryo-basic-intro.htm.php

Cryosurgery has been historically used to treat a number of diseases and disorders, especially a variety of benign and malignant skin conditions. Warts, moles, skin tags, solar keratoses, Morton's neuroma and small skin cancers are candidates for cryosurgical treatment. Several internal disorders, including liver cancer, prostate cancer, lung cancer, oral cancers, cervical disorders are treated with cryosurgery. Generally, all tumors that can be reached by the cryoprobes used during an operation are treatable. Although found to be effective, this method of treatment is only appropriate for use against localized disease, and solid tumors larger than 1 cm.

Cryosurgery is a minimally invasive procedure, and is often preferred to more traditional kinds of surgery because of its minimal pain, scarring, and cost; however, as with any medical treatment, there are risks involved, primarily that of damage to nearby healthy tissue. Damage to nerve tissue is of particular concern.

A common method of freezing lesions is using liquid nitrogen as the cooling solution. The super-cooled liquid may be sprayed on the diseased tissue, circulated through a tube called a cryoprobe, or simply dabbed on with a cotton or foam swab. Recent advances in technology have allowed for the use of argon gas to drive ice formation using a principle known as the Joule-Thomson effect. This gives physicians' excellent control of the ice, and minimizing complications using ultra-thin 17 gauge cryoneedles. http://en.wikipedia.org/wiki/Cryosurgery

The basic science of cryosurgery is an interdisciplinary research field involving both biology and engineering. The latter is focused on how to measure and predict the thermal and injury behavior using engineering tools.

Cryosurgery should be intensely monitored. If freezing is not sufficient, malignancies could recur in the tumors so treated, and inversely, if it is excessive it could affect adjacent healthy tissue.

Despite advances and particularly the application of this method in treatment of prostate related problems, cryosurgery did not become popular in the later part of the 20th century because of the complications associated with it. There was an inability to internally monitor the cryosurgical procedure as well as a lack of sophisticated cryosurgical instrumentation. Israel's choice of the field to develop the required instrumentation is to be seen as a deliberate choice in occupying a challenging and the most current area in medical devices.

The following is the country-wise distribution of the cryosurgery US patents (2001-10)

Table 7 Distribution of Patents dealing with Cryosurgery

	US Patents
US	202
Canada	45
Israel	24
Australia	3
Netherlands	3
Ukraine	3
China	1

France	1
Germany	1
Korea	1
Poland	1
Portugal	1
Russia	1

The analysis shows that there are as many as 61 organizations which have taken patents in this area. The work is mainly focused in the US and Canada, which together account for 51 of the 61 organizations identified (Table 8). The top five companies in the list belong to the US (3) and Canada (2).

Table 8 Number of organizations and patents obtained in cryosurgery research

	Organizations obtaining patents	number of patents
Canada	3	63
Germany	2	3
Israel	5	21
Norway	1	2
US	48	132
France	2	2

Nearly 30 of these patents have also been assigned to inventors themselves (without any organizational affiliation) indicating that the technology is yet at the initial stages.

The inventors in this domain have come from the US, Canada and Israel. Inventors have also come from a set of assorted countries like France, Germany, Korea, Poland, Netherlands, Norway, Austria, Ukraine and Russia. Though the inventor base is spread across the organization base specializing in the technology is small.

Table 9 Top companies working on innovation in cryosurgery related equipment

	US Patents
Cryocath Tech (Canada)	37
Endocare (Canada)	19
Cyrocor (US)	19
Atricure (US)	14
Galil Medical (Isarel)	13
Cyrovascular Systems (US)	13

Inventor team size in cryosurgery patents

Team size	Patents
1	83
2	65
3	39
4	28
5	20
6>	15

As shown in the table above inventor base in this area of specialization is broad, yet the organizations specializing is relatively small.

Five Israeli companies have also obtained patents on cryosurgery devices, including

Galil Medical Ltd. (13 patents)
Arbel Medical Ltd (5)
ITOS innovative Tech.in Ocular Surgery (1)
Mor Research Applications (1)

There are also 9 patents obtained by inventors themselves during the 2001-10 period.

Israel currently has no collaborative engagement with organizations or inventors outside the country, as per the patents data.

As could be seen (Table 9) most of the innovation on cryosurgery related equipment is taking place in the US and Canada based companies. Israel also has a set of companies with this focus.

Israel's Patents on Cryosurgery

Method for delimiting cryoablation by controlled cooling	Systems and methods for planning a cryoablation procedure and for facilitating a cryoablation procedure utilize integrated images displaying, in a common virtual space, a three-dimensional model of a surgical intervention site based on digitized preparato	Zvuloni; Roni (Haifa, IL, Schatzberger; Shaike (Haifa, IL
Cryogenic probe for treating enlarged volume of tissue	The invention proposes a cryoprobe for surgical and other treatments. The cryoprobe comprises a bellow-wise section that performs displacement of a distal cryotip forwards with elevation of operation pressure in the interior of the cryoprobe. Needle-wise	Levin; Alexander (Binyamina, IL, Toubia; Didier (Raanana, IL
Planning and facilitation systems and methods for cryosurgery	Systems and methods for planning a cryoablation procedure and for facilitating a cryoablation procedure utilize integrated images displaying, in a common virtual space, a three-dimensional model of a surgical intervention site based on digitized preparato	Zvuloni; Roni (Haifa, IL, Schatzberger; Shaike (Haifa, IL
Multiple cryoprobe apparatus and method	A cryosurgery apparatus is disclosed. The cryosurgery apparatus an introducer having a hollow and a distal portion, the distal portion being sufficiently sharp so as to penetrate into a body, the hollow of the introducer being designed and constructed for	Zvuloni; Roni (Haifa, IL, Schatzberger; Shaike (Haifa, IL
Method of controlling the temperature of gasses passing through a Joule-Thomson orifice	The present invention relates to apparatus, systems, and methods utilizing cryogenic cooling in an angioplasty balloon catheter for treatment of arterial stenosis and prevention of restenosis. More particularly, the present invention relates to an angiopl	Zvuloni; Roni (Haifa, IL, Bliweis; Mordechai (Haifa, IL, Schechter; Doris (Zikhron Yakov, IL, Amir; Uri (Or Yehuda, IL, McGlone; James (Garden City, NY
Planning and facilitation systems and methods for cryosurgery	Systems and methods for planning a cryoablation procedure and for facilitating a cryoablation procedure utilize integrated images displaying, in a common virtual space, a three-dimensional model of a surgical intervention site based on digitized preparato	Zvuloni; Roni (Haifa, IL, Schatzberger; Shaike (Haifa, IL
Cryosurgical instrument and its accessory system	The invention is directed to a cryosurgical instrument and to an accessory system operating on the base of refrigerant evaporation, wherein the portions of the	Levin; Alexander (Binyamina, IL

	refrigerant are periodically provided to the distal cryotip of the cryosurgical instrument via	
Multiple cryoprobe apparatus and method	A cryosurgery apparatus is disclosed. The cryosurgery apparatus an introducer having a hollow and a distal portion, the distal portion being sufficiently sharp so as to penetrate into a body, the hollow of the introducer being designed and constructed for	Zvuloni; Roni (Haifa, IL, Schatzberger; Shaike (Haifa, IL
Cryoplasty apparatus and method	The present invention relates to apparatus, systems, and methods utilizing cryogenic cooling in an angioplasty balloon catheter for treatment of arterial stenosis and prevention of restenosis. More particularly, the present invention relates to an angiopl	Zvuloni; Roni (Haifa, IL, Bliweis; Mordechai (Haifa, IL, Schechter; Doris (Yakov, IL, Amir; Uri (Yehuda, IL, McGlone; James (Garden City, NY
Method and a system for performing cataract surgery	A system for surgically removing a cataract from an eye includes a cryomanipulator having a body and a manipulator head with a cryogenic tip for selectively freeze-gripping a region of contact of the catartact and for manipulating it within the eye. The c	Nun; Yehoshua Ben (Doar Vitkin, IL
Apparatus and method for protecting tissues during cryoablation	An apparatus and method for protecting the neurovascular bundle during cryoablation of tissues of the prostate by heating the vicinity of the neurovascular bundle while cooling pathological tissues of a prostate to cryoablation temperatures, thereby cryoa	Cytron; Samuel (Yavne, IL, Sofer; Paul (Zofit, IL, Schechter; Doris (Zikhron Yakov, IL, Amir; Uri (Or Yehuda, IL, Zvuloni; Roni (Haifa, IL
Cryosurgical instrument and its accessory system	The invention proposes a cryosurgical instrument and its accessory system operating on the base of a refrigerant evaporation. The invention comprises combination of some technical solutions. Flow in a central lumen of the cryosurgical instrument has oscil	Levin; Alexander (Binyamina, IL
Systems for MRI-guided cryosurgery	The present invention is of systems and methods for MRI-guided cryosurgery. The systems enable a surgeon positioned next to a patient and within an MRI magnetic environment both to monitor progress of a cryosurgical intervention by observing MRI images of	Amir; Uri (Yehuda, IL, Berzak; Nir (Zikhron-Yaakov, IL, Bliweis; Mordechai (Haifa, IL, Leybin; Yura (Haifa, IL, Hillely; Ron (Zichron Yaakov, IL
Gas-heated gas-cooled cryoprobe utilizing electrical heating and a single gas source	The present invention is of device, system, and method for cooling and heating an operating tip of a cryoprobe using a single source of compressed gas. Cooling of the operating tip is effected by Joule-Thomson expansion of a high-pressure cooling gas thro	Bliweis; Mordechai (Haifa, IL, Amir; Uri (Or Yehuda, IL, Berzak; Nir (Zikhron-Yaakov, IL, Leybin; Yura (Haifa, IL, Livneh; Shimon (Kiryat-Tivon, IL
Method and a system for performing cataract surgery	A cataract removing device (CRD in a system for surgically removing a cataract from an eye includes a cryomanipulator having a body and a manipulator head with a cryogenic tip for selectively freeze-gripping a region of contact of the cataract and for ma	Nun; Yehoshua Ben (Doar Vitkin, IL
Cryogenic probe for treating enlarged volume of tissue	A cryoprobe for surgical and other treatments. The cryoprobe comprises an expandable section that performs displacement of a distal cryotip forwards when there is elevation of the operation pressure in the interior of the cryoprobe. Needle-wise metal elem	Toubia; Didier (Raanana, IL, Levin; Alexander (Binyamina, IL, Kaganovich; Miron (Haifa, IL
Cryosurgical instrument and its accessory system	The invention proposes a cryosurgical instrument and its accessory system operating on the base of a refrigerant evaporation. The invention comprises combination of some technical solutions. Flow in a central lumen of the cryosurgical instrument has oscil	Levin; Alexander (Binyamina, IL
Endometrial ablation device and method	A device for uniform ablation of the endometrium comprises a transparent inflatable coolable balloon, flexible cryoprobes operable to be advanced into the uterine cornuae, an applicator operable to deliver	Schechter; Doris (Zikhron Yakov, IL, Berzak; Nir (Zikhron-Yaakov, IL

	balloon and cryoprobes to and from the uterine ca	
Cryoprobe and method of treating scars	An intralesional method for treating a hypertrophic scar or keloid using a cryoprobe. The method comprises: (a inserting the cryoprobe into the hypertrophic scar or keloid so that the cryoprobe is positioned within the hypertrophic scar or keloid; and (b	Har-Shai; Yaron (Haifa, IL, Amar; Micha (Karmiel, IL

Galil Medical is the leading Israeli firm in the cryosurgery devices. It is leading a new era of minimally invasive cryotherapy solutions that enhance patient quality of life. Since its foundation, Galil Medical has dedicated extensive research toward increasing the ease of use and precision of cryotherapy and minimally invasive procedures.

Galil Medical's technology involves freezing and ablating diseased tissue in a technique referred to as cryotherapy, also referred to as cryoablation and cryosurgery. The core technology is based on the Joule-Thomson effect.

Galil Medical cryotherapy systems use compressed Argon gas to produce extremely low temperatures. As the gas passes through the cryoablation needle, the tip of the needle is cooled, forming an iceball, which engulfs the tumor and destroys the tissue. A variety of needle types is available to sculpt a freeze zone conformed to the tumor size and shape. Galil Medical cryosurgical systems precisely deliver sub-zero temperatures to target tissue with the aid of patented 17-gauge cryoablation needles and high-resolution imaging for the cryosurgical ablation of benign and cancerous tumors. The integration of high resolution imaging with ultrasound, CT, or MR enables a high level of control for needle placement and positioning, iceball formation in real-time and the freezing process during minimally invasive surgery.

It is too early to know how far Israel can make an impression in medical devices on cryosurgery. Nontheless, it has made a definite headway, among other medical devices, it is already third important player. Active collaboration with some of the US companies in this field would be the natural next step for the country to get a better foothold.

Collaboration is very less in these patents and Israel has no collaborative engagement with organizations or inventors outside the country. Israel also has several patents obtained by inventors themselves without organizational affiliation.

It is too early to know how far Israel can be among the leaders in medical device on cryosurgery. Nonetheless, it has made a definite headway, among other medical devices; it is already third important player and can make a mark for itself. Active collaboration with some of the US companies in this field would be the natural next step for the country to get a better foothold.

Israel has selected a new area where they have an opportunity to make an impact though not in number of patents, but in technology they are at par with the other leaders. On the whole strategy adopted by Israel in innovation relating to medical devices is to sneak into the patent wall erected by the major players. The country has chosen to fill the gaps with niche technologies and also relatively new areas such as in vivo camera, imaging technologies and the like. Going by the distribution of the innovations with various foci, cryosurgery is the new and emerging area on which Israel intends to obtain a cluster of patents. As the analysis shows in this field of specialization the country's innovation is on par with the leaders from the rest of the world.

Software Patents – A case of multiplexer patents

Software patent is a hotly debated issue in Israel. The courts have given nuanced verdict on the issue and seem to favour copyright to patent for software. The court has recently ruled that output of a software program as content is not patentable in the context of a patent case - Displaying thumbnails of internet sites when listing the names. Notwithstanding this Israel has obtained a host of software patents in the USPTO on wide-ranging software related technologies. These range from data base optimization, data flow on the network, routing, cryptography, multiplexing, fault recovery in the data transfer, etc.

Israel has over 520 US patents with one or other main classes under the topic. These patents are not in the application software domain and are invariably dealing with the base utilities that are applicable across the applications and hardware platforms. What is interesting and noticeable in that these patents fall under nearly 250 distinct sub-classes in the classification, indicating that the patents do not cluster around one or the other topic within software applications. Many of these softwares are embedded in nature and are part of the electronic system or sometimes the operating system. Multiplexer is one such device.

Various issues addressed by the patents on multiplexing include the following:

- Fault recovery
- Dataflow congestion
- Network configuration determination
- Routing, and the like

The following table gives a comparative display of software patents obtained by a select set of countries during the 2001-2010 period. The figures ae based on the US Patent Classification number assigned in the patents awarded to the countries.

Distribution of US Patents on multiplexer

	Israel	USA	World
370 Multiplex communications	482	19403	52807
705 Data processing: financial, business practice, management, or cost/price determination	82	10396	19554
708 Electrical computers: arithmetic processing and calculating	34	1458	4784
709 multicomputer data transferring	266	19266	40276
710 input/output	65	5591	16990
711 memory	121	8706	22966
713 support	122	10002	23018

Israel could at best be seen as a strong emerging country in software patenting and not as a leading one. A search of the US patent database for the years 2001-10 shows that the USA is ahead of Israel in number of patents on main classes. However, with the presence of several IT companies such as Microsoft, Cisco and the others with their R&D establishment have given a boost to the individual or startup R&D in this field. Though some of the patents point to path breaking applications, many are the new methods and alternate ways of handling the problem at hand.

Class 370 was taken as a case to analyze the patenting and its commercialization as there is substantial number of patents on the technology by Israel.

In electronics, a multiplexer is a device that selects one of several analog or digital input signals and forwards the selected input into a single line. A multiplexer of inputs has select lines, which are used to select which input line to send to the output. Multiplexers are mainly used to increase the amount of data that can be sent over the network within a certain amount of time and bandwidth. A multiplexer is also called a data selector.

An electronic multiplexer makes it possible for several signals to share one device or resource, for example one A/D converter or one communication line, instead of having one device per input signal. Conversely, a demultiplexer (or demux) is a device taking a single input signal and selecting one of many data-output-lines, which is connected to the single input. A multiplexer is often used with a complementary demultiplexer on the receiving end.

An electronic multiplexer can be considered as a multiple-input, single-output switch, and a demultiplexer as a single-input, multiple-output switch.

The US Patent Office Subject Manual defines the main class 370 as follows < http://www.uspto.gov/web/patents/classification/uspc370/sched370.htm >

This is the generic class for multiplexing or duplexing systems, methods, or apparatus.

Multiplexing includes time division multiplexing (TDM) frequency division multiplexing (FDM), orthogonal and quasi orthogonal multiplexing techniques, phantom connections and plural channel adaptive systems.

Telemetring

The distinction between multiplexing and selective or telemetry is that in multiplexing, the information is unrestricted as to content, (e.g., a teletype-writer which uses an alphabet to transmit unlimited information), whereas in selective or telemetry devices, the information is restricted as to content (e.g., a transducer measuring a single parameter).

370 class also includes elements and circuits forming sub combinations having a utility unique to multiplexing such as rotary distributors used as multiplexers, synchronizers used to control distribution of multiplexed channels, bridge duplex circuits, resonant circuits having a special utility in a frequency division multiplexing system.

This class excludes electrical circuits which may be used in multiplexing systems but are not unique to multiplex communications.

The following table given the US Patents granted to Israel during 2001-2010 period under the class 370. In this selection patents granted to Israel have 370 as the primary classification. The total for the rest of countries is computed for the same period, obtained by all the countries. In this 370 is one of the several classification numbers and not necessarily the main one. The selection includes only those on which Israel has obtained patents, as the intention was to show the relative strength of Israel in this technology.

US Patent Class	Scope	Israel Share*	USPTO Total*
370/200	PHANTOM:	3	26
370/203	GENERALIZED ORTHOGONAL OR SPECIAL MATHEMATICAL TECHNIQUES:	2	493
370/204	Plural diverse modulation techniques:	2	202
370/206	Quadrature carriers:	1	270
370/208	Particular set of orthogonal functions:	1	1011
370/216	FAULT RECOVERY:	2	806
370/217	Bypass an inoperative switch or inoperative element of a switching system:	4	516
370/218	Packet switching system or element:	7	389
370/219	Standby switch:	3	220
370/221	Bypass an inoperative station:	1	222
370/222	In a ring or loop network:	2	256
370/223	Using a secondary ring or loop:	4	158
370/224	Loopback of signals on the secondary ring or loop:	1	95
370/225	Bypass an inoperative channel:	1	390
370/229	DATA FLOW CONGESTION PREVENTION OR CONTROL:	7	1276
370/230	Control of data admission to the network:	12	2069
370/230.1	**Traffic shaping:**	**5**	**487**
370/231	End-to-end flow control:	3	753
370/232	Based on data flow rate measurement:	5	782
370/235	Flow control of data transmission through a network:	4	2354
370/236	Including signaling between network elements:	2	754
370/238	Least cost or minimum delay routing:	3	803
370/241	DIAGNOSTIC TESTING (OTHER THAN SYNCHRONIZATION):	3	708
370/241.1	Using OAM (Operation, Administration and Maintenance) cells:	1	120
370/242	Fault detection:	2	732
370/244	Of a switching system:	1	322
370/251	Having dedicated test line or channel:	1	102
370/252	Determination of communication parameters:	9	3195
370/254	NETWORK CONFIGURATION DETERMINATION:	8	1527
370/256	Spanning tree:	1	370
370/258	In a ring system:	4	166
370/259	SPECIAL SERVICES:	1	180
370/260	Conferencing:	2	515
370/261	Technique for setting up a conference call:	1	245

370/262	**Operator setup of the conference:**	**1**	**31**
370/277	Communication over free space:	2	100
370/280	Time division:	4	224
370/286	Echo suppression or cancellation:	2	320
370/310	COMMUNICATION OVER FREE SPACE:	2	788
370/311	Signaling for performing battery saving:	2	538
370/314	Using time division multiplexing:	1	103
370/316	Airborne or space satellite repeater:	1	353
370/317	Including noise compensation:	1	56
370/319	Multiple access (e.g., FDMA):	3	202
370/320	Code division (CDMA):	1	606
370/321	Time division (TDMA):	5	358
370/324	Synchronization:	1	245
370/328	Having a plurality of contiguous regions served by respective fixed stations:	5	2578
370/329	Channel assignment:	2	2167
370/332	Based upon a particular signal quality measurement:	1	965
370/335	Combining or distributing information via code word channels using multiple access techniques (e.g., CDMA):	1	2670
370/337	Multiple access (e.g., TDMA):	2	817
370/338	Contiguous regions interconnected by a local area network:	15	3479
370/342	Combining or distributing information via code word channels using multiple access techniques (e.g., CDMA):	1	2749
370/347	Multiple access (e.g., TDMA):	1	991
370/348	Channel reservation scheme:	1	396
370/350	Synchronization:	3	877
370/351	PATHFINDING OR ROUTING:	4	1191
370/352	Combined circuit switching and packet switching:	17	4359
370/356	Routing circuit switched traffic through a packet switching network:	3	978
370/359	Input or output circuit, per se (i.e., line interface):	1	153
370/360	Switching control:	1	412
370/366	Including serial-parallel or parallel-serial conversion for input or output:	1	105
370/369	Having time and space switches:	1	83
370/389	Switching a message which includes an address header (e.g., packet switching):	19	3430
370/390	Replicate messages for multiple destination distribution:	3	973
370/392	Processing of address header for routing, per se:	13	2905
370/393	Address concatenation:	1	106
370/394	Sequencing or resequencing of packets to ensure proper output sequence order:	2	742
370/395.1	Message transmitted using fixed length packets (e.g., ATM cells):	1	937
370/395.31	Connection identifier assignment: Including routing table:	1	359
370/395.32	Employing particular searching function (e.g., hashing, alternate, re-routing):	1	224
370/395.43	Based on service category (e.g., CBR, VBR, UBR, or ABR):	1	192
370/395.51	Utilizing a plurality of ATM networks (e.g., MPOA, SONET, or SDH):	2	131
370/395.62	Detail of clock recovery or synchronization:	1	132
370/395.64	Adapting connection-oriented variable bit rate (VBR) data (e.g., MPEG/HDTV packet video/audio over ATM or using AAL2):	2	140
370/397	Employing logical addressing for routing (e.g., VP or VC):	1	392
370/401	Bridge or gateway between networks:	24	4712
370/402	Bridge between bus systems:	2	258
370/403	At least one bus is a ring network:	1	131
370/405	The other networks are ring or loop networks:	1	56
370/412	Queuing arrangement:	9	1999
370/413	Having both input and output queuing:	4	342
370/417	Having output queuing only:	1	84

370/419	Input or output circuit, per se (i.e., line interface):	2	578
370/429	Particular storing and queuing arrangement:	1	526
370/432	Messages addressed to multiple destinations:	1	709
370/436	Combined time and frequency assignment	3	133
370/437	Adaptive selection of channel assignment technique:	1	464
370/442	Combining or distributing information via time channels using multiple access techniques (e.g.,TDMA):	4	598
370/445	Carrier sense multiple access (CSMA):	5	479
370/447	Arbitration for access between contending stations:	1	321
370/449	Polling:	1	253
370/458	Using time slots:	3	415
370/460	On ring or loop network:	1	36
370/463	Details of circuit or interface for connecting user to the network:	7	741
370/465	Adaptive:	2	1775
370/466	Converting between protocols:	11	1921
370/467	Conversion between signaling protocols:	1	552
370/468	Assignment of variable bandwidth or time period for transmission or reception:	6	1916
370/469	Processing multiple layer protocols:	1	985
370/470	Frame length:	2	310
370/473	Transmission of a single message having multiple packets:	1	472
370/474	Assembly or disassembly of messages having address headers:	4	1451
370/478	Combined time division and frequency division:	1	154
370/488	Connecting filters:	1	32
370/493	Combined voice and data transmission:	2	332
370/497	Using particular filtering technique:	1	57
370/498	Combining or distributing information via time channels:	1	213
370/502	Bus extenders:	2	33
370/503	Synchronizing:	4	1350
370/504	Reference indication consists of a gap:	1	39
370/508	Transmission time into time slots adjusted based upon propagation delay time:	1	162
370/510	Synchronization information is distributed over multiple frames:	1	157
370/513	Plural synchronization words:	1	60
370/514	Unique synchronization word or unique bit sequence:	1	213
370/516	Adjusting for phase or jitter:	3	543
370/522	Signaling (ancillary to main information):	1	494
370/532	Multiplexer or distributor and technique for handling low level input signal:	1	63
370/535	Multiplexing combined with demultiplexing:	2	683
370/537	Multiplexing plural input channels to a common output channel:	4	478
370/539	Multiple levels of multiplexing to form a multiplex hierarchy:	1	123

- For Israel these numbers represent the prominent subject of the patent. USPTO total represent one of the several USPC numbers used in the respective patents

Israel has obtained 482 patents under this class during the 2001-2010 period, and at best a minor player in the technology going by the numbers.

As could be seen from the table Israel has obtained patents on 122 specific class numbers under 370. Patents in sub-classes range from 1 to 24. On nearly a half of these sub-classes the country has only one patent, and more than 10 patents in only seven of the sub-classes. The latter category includes: Bridge or gateway between networks: (24); Switching a message which includes an address header (e.g., packet switching)(19); Combined circuit switching and packet switching(17); Contiguous regions interconnected by a local area network (15), Processing of address header for routing, *per se*(13); Control of data admission to the network (12); Converting between protocols (11).

The strategy seems not to dominate, (probably due to shortage of manpower and resources) but to improvise on a wide variety of specific aspects under the main technology with narrower scope. The approach seems to be to license the innovations as an improvement on the existing technology, particularly when the change is rapid. This indicates that the country's innovation on this subject is at the cutting edge level, as otherwise the efforts could be waste from the word go. Any breakthrough would give them considerable advantage in the short run.

The data were further analyzed to learn whether the country has gained by such an approach. To ascertain this it was examined whether these patents were licensed to companies which are in the telecom trade. It is also possible that the innovations may have also been harnessed by firms owning the patent rights by making their own products, etc. The licensing information was obtained from the USPTO database.

Fifty-six percent of these patents, making up 210 of the total 372 were licensed out and the ownership rights to technology are shared as per the 'Assignment Database' of the USPTO as on December 2012. The rest - 162 - remained with the original assignee. This shows that Israel's approach of trading in the cutting edge technology *per se* has yielded results. It was also noticed that several of these patents were licensed to more than one firms (some to as many as 10), which means return of several folds on investment. Most of the license transfers were to entities in the US and Canada.

China has also obtained 262 US Patents in this subject class (370) during the 2001-10 period. Analysis on the licensing of those patents indicates that only nine out of the 262 are licensed out. Of these nine patents, except one, the rest were technology transfers to entities within China. Technology trade does not seem to be the priority for China's assignees.

Through the Israel's experience, we can infer that in the innovation game, even in the fast growing sectors like electronics and software, countries can productively engage and trade innovations per se.

India

Innovation in India

S&T system in India consists of -

- Central Government's S&T Ministry / Departments and the science and technology institutions annexed to them;
- Independent research institutions;
- Research institutions affiliated to socio-economic and other ministries;
- University S&T Departments;
- State Government S&T Departments and institutions affiliated to the same;
- Non-governmental organizations in S&T research; and
- In-house R&D units affiliated to industries.

Growth of S&T in India can be conveniently categorized as follows:

The **infrastructures build up Phase** from 1947 to 1960, during which the broader planning and super structure of the institution base was established. Various fine-tuning and **reorientation** of this policy was taken up during the next three decades, namely 1960s to 1980s. The 1990s saw a shift in the emphasis with the coming of GATT and the WTO. Thus, during the 1990s S&T was to orient itself to the **market**. With the economic liberalization taking roots India has been in the **global innovation** race. In the first decade of 2000s our S&T human resources are harnessed both by our own institutions and also by hundreds of R&D set up of the MNCs within the country.

Table 1 Key economic figures for India

GDP (PPP Estimates US$ billions at purchasing power parity										
Values	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
India	444.57	465.22	544.87	654.87	808.67	908.46	1153.02	1252.04	1265.15	1648.85
GDP (PPP per capita US$ per capita at purchasing power parity										
India	1571.30	1728.93	1883.20	2063.09	2293.02	2545.43	2831.16	2986.60	3264.47	3523.04

Source: https://www.worldcompetitiveness.com/OnLine/App/Index.htm

Central Government S&T Departments include a host of institutions under Union Government's Department of S&T, Department of Atomic Energy, Department of Space, Department of Bio-technology, Ministry of Earth Sciences, Department of Scientific and Industrial Research, Indian Council of Medical Research, Indian Council of Agricultural Research, and the others. There are over 650 universities with science departments, which also carry out research at advanced levels. In all, according to a recent survey, there are nearly 1,400 institutions carrying out S&T research in the country with varying specializations, intensity, and mandate. About 15% of the registered companies in industrial sector invest on R&D, and some of them have full-fledged units devoted for the purpose. The country has given due attention to technology development with special emphasis on drugs & pharmaceutical, biotechnology, nanotechnology, and the like.

Technology Development Board of the union government assists the industrial concerns and other agencies, which attempt development and commercial application of indigenous technology or adapt imported technology to wider domestic applications.

Development and integration of technologies in areas such as: Glass Technology Up gradation, Development of Technology for Bio-fuels, Structure Technology for Distress Diagnostics, Water Purification, Bio-molecular Electronics and Conducting Polymers, ICT Systems For Application in Rural Areas are encouraged and monitored by Technology Systems Development Programme of the Central Government. This programme also promotes application of advanced technology for improving the performance, value addition and exportability of various products.Apart from these there are also several technology missions focusing on the special societal needs of the country.

The country has also taken cognizance of the current needs of increasing emphasis on innovation and has schemes such as Industrial R&D Promotion Programmes, under the Department of Scientific and Industrial Research, such as Industrial R&D Promotion, Technology Development and Demonstration, Technopreneur Promotion, Technology Management, International Technology Transfer, Technology Information Facilitation, and Technology Development & Utilization Programme for Women.

National Research and Development Council facilitates invention promotion through assisting in filing patents for innovations and commercialization of the technologies. Patent Facilitation Centre affiliated to TIFAC is involved in creating awareness on the patenting innovations and the law in the process.

The recent science, technology and innovation policy of 2013 ensures maximum incentives for individual inventors, and to our scientific and technological community.

To encourage R&D in general and industrial R&D in particular, the Government of India has adopted various policy measures from time to time. These include the following.

- ✓ Various schemes have been devised from time to time to encourage R&D.
- ✓ Industries having in-house R&D centres are allowed to write off R&D related revenue and capital expenditure. The companies and educational institutions engaged in R&D can also avail duty free import of analytical & specialty equipment.
- ✓ Industry / private sponsored research programme are allowed a weighted tax deduction of 125% on their R&D spend and select set of industries, such as Bio-technology, Drugs & pharmaceuticals, Electronic equipment, Chemicals and others are allowed Weighted tax deductions 150%
- ✓ Any wholly owned Indian company is allowed an excise duty exemption for three years on goods designed and developed and patented in any two countries from within India, Japan, US or Europe.

Table 2 **Key R&D Expenditure Figures**

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total expenditure on R&D Percentage of GDP									
0.81	0.80	0.78	0.73	0.81	0.80	0.79	-	0.80	0.85
Total expenditure on R&D per capita US$ per capita									
3.51	3.54	3.98	4.42	5.94	6.52	8.06	-	8.65	11.77
Business expenditure on R&D US$ millions									
697.81	719.67	959.85	1332.63	1983.79	2335.80	3099.34	-	3040.89	2803.25
Total R&D personnel in business full-time work equivalent (FTE 000									
318.44	-	-	-	-	391.15	-	-	-	-
Total expenditure on R&D (US millions									
3610.85	3702.97	4234.80	4775.26	6525.32	7270.76	9136.45	-	10136.29	14015.21

Source: https://www.worldcompetitiveness.com/OnLine/App/Index.htm

Excepting for the size of the economy, India is comparatively on the low end as to the other parameters relating to R&D. Business expenditure on R&D has registered an increase in the recent years, though it is too meager to make considerable impact. Total R&D expenditure in proportion to our GDP, which is also relatively low, to begin with, has further declined, indicating the expenditure has not kept up with the growth figures of the economy. Per capita R&D expenditure is also very low. Our per capita income is one-tenth of Israel, for instance, but our per capita R&D expenditure is less than a hundredth of the same country.

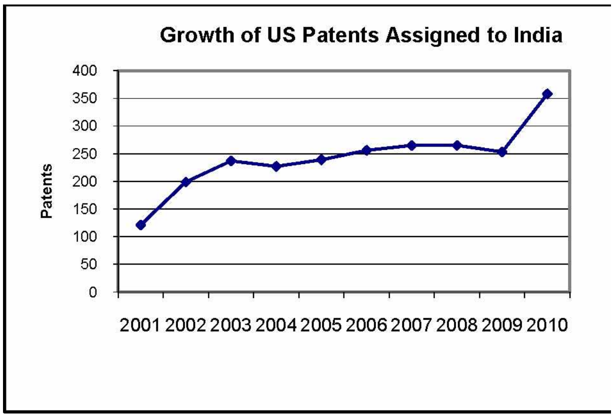
Patents assigned to India:

Number of patents assigned to India by the USPTO has increased three-fold 2001-2010 period. The growth of Indian patents during the previous decade, however, was impressive. It grew from a mere nine in 1991 to 86 in 2000. Decadal total, however, was only 316. There has been a gradual and consistent growth of innovation over the period. Cumulative Annual Growth Rate for the 2001-10 period is 34.93%.

Table 3 **US Patents Assigned to India**

Years	Patents
2001	121
2002	199
2003	237
2004	227
2005	239
2006	256
2007	265
2008	265
2009	253
2010	358
Total	2420

CAGR 34.93%

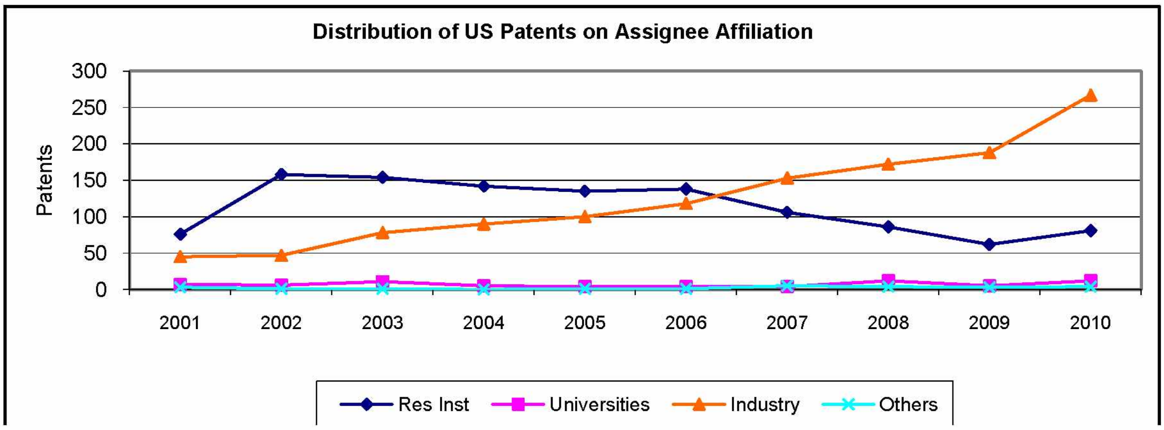


Assignee Affiliation

As has been stated earlier four affiliations were considered in tabulation, including research institutions, universities, industries, and others. On the whole, for the period under consideration, 47% of the patents came from research institutions and industries contributed 52% of the total. Universities had a minor share of 3% with 70 patents in all.

Table 4 **Distribution of Assignees on Affiliation**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Res. Inst.	76 (62.8)	158 (79.4)	154 (65)	142 (62.6)	135 (56.5)	138 (53.9)	106 (40)	86 (32.5)	62 (24.5)	81 (22.6)	1138 (47)
Universities	7 (5.8)	6 (3.0)	11 (4.6)	5 (2.2)	4 (1.7)	4 (1.6)	4 (1.5)	12 (4.5)	5 (2)	12 (3.4)	70 (2.9)
Industries	45 (37.2)	47 (23.6)	78 (32.9)	90 (39.6)	100 (41.8)	118 (46.1)	153 (57.7)	172 (64.9)	188 (74.3)	267 (74.6)	1258 (52)
Others	3 (2.5)	1 (0.5)	1 (0.4)	0 (0)	1 (0.4)	1 (0.4)	5 (1.9)	4 (1.5)	3 (1.2)	4 (1.1)	23 (1)
Total	121	199	237	227	239	256	265	265	253	358	2420



The Indian trend, as could be noticed, is interesting. The share of research institutions, which was as high as 80% in 2002, reduced to 22% in 2010. The decline has been steady and it has occurred, both as a proportion of the total and also in actual numbers. As opposed to this, the industry has registered a growth from 23% in 2002 to almost 75% in 2010. Universities show a dismal picture all through the period. Unlike most of the other countries research institutions have the most patents during the decade taken for the study. Universities do not seem to be in the patenting mode either because of absence of innovation activities or lack of awareness on patenting the same.

The picture is not rosy when we consider the growth in actual numbers. The overall number for the country has increased, though marginally. Among other things, the trend calls for spreading awareness on patenting, and also perhaps an understanding of what is patentable innovation.

Among the major assignees in India over the ten-year period are:

- Council of Scientific and Industrial Research (New Delhi, IN 990
- STMicroelectronics Ltd. (Uttar Pradesh, IN 162
- Ranbaxy Laboratories Limited (Gugaon, IN 76
- Dr. Reddy@s Laboratories Limited (Hyderabad, IN 66
- Biocon India Limited (Bangalore, IN 38
- Dr. Reddy's Laboratories, Inc. (Bridgewater, NJ 36
- Orchid Chemicals & Pharmaceuticals Limited (Chennai, IN 33
- Cipla Limited (Mumbai, IN 32
- Hetero Drugs Limited (Hyderabad, IN 30
- Indian Oil Corporation Limited (Mumbai, IN 29
- Dabur Research Foundation (Ghaziabad, IN 27
- Lupin Laboratories Limited (Mumbai, IN 25
- Ittiam Systems (P Ltd. (Bangalore, Karnataka, IN 24
- Sasken Communication Technologies Ltd (Bangalore, IN 23
- Sun Pharmaceutical Industries Limited (Mumbai, IN 22
- Mahindra Navistar Automotives Limited (IN 22
- Wockhardt Limited (Mumbai, IN 22

US patents Obtained by CSIR - 2001-10

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Patents	58	128	137	130	120	127	95	74	54	67

CSIR is a conglomerate of 39 research institutions and the patents have come from different entities, though all of them are assigned to the parent body. Three-fourths of the patents from the industry sector focus exclusively on pharmaceuticals and drug discovery.

There are 17 assignees in case of India with more than 20 patents during the 2001-2010 period. Of these the top two make up 47% of the total.

Though research institutions' share has declined over the period, comparatively it seems to be a class apart *vis-a-vis* other countries considered in the study. Chinese research institutions, for instance, have so far never registered as many patents as that of corresponding Indian institutions. The patents have mainly originated from CSIR. The other major research set-ups like ICMR, ICAR are conspicuous in their absence from the list. IITs in all have 18. IIT Kharagpur with five tops the list. IIT Chennai, Delhi, Kanpur and Mumbai figure in the list. Indian Institute of Science has nine US patents obtained during the decade.

Assignee Distribution

Importance of collaboration by institutions engaging in research, and benefits accruing through such technology management strategy cannot be over emphasized. Trends in such collaboration are presented in Table 5.

Indian patents are increasingly outcome of non-collaborative individual entity efforts both for industry and research institution. It has remained over 90% 'single entity' patents and was as high as 96% in 2010. On the whole, for the period considered, the figures show that only seven percent of the total patents are result of collaborative R&D. Both research institutions and industrial R&D establishments seem to act separately in their technology development pursuits. This could be a reflection of lack of industrial joint ventures that matter, and lack of application development among the academic institutions resulting in them acting independently of one another. The relative smallness of the research projects may also be a reason, as the minor projects do not call for active collaboration among organizations.

Table 5 **Distribution of Assignees on Collaboration**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Non-collab	106 (87.6)	180 (90.5)	226 (95.4)	211 (93.0)	225 (94.1)	235 (91.8)	242 (91.3)	247 (93.2)	239 (94.5)	343 (95.8)	2254 (93.1)
Collab.	15 (12.4)	19 (9.5)	11 (4.6)	16 (7)	14 (5.9)	21 (8.2)	23 (8.7)	18 (6.8)	14 (5.5)	15 (4.2)	166 (6.9)

Collaborative patenting among industries:

Patents obtained by Indian industries are also predominantly non-collaborative R&D efforts (92% overall for the decade, and only a handful of them are the result of inter-firm collaboration (Table 6). Industry collaboration with university and research bodies is also negligible, and has only yielded patents in the range of 0-10 in any given year, and for the decade as a whole it is just 26. Indian industries that are patenting have to wake up to the concept of alliances in innovation process and technology management. It could be because of lack of understanding of the importance of innovation and need for interfacing with other agencies that specialize in the area.

Table 6 Distribution of Assignees within Industries

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Industry Non-collab %	33 (75)	33 (70.2)	72 (96)	79 (95.2)	90 (90.9)	103 (88.8)	138 (90.8)	158 (94.0)	176 (93.6)	258 (95.9)	1138 (91.8)
Industry Collab %	3 (6.8)	3 (6.4)	2 (2.7)	3 (3.6)	9 (9.1)	10 (8.6)	12 (7.9)	9 (5.4)	9 (4.8)	8 (3.0)	68 (5.5)
Industry-Res Inst Collab %	7 (15.9)	10 (21.3)	0 (0.0)	0 (0.0)	0 (0.0)	3 (2.6)	2 (1.3)	1 (0.6)	2 (1.1)	1 (0.4)	26 (2.1)
Industry-Univ. Collab %	1 (2.3)	1 (2.1)	1 (1.3)	1 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.5)	2 (0.7)	7 (0.6)
Total	44	47	75	83	99	116	152	168	188	269	1239

International Collaboration

The Indian story on the international collaboration is not rosy either, and in percentage terms it is still hovering around single digit (Table 7).

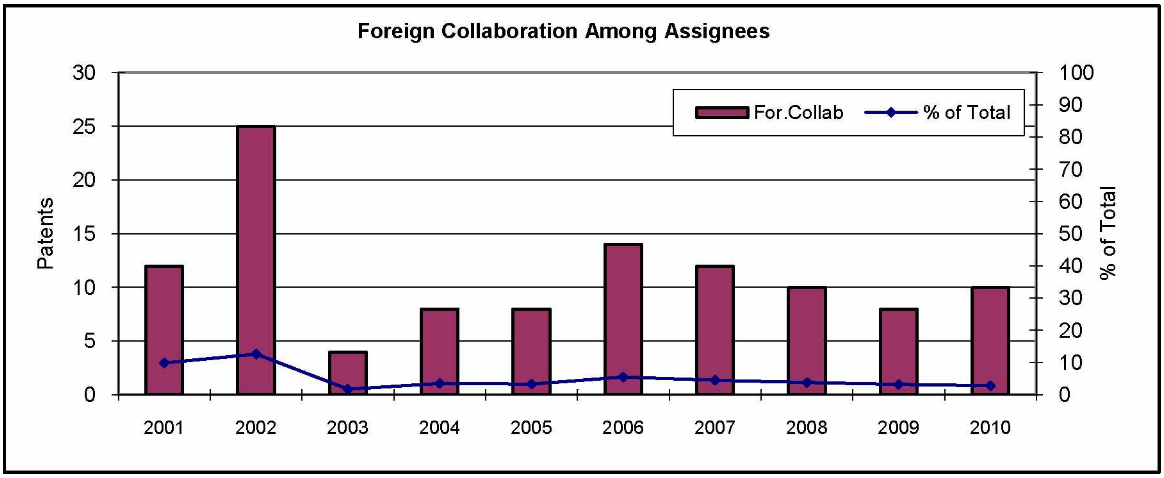
Foreign collaboration in itself may not be an indicator of any significance, unless the technology being patented is from a cutting edge field. In such cases a joint effort may not be always readily forthcoming. However, such collaboration whenever noticed indicates the strategy of individual firm's interest in pre-competition innovation. Such collaborations facilitate enhancing the IPR presence and the positive fallout of networking.

Table 7 **Assignees Collaboration with Foreign Entries**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Foreign Collab	12	25	4	8	8	14	12	10	8	10	111
% of total patents	9.9	12.6	1.7	3.5	3.3	5.5	4.5	3.8	3.2	2.8	4.6

Table 8 **Distributions of assignees among academic bodies**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Res Inst. Total	76	158	154	142	135	138	106	86	62	81	1138
Ind-Res Inst. (Collab)	8	10	3	7	0	5	3	5	2	1	44
Res. Inst (Solo)	67	142	146	130	132	127	101	77	59	79	1060
Res. Inst (Collab)	0	3	2	3	2	6	2	0	0	0	18
Res. Inst Univ (Collab)	1	2	3	1	1	0	0	4	0	1	13
Univ. Total	7	6	11	5	4	4	4	12	5	12	70
Ind-Univ Collab	1	1	1	1	0	0	0	0	1	2	7
Univ (Solo)	3	3	7	2	3	3	4	8	3	7	43
Univ. (Collab)	2	0	0	0	0	1	0	0	0	0	3



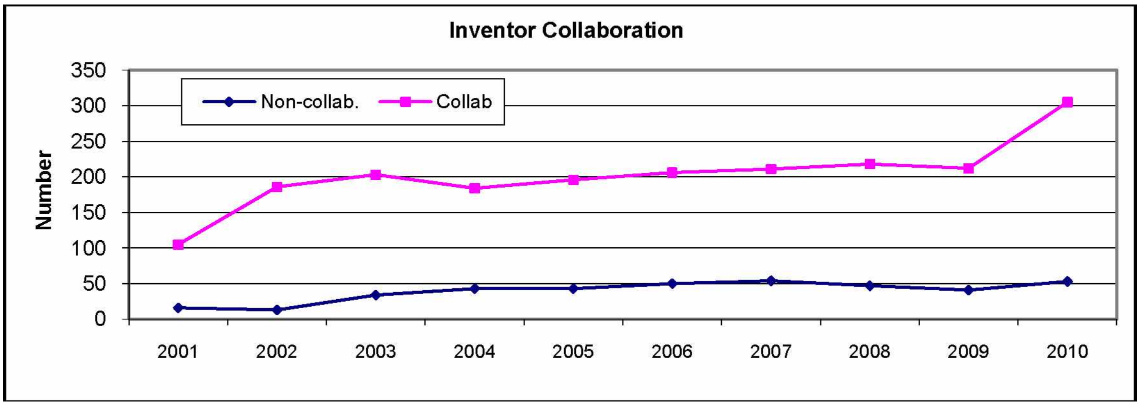
Even as to the collaboration among the academic bodies (Table 8) - universities and research institutions that have been granted patents - the trend has been to 'go alone' in India. Inter-institutional collaboration, be it between more than one research institution, more than one university, or research institution and university, is negligible. In actual numbers, it is below five in any of these categories in a given year.

Inventor Collaboration

It is interesting to note the collaboration among the inventors who have worked for the patented technologies. (Table 9)

Table 9 **Inventor Collaboration**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Non-collabo rataive %	16 (13.2)	13 (6.5)	34 (14.3)	43 (18.9)	43 (18.0)	50 (19.5)	54 (20.4)	47 (17.7)	41 (16.2)	53 (14.8)	394 (16.3)
Collabo rative %	105 (86.8)	186 (93.5)	203 (85.7)	184 (81.1)	196 (82.0)	206 (80.5)	211 (79.6)	218 (82.3)	212 (83.8)	305 (85.2)	2026 (83.7)



In our context patents have increasingly come from collaborative teams of inventors and have remained above 80%, all through the years. It was as high as 93% in 2002. As to the team composition, there is an even distribution of teams with 2, 3 or more inventors. This composition is an indicator of the nature of innovation, in terms of the country's research base. As sole individuals can no longer carry out high technology research all by oneself, the team size is an indirect indicator of the level of patented technologies. It could also be an indicator of work norms and hierarchy in academic and non-academic institution.

Table 10 **Distribution of inventors**

No of Inventors	Occurrence	%
1	316	13.06
2	511	21.12
3	471	19.46
4	347	14.34
5	285	11.78
6>	490	20.25

An interesting piece of data that comes along with this is the number of distinct inventors. India had 4,794 successful inventors during the years 2001-2010 period going by the US patents assigned to the country. A large proportion of inventors hold, either completely or in part, one or two patents. It is as high as 84%. Many of these could be new patent holders and given the due assistance could be more productive on this front. The per capita patents work out to be 0.51 in India. On the face of it our patent productivity with the existing inventor base engaged in the activity is relatively low.

The inventor base is growing on a year on year basis and for the 2001-2010 period. CAGR for the duration works out to be 29.51%.

Table 11 Growth of inventors

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010		Total
No of new Inventors	361	453	482	487	501	464	457	466	468	655		4794
Year on Year Increase		125.48	106.40	101.04	102.87	92.61	98.49	101.97	100.43	139.96	107.70	

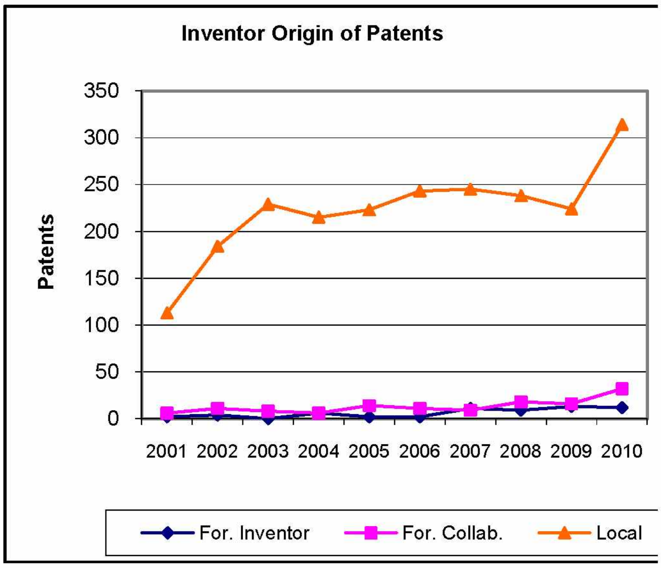
CAGR 29.51

Outsourced Innovations

It is known that the patents assigned to institution/industrial firms of a given country need not be invented within its own geographical territory. There are always instances of work outsourced or carried out by inventors elsewhere. It is also true that when the inventors collaborate, it could be with other inventors from within or outside the country. Such an analysis for India show that our collaboration is mostly within the country (Table 12), with an average of 92% for the period under study. Both in actual numbers and as a proportion to the total foreign collaborations are negligible. Here is perhaps a lesson for the Indian industry in effective management of innovation on the way to enhance their impact through patented innovations. Other countries, particularly China, have extensively collaborated with foreign institutions and inventors on the projects, which have resulted in patents. Such collaborations have been the learning experience for China, both at inventor and assignee level.

Table 12 Distribution on inventor Collaboration

	Foreign Inventor %	Foreign Collab %	Local %	Total
2001	2 (1.7)	6 (5.0)	113 (93.4)	121
2002	4 (2.0)	11 (5.5)	184 (92.5)	199
2003	0 (0.0)	8 (3.4)	229 (96.6	237
2004	6 (2.6)	6 (2.6)	215 (94.7	227
2005	2 (0.8)	14 (5.9)	223 (93.3	239
2006	2 (0.8)	11 (4.3)	243 (94.9	256
2007	11 (4.2)	9 (3.4)	245 (92.5)	265
2008	9 (3.4)	18 (6.8)	238 (89.8)	265
2009	13 (5.1)	16 (6.3)	224 (88.5)	253
2010	12 (3.4)	32 (8.9)	314 (87.7)	358
	61 (2.5)	131 (5.4)	2228 (92.1)	2420

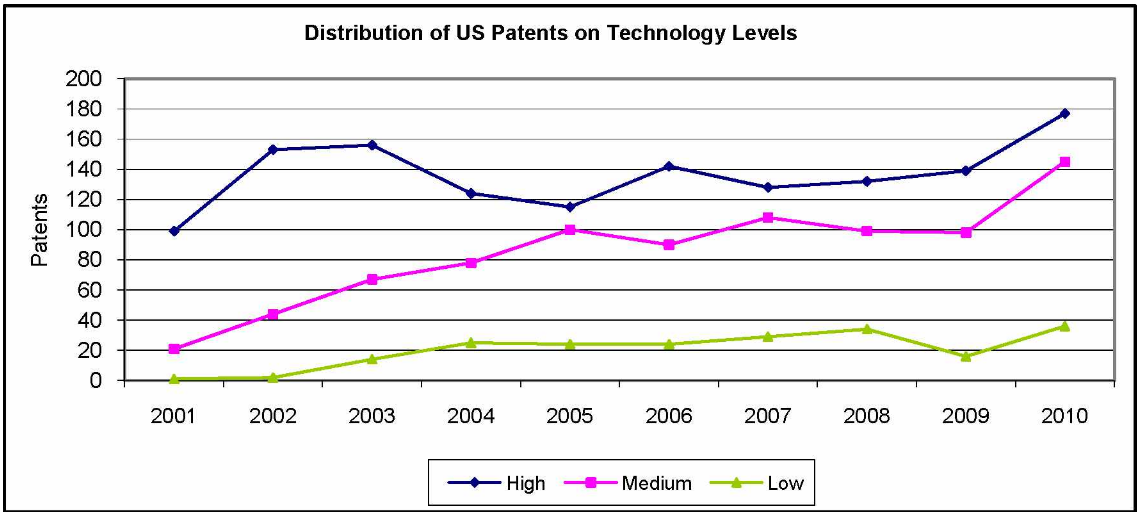


Technology level of patents

The technology level mix of Indian patents obtained in the US PTO is unlike Israel and China considered in the study (Table 13). High technology patents, with the inventions either originating from research labs or cutting edge technologies are more than the other two categories. This could be due to Indian focus which has been innovation in pharmaceuticals and drugs, biotechnology, organic as well as inorganic chemical processes. India has only a few patents that could be categorized as low technology during the period, and these are mainly ornamental designs going with gems and jewelry.

Table 13 Distribution of patents on Technology Levels

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
High %	99 (81.8)	153 (76.9)	156 (65.8)	124 (54.6)	115 (48.1)	142 (55.5)	128 (48.3)	132 (49.8)	139 (54.9)	177 (49.4)	1365 (56.4
Medium %	21 (17.4)	44 (22.1)	67 (28.3)	78 (34.4)	100 (41.8)	90 (35.2)	108 (40.8)	99 (37.4)	98 (38.7)	145 (40.5)	850 (35.1)
Low %	1 (0.8)	2 (1.0)	14 (5.9)	25 (11.0)	24 (10.0)	24 (9.4)	29 (10.9)	34 (12.8)	16 (6.3)	36 (10.1)	205 (8.5)
Total	121	199	237	227	239	256	265	265	253	358	2420



Indian high technology patents registered a slight decline from a 156 in 2003 to 139 in 2009. On the whole figures stood at 56% for the decade. Our high technology patents include drugs and pharmaceuticals, processes and methods in the organic and inorganic chemistry, biochemistry, nanomaterials. Electronics, metal processes, electrical devices, water treatment. Various processes in industrial chemistry largely make up the medium technology patents.

Table 14 Inventor Collaboration Across Technology Levels

	Low			Medium			High		
	Collab %	Non-collab %	Total	Collab %	Non-collab %	Total	Collab %	Non-collab %	Total
2001	1 (100.0)	0 (0.0)	1	12 (57.1)	9 (42.9)	21	98 (99.0)	1 (1.0)	99
2002	2 (100.0)	0 (0.0)	2	40 (90.9)	4 (9.1)	44	151 (98.7)	2 (1.3)	153
2003	10 (71.4)	4 (28.6)	14	52 (77.6)	15 (22.4)	67	143 (91.7)	13 (8.30)	156
2004	17 (68.0)	8 (32.0)	25	68 (87.2)	10 (12.8)	78	99 (79.8)	25 (20.2)	124
2005	8 (33.3)	16 (66.7)	24	92 (92.0)	8 (8.0)	100	95 (82.6)	20 (17.4)	115
2006	13 (54.2)	11 (45.8)	24	75 (83.3)	15 (16.7)	90	119 (83.8)	23 (16.2)	142
2007	13 (44.8)	16 (55.2)	29	95 (88.0)	13 (12.0)	108	106 (82.8)	22 (17.2)	128
2008	19 (55.9)	15 (44.1)	34	90 (90.9)	9 (9.1)	99	98 (74.2)	34 (25.8)	132
2009	10 (62.5)	6 (37.5)	16	88 (89.8)	10 (10.2)	98	123 (88.5)	16 (11.5)	139
2010	23 (63.9)	13 (36.1)	36	137 (94.5)	8 (5.5)	145	141 (79.7)	36 (20.3)	177
	116 (56.6)	89 (43.4)	205	750 (88.2)	100 (11.8)	850	1173 (85.9)	192 (14.1)	1365

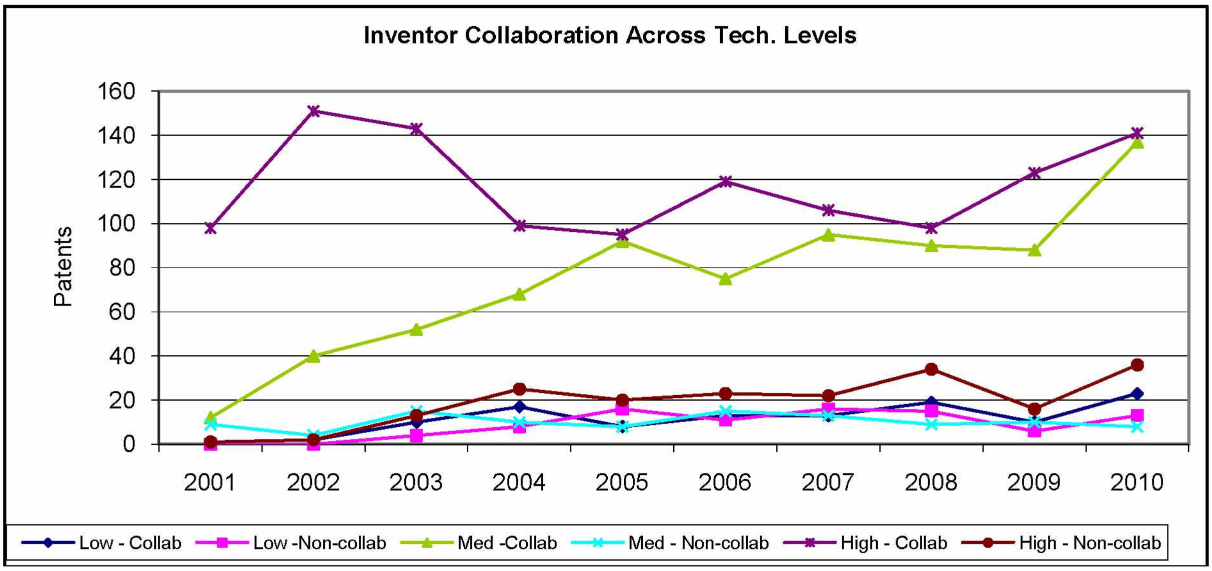
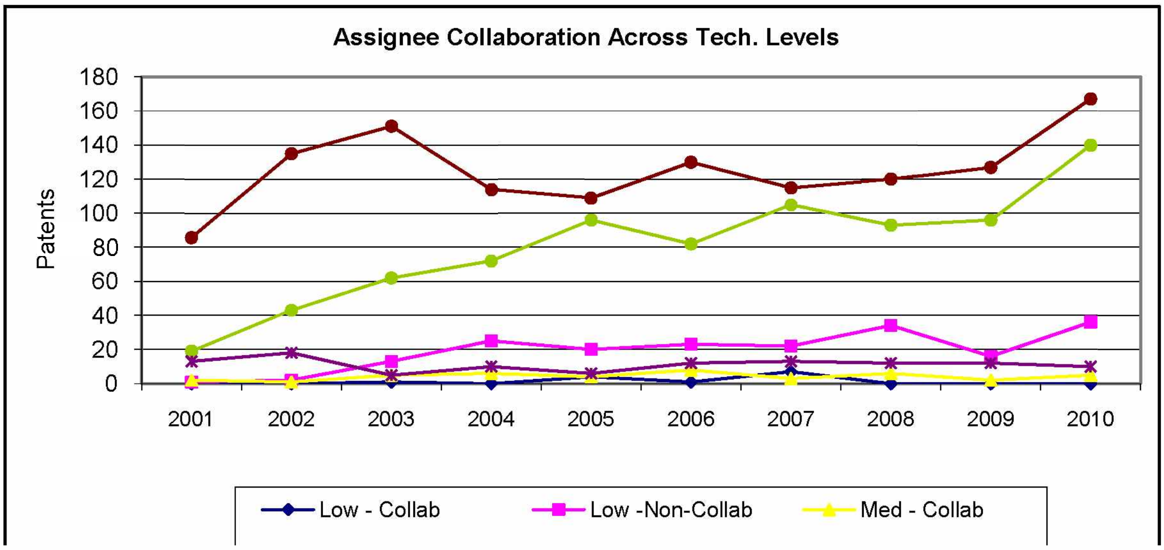


Table 15 Inventor Nationality Across Technology Levels

	Low				Medium				High			
	Foreign %	For. Collab %	Local %	Total	Foreign %	For Collab %	Local %	Total	Foreign %	For. Collab %	Local %	Total
2001	2 (9.5)	5 (23.8)	14 (66.7)	21	0 (0)	0 (0)	1 (100)	1	2 (2.0)	5 (5.1)	92 (92.9)	99
2002	4 (9.1)	8 (18.2)	32 (72.7)	44	0 (0)	0 (0)	2 (100)	2	4 (2.6)	8 (5.2)	141 (92.2)	153
2003	0 (0.0)	5 (7.5)	62 (92.5)	67	0 (0)	0 (0)	14 (100)	14	0 (0.0)	5 (3.2)	151 (96.8)	156
2004	4 (5.1)	3 (3.8)	71 (91.0)	78	2 (8.0)	1 (4.0)	22 (88.0)	25	4 (3.2)	3 (2.4)	117 (94.4)	124
2005	1 (1.0)	10 (10.0)	89 (89.0)	100	0 (0)	0 (0)	24 (100)	24	1 (0.9)	10 (8.7)	104 (90.4)	115
2006	1 (1.1)	4 (4.4)	85 (94.4)	90	0 (0)	1 (4.2)	23 (95.8)	24	1 (0.7)	4 (2.8)	137 (96.5)	142
2007	9 (8.3)	5 (4.6)	94 (87.0)	108	0 (0)	0 (0)	29 (100)	29	9 (7.0)	5 (3.9)	114 (89.1)	128
2008	7 (7.1)	12 (12.1)	80 (80.8)	99	2 (5.9)	0 (0)	32 (94.1)	34	7 (5.3)	12 (9.1)	113 (85.6)	132
2009	6 (6.1)	14 (14.3)	78 (79.6)	98	2 (12.5)	1 (6.3)	13 (81.3)	16	6 (4.3)	14 (10.1)	119 (85.6)	139
2010	5 (3.4)	8 (5.5)	132 (91.0)	145	3 (8.3)	23 (63.9)	10 (27.8)	36	5 (2.8)	8 (4.5)	164 (92.7)	177
Total	39 (4.6)	74 (8.7)	737 (86.7)	850	9 (4.4)	26 (12.7)	170 (82.9)	205	39 (2.9)	74 (5.4)	1252 (91.7)	1365

Table 16 Distribution of collaboration on Assignees

	Low			Medium			High		
	Collab %	Non-Collab %	Total	Collab %	Non-Collab %	Total	Collab %	Non-Collab %	Total
2001	0 (0.0)	1 (100)	1	2 (9.5)	19 (90.5)	21	13 (13.1)	86 (86.9)	99
2002	0 (0.0)	2 (100)	2	1 (2.3)	43 (97.7)	44	18 (11.8)	135 (88.2)	153
2003	1 (7.1)	13 (92.9)	14	5 (7.5)	62 (92.5)	67	5 (3.2)	151 (96.8)	156
2004	0 (0.0)	25 (100)	25	6 (7.7)	72 (92.3)	78	10 (8.1)	114 (91.9)	124
2005	4 (16.7)	20 (83.3)	24	4 (4.0)	96 (96.0)	100	6 (5.2)	109 (94.8)	115
2006	1 (4.2)	23 (95.8)	24	8 (8.9)	82 (91.1)	90	12 (8.5)	130 (91.5)	142
2007	7 (24.1)	22 (75.9)	29	3 (2.8)	105 (97.2)	108	13 (10.2)	115 (89.8)	128
2008	0 (0.0)	34 (100)	34	6 (6.1)	93 (93.9)	99	12 (9.1)	120 (90.9)	132
2009	0 (0.0)	16 (100)	16	2 (2.0)	96 (98.0)	98	12 (8.6)	127 (91.4)	139
2010	0 (0.0)	36 (100)	36	5 (3.4)	140 (96.6)	145	10 (5.6)	167 (94.4)	177
	13 (6.3)	192 (93.7)	205	42 (4.9)	808 (95.1)	850	111 (8.1)	1254 (91.9)	1365



Further classification of patent data on technology levels show that inventor collaboration is high for India in medium and high technology patents (Table 14).

India too has a few high technology patents with exclusive foreign innovators, but these are very few in number compared to China and could be treated as stray cases (Table 15)

Other observations in the context that could be inferred include:

- ✓ Inventor collaboration is relatively low and the collaboration seems to correlate with the technology level of patents (56% in low technology). Higher the level of technology more frequent the collaboration. This is true of both medium and high technology innovations (Table 14).
- ✓ There is an overlap in the trend of foreign assignee collaboration and that of inventors going with technology level of patents. Higher the technology level, greater is the chance of such collaboration among the assignees (Table 16) and inventors. Over a hundred patents, making up 8% of the high technology, have one or more joint foreign assignees.

The actual difference in the patent performance of India and other two countries considered in the study seem to lie in medium and low technologies. India also has registered a modest increase in medium technologies on the whole, averaging to 37% of the total for the years. In actual numbers though, it still hovers around one hundred per annum in recent years.

The low technologies, which are defined to be patents with low level of technical novelty in otherwise proven technologies, do not seem to be our priority. The highest number of such patents in a year was 36 taken in 2010, as opposed to 771 for the same year by China.

The low technology patents from India, which we are waking up to in the recent years, are almost all local in terms of inventors and are also mostly without any collaboration among the assignees. India has obtained very few design patents (Table 17).

Table 17 Distribution of Low Tech patents

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Design Patents %	0 (0.0)	0 (0.0)	2 (14.3)	7 (28.0)	13 (54.2)	8 (33.3)	12 (41.4)	14 (41.2)	19 (118.8)	35 (97.2)	110 (53.7)
Others %	1 (100.0)	2 (100.0)	12 (85.7)	18 (72.0)	11 (45.8)	16 (66.7)	17 (58.6)	20 (58.8)	-3 (-18.8)	1 (2.8)	95 (46.3)
Total	1	2	14	25	24	24	29	34	16	36	205

Technology level of patents across assignee categories

Most of the Indian high technology patents by industry assignees are those on pharmaceuticals and process patents relating to synthesis of chemical compounds leading to drugs. Table 18 presents the distribution of our patents across technology levels and assignee affiliation.

Table 18 **Distribution of Patents Across Assignee Categories**

	Industrial Firms	**Research Institutes**	**Universities**
High	638 (45.44)	726 (51.71)	40 (2.85)
Medium	480 (54.55)	372 (42.27)	28 (3.18)
Low	140 (77.35)	39 (21.55)	2 (1.10)

Total differs as in this grouping patens may fall in more than one category

The patents filed by the industry sector under medium technology category predominantly belong to three fields

- Electrical/electromagnetic apparatus including electrical/electro-magnetic field, consisting of a variety of lab-oriented apparatus like circuit breakers, voltage regulators, hysterisis loops, signal regulators, noise reduction technologies, programmable circuitry etc.
- Electronics, including power electronics as well as analog and digital electronics. In this context, it can be noted that various parts of a computer architecture namely memory programming, arrays, chip design come under this field. We see quite a lot of semiconductor devices in the analog section as well programmable logic arrays in the digital section. Patents on some new technologies such as GPS, FPGA etc can also be seen.
- The last category of the Indian medium tech patents is that of industrial chemistry. Apart from these, one can also see a good number of patents on organic salts, herbal compositions as well elasto-rubber & polymers.

Though a few patents on semiconductor devices, aerospace and automotives are also present, the patents are mainly distributed among the above three categories.

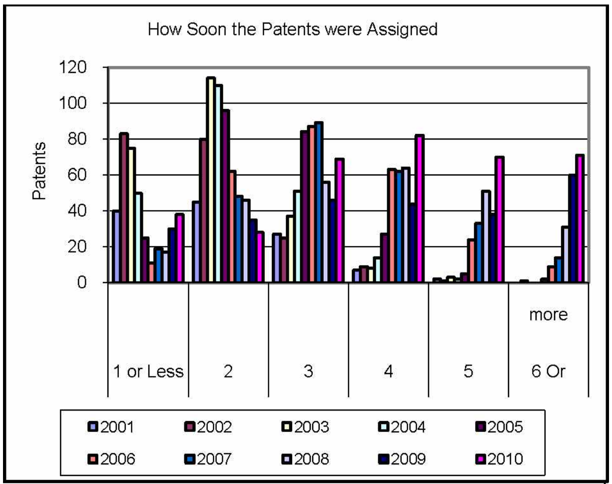
Thus, the Indian industrial patents mainly revolve around electrical and electronics, and most of which are not home/ consumer products. They are also based on laboratory research and are of major importance in cutting edge fields such as semiconductors, communication, power generation, etc.

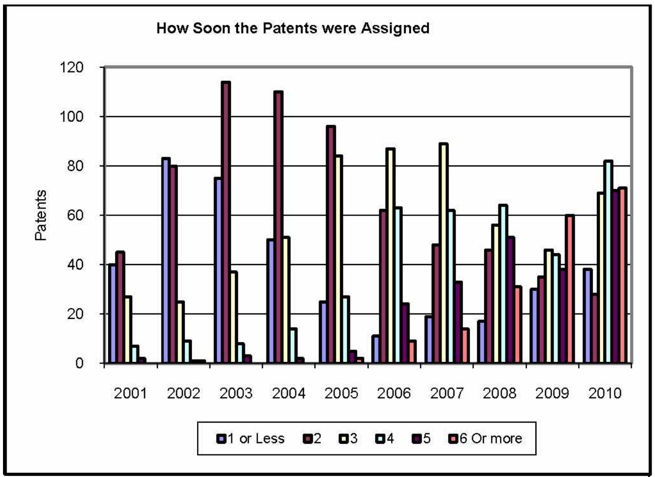
How soon were the patents assigned

The technology composition of patents is also reflected in the duration it takes to obtain the US patents. On an average it takes four years for an Indian patent to be assigned. Over 60% of the patents in 2007 to 2010 were filed four years before that date. There is also a corresponding decrease in the patents obtained within two years.

Table 18 **Time duration in obtaining US Patents**

	1 Year or Less	2	3	4	5	6 or more	
2001	40	45	27	7	2	0	121
2002	83	80	25	9	1	1	199
2003	75	114	37	8	3	0	237
2004	50	110	51	14	2	0	227
2005	25	96	84	27	5	2	239
2006	11	62	87	63	24	9	256
2007	19	48	89	62	33	14	265
2008	17	46	56	64	51	31	265
2009	30	35	46	44	38	60	253
2010	38	28	69	82	70	71	358
	388	664	571	380	229	188	2420





Subject focus of patents

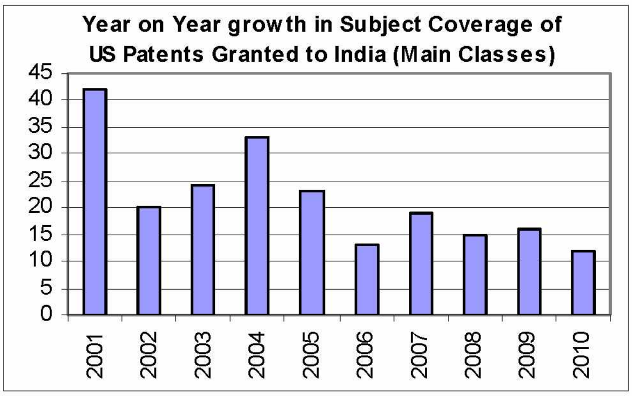
A count of the broad subject areas of focus based on the US Patent Subject Manual also confirms that Indian efforts are largely science based. Pharmaceuticals, drugs research and laboratory based chemistry make up roughly 30% of the patents. Absence of innovation in other fields of technologies reflect either the absence of technology need or the resource crunch. It could also be due to lack of awareness and relative low importance attached to the same. Patents obtained by India do not necessarily commensurate the S&T base the country has. It appears that apart from awareness, there is a need to provide mentoring and handholding in patenting innovation.

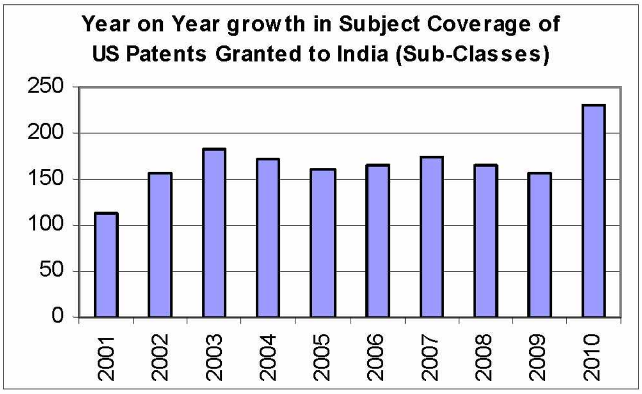
Areas of innovation by India	
Chemistry of organic & inorganic compounds 549,435,546,548	737
Drug, bio-affecting and body treating compositions 424,514, 517	1034

Indian patents during the 2001-2010 period fall under 217 distinct US patent main classes, and 1681 sub-classes (Table 21). CAGR for the distinct main classes is 17.85%, and for the sub-classes 30.88% within the narrower set of main classes, our innovations are diversifying into narrower aspects. Drugs, pharmaceuticals and chemistry make up a major portion of the same. Other classes indicative of the nature of topics / products innovated on include: food and edible materials (28, Jewelry design (28), transportation (25), multiplex communication (24) data processing, calibrating, testing (27), information storage and retrieval (18), multi-cellular living organisms (25), Measuring and testing (9), synthetic resins (16, coded data generation (7), electricity - measuring and testing (5), plastic article / earthen ware - shaping or treating (3), metal working (2), Brakes (2), surgery (3) etc. A closer look at the patents and their claim suggests that the patents are not marginal improvements as is the case with countries like China. However relative narrow spread of topics / products patented suggest that the invention and patenting activity is limited to those with high technical proficiency and not pervasive in all enterprises and at all levels of technology.

Table 21 Growth in patent subject classes

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	CAGR
Main class	42	20	24	33	23	13	19	15	16	12	217	17.85%
Sub-class	114	157	183	172	161	166	175	166	156	231	1681	30.88%





India is not only lagging behind in patents but also in the subject spread of the same. Comparatively our R&D seems to be confined to far fewer specializations. The country has over one hundred patents in three classes during the decade (Table 22). This reflects clustering of patents. Subject spread, otherwise is narrower. The number do not suggest that we have sufficient technology strength to bargain for any leverage.

Table 22 - Distribution of Patents on US Patent Classification Classes

Patents	No of Patent classes
> 200	2
150-200	1
100-150	-
50-100	7
40-49	2
30-39	6
20-29	10
10-19	24
9	2
8	5
7	3
6	7
5	5
4	15
3	19
2	34
1	75

Distinct Assignees:

Distribution of distinct assignees and the corresponding number of patents also reveal that India has far fewer entities in all intervals (Table 23). Particularly noticeable is the relatively small numbers in the categories of fewer patents like, ones or twos. Most of the other counties considered in the study have majority of their assignees in this category, which indicate a wide spread innovation activity, including possibly new inventors. There is an urgent need for getting more organizations on to the R&D and patenting mode.

Table 23 Distribution of Patents on Unique Assignees

No. of Assignees	Patents
2	>100
-	90-99
-	80-89
1	70-79
1	60-69
-	50-59
-	40-49
5	30-39
8	20-29
19	10--19
24	6--9
42	3--5
58	2
226	1

Table 24 Growth of Assignees

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010		Total
No of new assignees	46	27	42	43	36	36	38	36	32	50		386
Year on Year Increase		58.70	155.56	102.38	83.72	100.00	105.56	94.74	88.89	156.25	105.09	

CAGR 23.7%

On the whole 386 distinct entities, inclusive of laboratories and industrial enterprises, have obtained patents during the 2001-2010 period. There has been a slow but steady growth of new entities obtaining patents. CAGR of assignees is 23.7% for the decade. Despite this increase, as our base figures are far less, (even with a higher number of patents in 2001) the cumulative number of assignees as they stand now is relatively modest.

Summary:

- Indian patents obtained in the USPTO have registered a growth trend during the 2001-10 period. Pace of growth is comparatively slow.
- Industry ownership of the patents is relatively small in actual numbers.
- Indian patents are largely based on lab oriented processes and less of products.
- Assignee collaboration is very less and at the same time inventor collaboration is high.
- India's assignee base and inventor base, as for as these patents are concerned, is small.
- Our subject expanse of the patented technologies is relatively less.

Indian Patents Obtained in IPO

Indian Patents Obtained in IPO

Unlike the Indian patents in the US PTO, those obtained in the Indian Patent Office (IPO) are promising in number and technology range. IPO, as per its Annual Report (2009-2010) claim that patents grant to during the decade to be around 14,000. The IPO database, on the other hand, retrieves a varying number (Table 1). Enquiries in the Indian Patent Office, New Delhi, confirmed that the database discrepancies exist, and the paper documents were not in shape for record creation.

The study also explored Derwent Innovation Index to retrieve the IPO related data for the period. This database, created with a different primary purpose, does not provide the query options to extract the relevant data. Improvised methods for retrieval indicated the numbers that would not reconcile either with the IPO annual report or their public domain database. Derwent Innovation Index includes in its database pre-grant publication of patents and the patents granted by the IPO. Patents obtained from across the offices are bundled together based on what the publication evaluates as overlapping innovations.

The best option under the situation was to analyze the data retrievable from the IPO public domain database. The results could be considered as broad trends. As the country-wise retrieval is not made available in this database, the entire set of records that could be retrieved for 2001-2010 was downloaded. From these all the records that matched with Indian locations were identified for analysis. Thus, a subset of Indian patents was made after downloading the entire set of patents for the period 2001 -2010.

Table 1 **Patents Assigned to India In IPO**

Retrieved from IPO database		IPO Annual Report (2009-10)	
2001	1	2000-01	399
2002	20	2001-02	654
2003	32	2002-03	494
2004	120	2003-04	945
2005	205	2004-05	764
2006	871	2005-06	1396
2007	1766	2006-07	1907
2008	2056	2007-08	3173
2009	1664	2008-09	2541
2010	1164	2009-10	1725

Under Indian patent law, the patent application is given an application number on its filing. It is published in the patent office's official publication after 18 months from the date of filing based on the applicant's request. Beyond this stage the patent is examined for various provisions of the Patent Act and made open to challenge. No patent, however, can be granted till six months after the date of publication. Patent rights are granted for 20 years from the date of application.

Growth of Patents

Indian patents show a remarkable increase staring with just around 20 in the first two years of the decade to over 2,000 in 2008. There is a decline in the number in the last two years of the decade. The decline, among other things, is also attributed to shortfall of examiners by the IPO. However, the patent applications by Indians are on the raise as reflected in the IPO annual report for the period.

Assignee distribution:

Research institutions, led by CSIR, were in the forefront during the first few year of the decade. From 2005 onwards this lead has been wrested by the industry sector to an extent (Table 2). Indian universities have contributed to innovation in a much bigger way than what is noticed in the context of the US Patents. Contribution of 5% to 6% of the total from the universities has continued throughout the second half of the decade. The 'Others' category also has a substantial number during the years. These make up almost 20% of the total for the decade. The 'Others' include mainly individuals obtaining patents in their personal capacity. Several innovations in this category, as could be made out from the contents, are ideas worked in their institutional capacity. The representative examples are:

- *A process for preparing substrates for cultivation of button mushrooms of both winter and summer varieties [211708]*
- *A process of preparing ferro-electric material [215888]*
- *A system to prevent the formation and escape of vapours of highly inflammable liquids from storage tanks [219430]*
- *An improved intelligent modem for metering application [216088]*
- *G-stroke engine [207573]*
- *Static electric motor device for converting static charge / electricity into useful form of energy [211679]*
- *Synergistic red blood corpuscle (RBC) aggregating tonic solutions with a long shelf for determining osmotic fragility of red cells in microtitre plate wells. [216317]*

Table 2 Distribution of Assignees on Affiliation

	Res. Inst	%	Univ	%	Industry	%	Others	%	
2001	1	100.00		0.00		0.00		0.00	1
2002	18	85.71	1	4.76		0.00	2	9.52	21
2003	23	71.88	0	0.00	7	21.88	2	6.25	32
2004	91	75.83	1	0.83	19	15.83	9	7.50	120
2005	30	14.56	14	6.80	116	56.31	46	22.33	206
2006	168	19.18	49	5.59	457	52.17	202	23.06	876
2007	249	13.93	118	6.60	985	55.12	435	24.34	1787
2008	764	36.43	119	5.67	838	39.96	376	17.93	2097
2009	696	40.94	87	5.12	659	38.76	258	15.18	1700
2010	410	34.25	76	6.35	507	42.36	204	17.04	1197
	2450	30.48	465	5.79	3588	44.64	1534	19.09	8037

figures do not tally as the patents could have assignees from more than one affiliation

The patents stand in the innovators name, as the respective institutions may not have formed patenting guidelines. This also happens when institutions do not appreciate the value of IPR for the institution. On the whole, a large 'academic IP ownership' could be noticed in the patents, a definite trend is missing as the number and assignee composition has varied considerably from year to year.

Assignee collaboration:

A large majority of these patents were filed and obtained by assignees working on their own. Collaborative invention could also be noticed during the later half of the decade. Assignee collaboration ranged from 18% to 42% of the total. There is no definite trend that could be noticed on the face of it, as the total number in both the categories, viz., collaborative and non-collaborative, has varied from year to year. Non-collaborative patents make up 75% of the total for the decade (Table 3)

Table 3 Distribution of Assignees

	Non-collab	%	Collab.	%	Total
2001	1	100.00	0	0.00	1
2002	20	100.00	0	0.00	20
2003	29	90.63	3	9.38	32
2004	111	92.50	9	7.50	120
2005	118	57.56	87	42.44	205
2006	588	67.51	283	32.49	871
2007	1240	70.22	526	29.78	1766
2008	1590	77.33	466	22.67	2056
2009	1355	81.43	309	18.57	1664
2010	891	76.55	273	23.45	1164
	5943	75.24	1956	24.76	7899

The data were analyzed to decipher collaboration among the assignee categories. The results indicate that barring a few exceptions patenting firms have not collaborated, either with other firms or with academic entities (Table 4). Industrial firms and research institutions/ universities largely stand apart in technology generation. They act independently.

Table 4 Distribution of Assignees within Industries

	Industry (Non-collab)	%	Industry (Collab)	%	Ind-Res. Inst.	%	Ind-Univ	%	Ind-Oth	%	
2001											
2002											
2003	7	100.0									7
2004	19	100.0									19
2005	113	97.41	2	1.72			1	0.86			116
2006	447	97.81	4	0.88	3	0.66	1	0.22	2	0.44	457
2007	963	97.77	7	0.71	9	0.91	6	0.61			985
2008	804	95.94	7	0.84	4	0.48	11	1.31	12	1.43	838
2009	639	96.97	8	1.21	4	0.61	5	0.76	3	0.46	659
2010	488	96.25	4	0.79	4	0.79	6	1.18	5	0.99	507

Table 5 Foreign Collaboration			
	Foreign Collab.	% of total Patents	Total
2001	-	-	1
2002	-	-	20
2003	-	-	32
2004	-	-	120
2005	-	-	205
2006	2	0.23	871
2007	4	0.23	1766
2008	6	0.29	2056
2009	4	0.24	1664
2010	1	0.09	1164
	17	0.22	7899

Barring a few exceptions, foreign collaboration is not to be seen in the Indian patents (Table 5). There were only 17 such patents with foreign collaboration during the entire decade. This is a reflection on our priorities and programmes. This could also be due to varying emphasis on technology generation or mismatch in our relative level of expertise.

Inventor distribution:

Inventor collaboration is very high in our patents. it almost nears 70% of the patents for the decade. The proportion of patents with inventor team of two or more has ranged from 50% to 80% of the total over the years considered (Table 6). This trend of wider inventor level collaboration could also be noticed among the patents obtained by India in the US PTO. These collaborations are almost all local in their composition. Foreign collaboration in innovation is less than 0.5 percent for the entire decade. However, exclusive end-to-end outsourcing of invention to foreign inventors is present (Table 8). These are mostly the ones patented by Hindustan Unilever and a few other industrial firms.

Inventor collaboration is high with the team size of two or three. It tapers off in proportion to total as the team size increases. Nonetheless, around 10% of the filing has six or more persons associated with the patent. This is an unusual pattern noticed only in our context, among the countries examined in the study.

Table 6 Inventor Distribution

	Single	%	Collab	%	Total
2001	0	0.00	1	100.00	1
2002	3	15.00	17	85.00	20
2003	5	15.63	27	84.38	32
2004	20	16.67	100	83.33	120
2005	79	38.54	126	61.46	205
2006	352	40.41	519	59.59	871
2007	798	45.19	968	54.81	1766
2008	599	29.13	1457	70.87	2056
2009	407	24.46	1257	75.54	1664
2010	278	23.88	886	76.12	1164
Total	2541	32.17	5358	67.83	7899

Table 7 Distribution of inventors

No of Inventors	Occurrence	%
1	2442	30.92
2	1649	20.88
3	1425	18.04
4	1052	13.32
5	613	7.76
6>	718	9.09
	7899	

Table 8 Distribution on inventor Collaboration

	Foreign	%	Foreign Collab	%	Local	%	Total
2001					1	100.00	1
2002					20	100.00	20
2003					32	100.00	32
2004					120	100.00	120
2005	2	0.98			203	99.02	205
2006	26	2.99	1	0.11	844	96.90	871
2007	93	5.27	2	0.11	1671	94.62	1766
2008	43	2.09	14	0.68	1999	97.23	2056
2009	20	1.20	5	0.30	1639	98.50	1664
2010	7	0.60	4	0.34	1153	99.05	1164
	191	2.42	26	0.33	7682	97.25	7899

Technology level of patents

High technology patents are those which have laboratory based processes or those falling in the field of cutting edge technologies like biotechnology, drugs, pharmaceuticals, nanotech, semiconductors, etc. It is interesting to note that total in this category for the local patents surpass that of the US Patents we have obtained in the same category (Table 9). High technology patents have grown considerably in the years after 2008 (Table 10) and so too are the medium technology patents in the post 2007 period. Some of the representative medium technology patents are as follows:

- *A detachable amounting arrangement for catalytic converter for all two-wheelers [207544]*
- *A device for manufacturing chiki and other allied traditional ethnic Indian food products and a method of manufacturing said products using the device [208268]*
- *A method for reducing colour loss from hair treated with an oxidative hair dye [208789]*
- *A process for making a power tea product [207587]*
- *A process of production of secondary metabolites by culturing plant parts [207564]*
- *A resin for use in a dentine bonding agent [207547]*
- *A topical composition for human skin/ SP [208862]*
- *An improved method of liquefaction of coal and reactor therefore [208758]*
- *Anti-microbial compositions comprising a salt of a transition metal chelator [209133]*
- *Compositions containing quarternary ammonium compound [207593]*
- *Group energy metering system [208852]*

Table 9 Distribution of patents on Technology Levels

	High	%	Medium	%	Low	%	Total
2001	0	0.00	1	100.00	0	0.00	1
2002	17	85.00	3	15.00	0	0.00	20
2003	16	50.00	16	50.00	0	0.00	32
2004	61	50.83	59	49.17	0	0.00	120
2005	12	5.85	193	94.15	0	0.00	205
2006	98	11.25	772	88.63	1	0.11	871
2007	152	8.61	1606	90.94	8	0.45	1766
2008	525	25.54	1528	74.32	3	0.15	2056
2009	491	29.51	1170	70.31	3	0.18	1664
2010	269	23.11	894	76.80	1	0.09	1164
Total	1641	20.77	6242	79.02	16	0.20	

There is a very meager representation of what could be classified as low technology or soft patents. This could be because of designs are treated separately in our context. Some of the patents in the low technology category are listed below:

- *A coconut frond shredder [208703]*
- *An improved disposable garbage bin [215662]*
- *Cloth hanging clip [227858]*

Subject classification

As Indian patent office does not classify patents on US PTO subject classification, the patents were categorized on their broad subject groups. In all they fell in to 18 broad categories, including 'others' which contain those that did not fit in the defined categories. Based on this grouping we could arrive at three different clusters. The first cluster included patents on subjects such as chemical technology (2352), mechanical engineering (1444), and drugs and pharmaceuticals (1401). Chemistry patents are those used in industrial processes, fertilizers, toiletries and the like. Together these three clusters total to over 5,000 patents during the decade and make up over 60% of our output. The second cluster includes electronics (426), metallurgy (420), electrical engineering (339), food technology (295), textiles (191), and medical devices (155). The third cluster includes those patents dealing with civil engineering (83), software related technologies (71), ceramics (65), optical instruments (37), environmental technology (35), nanotechnology (33). We also have a little more than 300 patents on various other technologies which could only grouped as 'others'. These include innovations on

- *A coin planchet [220311]*
- *A Container [203416]*
- *A Geometrical instrument for constructing regular polygons [203361]*
- *A process to develop picturesque designs using water as the medium [202805]*
- *A system for conversion [198370]*
- *An improved bamboo playhouse [220222]*
- *Auspiwatch time piece for ascertaining auspicious moment [222094]*
- *Permanent calendar [198361]*
- *Toothbrush [211111], and such others.*

Patents growth has been consistent on the technologies, which make the first cluster.

Table 10 Subject-wise distribution of Indian patents (IPO)

	BIO	CER A	CHE M	CIVI L	ELE CTRI C	ELE C TRO NICS	ENV	FOO D	MEC H	MED DEV	MET AL	NAN O	OPT	OTH ERS	PHA RMA	SOF T	TEX	TOTAL
2001								1										1
2002	3		12		1			2							2			20
2003	1		15					2	1	1				4	8			32
2004	7	2	50	2	2	4		11	9		8			5	18		2	120
2005	4	3	33	2	2	14		13	46	3	31	1	1	13	29		10	205
2006	15	5	182	9	46	54	5	21	221	26	35	3	1	48	148	6	46	871
2007	34	14	444	20	96	103	9	51	358	42	89	6	7	84	348	16	45	1766
2008	66	24	679	29	101	117	2	54	356	46	96	10	9	60	343	24	40	2056
2009	61	12	604	10	50	85	10	73	229	22	102	7	10	57	282	19	31	1664
2010	52	5	333	11	41	49	9	67	224	15	59	6	9	38	223	6	17	1164
	243	65	235 2	83	339	426	35	295	144 4	155	420	33	37	309	140 1	71	191	7899

High growth sectors like electronics have, unfortunately, got relegated to second level in our context, going by the patented innovations. Nanotechnology patenting is also low compared to the numbers obtained by other competing countries on the whole. Our focus seems to be in discovering new processes for the known pharma products and those catering to immediate industrial needs. Some of the patents listed below showcase the diversity of our innovation interest.

How soon were the patents assigned

Patents were analyzed as to how soon they get awarded in the country. On an average it has taken over five years to get the patent grant. Nearly one-third of the patents have taken seven or more years, and in an extreme case it has taken Indian Patent Office 17 years to grant the patent (Table 11). The examination procedure seems to be slow, though the speed of processing seems to have improved in the recent years as could be seen from the available data.

Table 11 How soon were the patents assigned

Years	1	2	3	4	5	6	7	8	9	10>
Patents	69	402	1022	1377	1278	1091	747	594	515	800

Years	1	2	3	4	5	6	7	8	9	10>
2001-05	4	24	25	42	71	47	29	33	72	27
2006	20	82	193	171	145	69	56	24	48	63
2007	13	93	363	443	254	197	180	103	48	72
2008	29	135	159	333	309	251	206	160	190	284
2009	3	63	167	207	273	256	156	220	102	217
2010		5	115	181	226	271	120	54	55	137
	69	402	1022	1377	1278	1091	747	594	515	800

Growth of Inventor / Assignee pool

Patents were also analyzed to find out whether inventor and assignee pools are growing over the period. The results indicate a very promising growth of inventors. On the whole 11,856 individual inventors (Table 12) who have one or more patents could be identified. New addition to this pool during the decade works out to a CAGR of 84.58%. The growth has ranged from 74% in 2009 to 369% in 2004. This is a very promising trend for innovations in India. Of the identified inventor pool, 133 had 10 or more patents during the period, 8,662 had one patent (or part thereof) (Table 13). Those in the one patent category are likely to be in the pool of new inventors, which augers well for the country. The inventor base compares favourably with that of China and Israel as observed in the context of their US Patents.

Table 12 Distinct inventor and Assignees

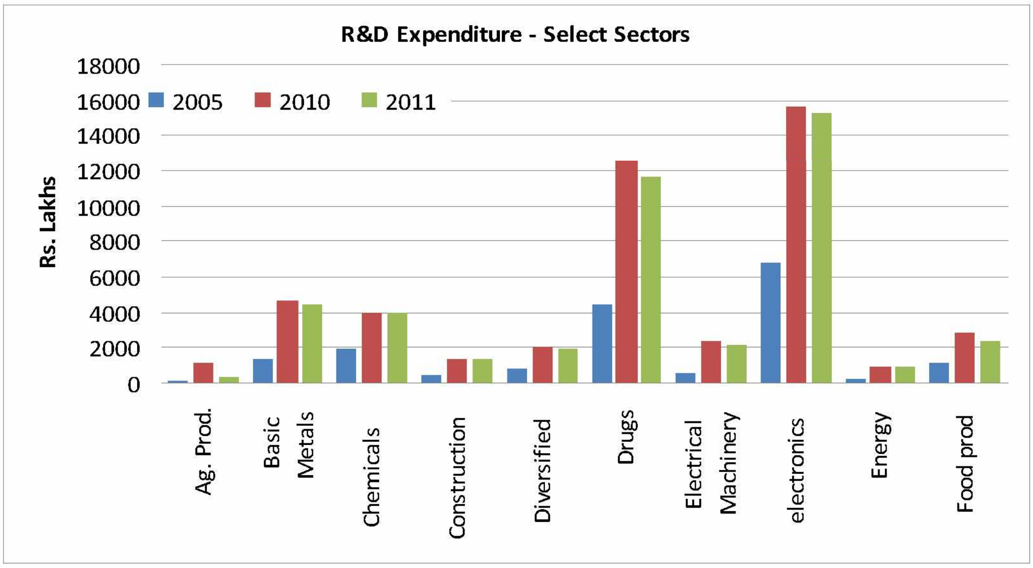
Year	Inventors	Year on year growth	Assignees	Year on year growth
2003	88		12	
2004	325	369.32	29	241.67
2005	439	135.08	137	472.41
2006	1391	316.86	427	311.68
2007	2471	177.64	758	177.52
2008	3094	125.21	619	81.66
2009	2312	74.73	347	56.06
2010	1736	75.09	328	94.52

CSIR (1505), Hindustan Unilever (497 + 146), BHEL (199), SAIL (165), IITs (162) have more than one hundred patents. This top list is closely followed by Samsung India (99, Tata Steel (78), DRDOs (72), TVS Motors (71), Lakshmi Machine Works (70) ISRO (66), Natco Pharma (60) IISc. (57), Cadilla Healthcare (56), Dr Reddy's

Laboratories (53). Eight-hundred-and-thirty (830) organizations in all, have obtained patents in India. Year on year growth of the new additions to the pool of assignees is promising with maximum addition observed in 2006 and 2007 (Table 12). As was mentioned earlier the 'others' category has a large pool, which indicate the individual interest in the IPR ownership.

Industrial R&D expenditure

The analysis also explored whether sector-wise industrial R&D has a bearing on the patents we have obtained in our country. The relevant data (Table 13) show a broad correlation between the two. Our industrial R&D expenditure is high in drugs and pharmaceuticals, transport, non-electrical machinery, chemicals, among others. Our patents in drugs, mechanical engineering and chemical engineering are higher (Table 11). However, R&D investment in electronics, which is second only to R&D on transport sector has not yielded the corresponding level of innovations. Higher R&D investment by the companies in different sectors could yield more innovations and patents. At present these investments are too meager in international comparisons.



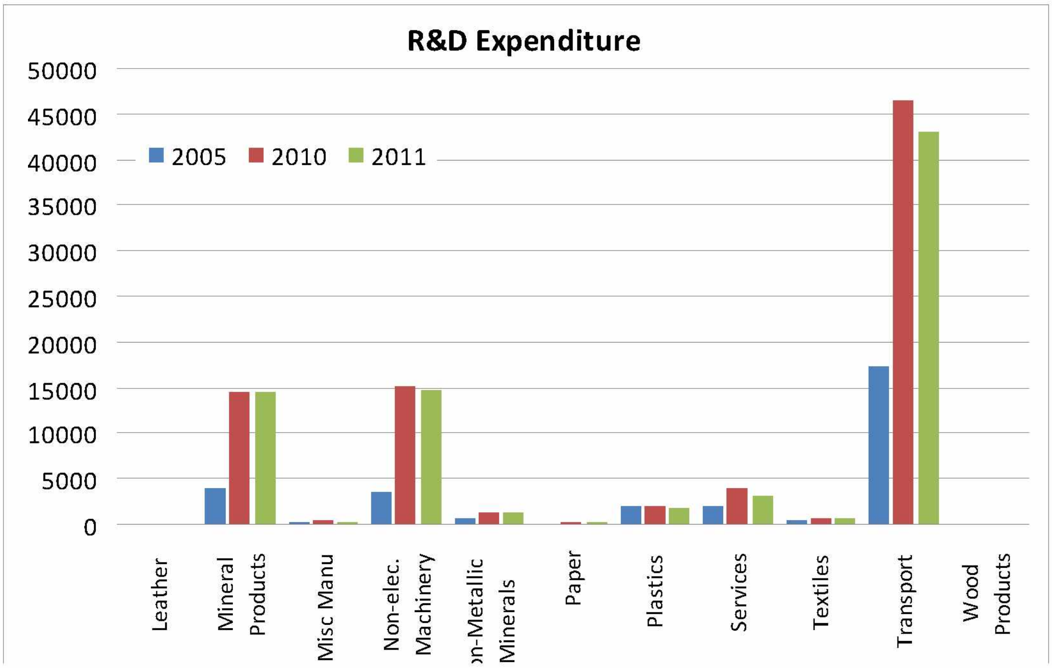


Table 13 Sector-wise industrial R&D expenditure

	R&D Expenditure RS Lakhs			R&D Intensity		
	2005	**2010**	**2011**	**2005**	**2010**	**2011**
Agri. Products	142.8	1180.1	306.1	0.09	0.38	0.14
Basic Metals	**1365.4**	**4673.4**	**4466.3**	**0.06**	**0.11**	**0.12**
Chemicals	**1963.1**	**3957.9**	**3924.2**	**0.41**	**0.47**	**0.49**
Construction	485.1	1303.3	1302.4	0.08	0.06	0.07
Diversified	786.4	1983.7	1965.8	0.22	0.25	0.33
Drugs	**4436**	**12544.2**	**11686.6**	**3.36**	**4.24**	**4.50**
Electrical Machinery	621.5	2370.7	2181.3	0.16	0.29	0.35
electronics	6799.7	15637.5	15233.3	0.60	0.75	0.91
Energy	246.7	872.6	858.7	0.02	0.04	0.06
Food prod	1087.4	2868.1	2370.6	0.13	0.18	0.19
Leather	30.1	59.8	5.5	0.09	0.11	0.02
Mineral Products	**3966.6**	**14521.3**	**14433.5**	**0.06**	**0.11**	**0.11**
Misc Manu	193.8	521.5	117.3	0.65	1.01	0.34
Non-elec. Machinery	**3584.5**	**15172.6**	**14712.8**	**0.56**	**1.18**	**1.42**
Non-Metallic Minerals	583.8	1236	1208.8	0.08	0.07	0.08
Paper	90.4	306.4	198.7	0.04	0.08	0.07

Plastics	1940	2081.8	1829.3	0.32	0.23	0.22
Services	1971.8	3971.7	3064.8	0.04	0.04	0.05
Textiles	404.8	745.8	721.4	0.05	0.05	0.06
Transport	**17391.6**	**46450.3**	**43010.8**	**1.16**	**1.36**	**1.52**
Wood Products	8.8	14	6.8	0.06	0.04	0.02

Technology Transfer / Licensing of US Patents

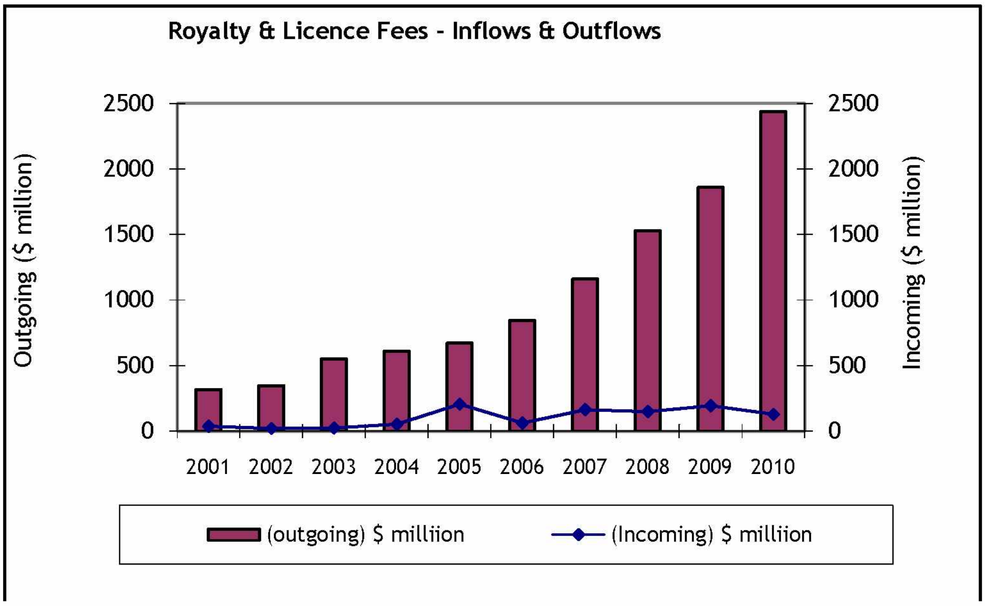
Patent assignment database of the US PTO was examined thoroughly for all the patents obtained by India to ascertain technology transfer or further assignment of these technologies. One hundred and seventy three (173) of our patents - 173 of the total 2420 obtained during the period - resulted in licensing to other entities. A closer look at the organizations involved in the technology trade revealed that a small proportion of this total was in-group trading, that is. licensing to a subsidiary company under its larger umbrella. Thirty-two of the 173 were such internal trading. This makes 7.15% of our patents were licensed on the whole and 5.83% of the total, if we leave out the transfer to one's own subsidiary companies.

Technology Import and Export

Despite our innovations and patents, both in the Indian patent office and the US PTO, we are net importers of technology. This indicates that we are not self sufficient in our technology growth. Incoming license fees has increased, but they do not balance with the outgoing royalty / license fees, which is around ten-fold more than what we earn through our innovations. This is a measure of the technology gap that exists in the economy. Incidentally, we pay thrice as much license fees than Israel and earn considerably less as incoming revenue on this count. This is also an indication of the urgent need for taking up the innovation and IPR activities.

Table 14 Licence fees & Royalties

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
(outgoing) $ million	317	345	550	611	672	846	1,160	1,529	1,860	2,438
(Incoming) $ million	37	20	24	53	206	61	163	148	193	129


Royalty & Licence Fees - Inflows & Outflows
Outgoing ($ million)
Incoming ($ million)
2500
2000
1500
1000
500
0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
(outgoing) $ milliion
(Incoming) $ milliion

Invention Strategy

Invention Strategy

Strategy is "a careful plan or method especially for achieving an end, tactics is the art or skill of using available means to reach an end. Strategy is a summary of how objectives will be pursued.[1]

A technology strategy, which includes innovation strategy, is in essence a broad formula for how S&T is going to compete, what its goals should be, and what policies are needed to carry out those goals. Miller [2] summarises the common strategy classification systems by employing some generic technological concerns to achieve a more basic level of appreciation. He blends three ideas about technology: production methods schema (batch, mass and continuous), moderated by rate of innovation and product sophistication. These three ideas are correlated with six types of production system and again strategy classification systems of Ansoff & Stewart [3] Freeman [4] and Miles & Snow [5]

Technology strategies [2]

	Ansoff Stewart (1967)	Freeman (1974)	Miles & Snow (1978)
Innovative batch	First to market	Offensive	Prospector
Established batch	Follow the leader	Defensive / imitative	Analyzer
Modified process	Applications engineering	Dominant	Analyzer
Flexible line	Applications engineering	Opportunist	Analyzer
Fixed line	"me too"	Imitative / traditional	Analyzer / defender
Unaltered process	"me too"	Dependant / traditional	Reactor / defender

More specifically an innovation strategy guides decision on how the resources are to be used to meet a firm's / country's objective for innovation and thereby build value and competitive advantage. It entails judgment about what kind of innovation process is more appropriate for the circumstances and ambitions. An innovation strategy identifies that technologies and markets it should best develop and exploit to create and capture value.

Innovation Strategies

.	Proactive	Active	Reactive	Passive
Objectives	Technological and market leadership	Not first to innovative, but prepared to follow quickly	Wait and see, Fallow a long way behind	Do what is demanded by customers or dominant firms
Types of technological innovation	Radical and incremental	Mainly incremental	Entirely incremental	Occasionally incremental
Knowledge sources	Science: in-house R&D; Collaboration with technology leaders;	In-house R&D; Collaboration with technology leaders, customers, and suppliers	Competitors; customers; purchase of licenses	Customers
Innovation expenditure	Basic and applied R&D; products and services new to the world; operations; education and	Applied R&D; products and services new to the firm.	Focus on operations	No formal activities

	training			
Risk acceptance	High risk projects	Medium - low risk projects	Low risk projects	No risk taken
Main forms of appropriability	IPRs, secrecy; complementary assets; speed	Complementary assets; speed	None	None

Dodgson, Mark and others [7]

As stated in the table four different innovation strategies could be recognized. These are: **Reactive** - where the innovation is entirely incremental; including **Active** - where in the innovation is mainly incremental, that is not being first to innovate, but being prepared to follow; **proactive** - in which the innovation is mainly radical in nature; and **Passive** where no innovation activity is pursued.

Proactive innovations are usually science-based and could be both basic and applied research. Proactive innovators maintain an in-house R&D establishment and it may also collaborate with leaders.

Active innovation is mainly applied R&D in nature and is carried out as in-house R&D and may also have collaboration with leaders in the field.

Patent Strategy

Intellectual Property strategy, as opposed to innovation strategy is more narrowly viewed as specific to products of innovation. These strategies are viewed in varied ways in writings on technology management and innovation. Among other things, these include:

Level 0 Non-strategy
1 Defensive - Build a portfolio to protect the core business
2 Cost control - Takes step to prioritize and establish clear criteria for deciding what to protect. Distinguish core and non-core assets
3 Profit center - extract value directly from its IP portfolio. Sell non-core IP as soon as possible. IP management team would be more aggressive focusing on possible infringers etc
4 Integrated - Integrate IP strategy with organizational strategy
5 Visionary - Organization, at the highest level locks at the future to make out like friends in IP Law / practice and uses this information to decide on the strategy

More descriptive narration of these strategies include:

Switching from do nothing to do something organization.

Minimalist, wherein the organization would take action only when informed of the infringement and mostly settle the issue through negotiation or refutes the charges as required

Patent strategies are also conceptualized as **fences**, **mazes**, **floods**, **walls and gates** depending on how the technology protection is executed.

In this the technology protection would be analogous to a homesteader clears one patch of pasture and fences it in. Then some more trees are cleared to make a new pasture and extends fences like that.

Or dominate the technology with a broad pioneering patent, and then protect improvements inside / outside the scope of the dominant patent.

Building a patent cluster around a new technology area also referred to as a **blanket or flood strategy.** A team methodically researches an entire technology area surrounding a research goal; the firm then files a set of medium -scope patents covering each facet of the technology.

Blanketing can also be used by second-comer firms.. Second-comers can blanket an original innovation with all possible variations.

Wall strategy depends on steady investment in research and periodic protection. New wall / hurdles are created in waves periodically around the main innovation.

Super monopoly as a strategy is where competitors have to use a given technology or stay out of the market. This could go with a process required for environmental clearance, and such crucial intermediate technologies.

Patent strategies would change depending on how established is a technology. In the early stages of the technology a few broad applications for key innovations would do. In the middle stages the rights could be expanded globally in relevant countries, and if the technology is old, the firms have to build a diverse portfolio in various technologies both with pioneering and improvement patents.

The strategies could also vary with the nature of technology. In life sciences, many of the basic research and specific products are patented. In electronics, scores of patents are obtained on methods and hardware and some on software. Customer products would have to be protected with incremental patents and design patents. Business methods and underlying hardware are patented in entertainment industry and academic patenting by universities and research institutes would be mostly early stage inventions and these technologies are also licensed out quickly.[11]

Patents ensure the assignees to achieve rights over scientific advances; gain control over markets; and renew existing products by adding new feature. Firms obtain patents to create value. Germeraad [12] based on Games of innovation model [13] enumerate several innovation strategies. The strategy framework is based on two key elements, namely - time it takes to create a working technical prototype of a new product or service (time-to-prototype) and the time it takes for a prototype product or service to reach the market (time-to-market). Germeraad [12] lists several strategies. In general, an industry based on the development of new scientific knowledge will have a long time to prototype, one based on the development of new engineering practice to apply this science will have a medium time-to-prototype, and one requiring application of known science and engineering practice will have short time-to-prototype.

Where it takes a long time to develop prototype, R&D is outsourced, managed and leveraged for the scientific insights it creates. This may include use of University / research institute partners. On the other hand, if the prototype could be created quickly because they can be adopted from other industries or from the existing S&T know how / standard R&D could be fully in-house.

So also, time-to-market varies with the regulatory requirements. It is long when the need for regulatory compliance is lengthy, and short when this need is non-existent. R&D is resourced, managed and leveraged differently depending on this time scale. When govt approval is required and conform to the external standards, R&D workers must be familiar with the procedure for testing and documenting.

Based on this understanding Germeraad [12] presents the following schema. Patenting strategies, consisting of portfolio size, patent fences, claim quality, scope and geographical coverage, are summarized in the table below as follows:

	Longest Time to Prototype	**Medium Time to Prototype**	**Shortest Time to Prototype**	
	(Major Scientific Discovery Using Basic Research)	(Major Advances Using Basic Science and Engineering)	(Marginal Advances Using Application Science & Engineering)	
Longest Time to Market (Govt. Regulations)	Technology Races	Safety Journeys	Asset-Based Problem Solving	
Medium Time to Market {Industry Standards)	RD&E Tools & Services	Battles for Architecture	Innovating in Packs	Consumer Research & Marketing
Shortest Time to Market (Customer Expectations)	Unique Gadgets	Systems Design & Consulting	High-Technology Craft	News, Clothing, Food

	Feature	Patent Strategy
Technology Races	Innovation model relies on basic science research, which may take years' to develop. Includes technologies like biotech, nano tech, fuel cells, etc.	• Build the largest portfolio possible in an embryonic market • Construct patent fences • Multi generation patents • Build portfolio faster than others in the field • Patent claim quality high
RD&E Tools & Services	This would include sectors like, drug research, engineering test equipment, specialty cosmetics research, etc	• There should be minimum of single generation patent fences are desired • Portfolio should include 'grandfather patents' covering core business • Firms should build their portfolios
Unique Gadgets	These include technologies which are relatively easy to commercialize. These include, specialty consumer products which have scientific content, like computer chip, new batteries, etc.	• Players seek to be sole patent holders dominating the market • Patent fences are used to discourage competitors • Claim scope is broad and claim quality need not be high
Safety Journeys	These technologies include Prototypes are generated relatively quickly. The technologies take longer time to market due to govt. regulations. Industries falling in the category are pharma, medical equipment, aerospace etc.	• Technology growth rates are relatively slow. • Own 'grandfather patents' to address the potential litigation • quality of claim need not be high

Battle for architecture	These include mass software, Computers, networking, Internet, Telecom, semiconductors etc. In this the product life cycle is short	• Firms may not be able to own a large share of patents • Patent fences are imperative • Patent by incremental work to build the portfolio and protect the advantages gained
System design	These include enterprise solutions, System design etc	• Patent fences are few in the area
Asset based problem solving	Generally the technologies in this group are controlled by govt. regulations due to environment, health or societal interest. The technologies include power, petrochemicals, mining etc.	• These field support old technologies • most of the innovations are incremental in nature • Patent fences do not generate commercial return
Innovation in packs	In this group are technologies in which the underlying science is largely known. Industrial standards govern the introduction of products. These include chemical products, polymers, packaging technologies, building materials etc.	• Largely incremental innovation • Patenting fencing of atleast one generation is desirable • There is a need to have a new product roadmap • Because of incremental innovation quality of claims could be low
High Technology Crafts	These include specialty food, food ingredients, industrial controls, etc. Effort required in prototyping is low.	• Most innovations in this category are incremental • New ideas come as a reaction to competitor goods • firms have to build portfolios quickly with new technologies • Good quality claims • Scope of the patent needs to be broad
Consumer research and marketing	These technologies include mass consumer products, automobile, etc	• A few grandparent patents dominate the industry • A large number of innovations are created by many inventors • More often trade secret is the order • patent fences are rare in these technologies • Only a few big firms would have large portfolios
New, cloths, commodity food, etc	In this category technology innovations are low patents are not the primary means of creating sustainable advantage	• These are generally soft / design patents • claims are not of high quality

Given below is the distribution of Indian patents obtained in USPTO and IPO on the 11 categories. Patents obtained from IPO are skewed to 'innovation in packs' - category of products where the basic science is well known. These include most of our (industrial) chemicals related patents. Also to be noted is the more than normal clustering in our patents related to pharmaceuticals and medical devices which are grouped under 'safety journeys'. We are relatively weak in 'technology race' and in 'battle for architecture' which govern the telecommunication standards and the equipment related to that. Our patents on "consumer research" are also low considering the market size the country enjoys. We are low on the 'Longest Time to Prototype' category of patents. We are also giving a lee way to outside players to exploit the computer software related innovations, in the nature of communication systems, MIS systems, etc.

	Indian Patents (2001-10) in	
	USPTO	IPO
Technology Races	21	278
RD&E Tools & Services	**389**	**486**
Unique Gadgets	53	**896**
Safety Journeys	**873**	**1563**
Battle for architecture	184	3
System design	136	156
Asset based problem solving	42	1
Innovation in packs	**488**	**2718**
High Technology Crafts	45	**303**
Consumer research and marketing	**189**	**1483**
New, cloths, commodity food, etc		12

Given below are some of the representative Indian patents from Indian Patent Office.

Battle for Architecture		
236667	STERLITE TECHNOLOGIES LIMITED (E1/E2/E3 MIDC, Waluj, Aurangabad-431136,) ;	OPTICAL FIBER HAVING LOW AND UNIFORM OPTICAL ATTENUATION LOSS ALONG THE ENTIRE LENGTH AND METHOD FOR FABRICATING THE SAME
235626	STERLITE TECHNOLOGIES LIMITED (E-2, MIDC, WALUJ Aurangabad) ;	OPTICAL FIBER WITH LOW ATTENUATION AT 1380 NM WAVELENGTH REGION AND THE METHOD OF PRODUCING THE SAME
233682	INDIAN INSTITUTE OF TECHNOLOGY (KHARAGPUR) ;MEDIA LAB ASIA (SAMRUDDHI VENTURE PARK, CENTRAL MIDC ROAD, #2, 4TH FLOOR, ANDHERI (EAST), MUMBAI 400093) ;	SYSTEM FOR AN INTUITIVE, CUSTOMIZABLE, MULTILINGUAL AND RECONFIGURE ABLE AUGMENTATIVE COMMUNICATION .
Consumer Research		
206894	DALMIA INSTITUTE OF SCIENTIFIC AND INDUSTRIAL RESEARCH (POST BOX NO.2RAJGANGPUR-770017, DIST, SUNDERGARH) ;	A HOLDER-CUM-DISPENSER OF COIN OF SAME OR DIFFERENT DENOMINATIONS
231551	TECHNOCRATS PVT. LTD (A-11, GREEN PARK, NEW DELHI, INDIA.) ;	A PROCESS FOR PREPARING FRICTION TAPE
197943	TTK PRESTIGE LIMITED (11TH FLOOR, BRIGADE TOWER , 135 BRIGADE ROAD, BANGALORE-560 025, KARNATAKA) ;	A SYSTEM PRESSURE RELEASE DEVICE FOR A PRESSURE COOKER
224927	MHATRE RAMESH NANA (B-701,CENTRE POINT, PANCH PAKHADI, THANE(WEST)400 602, MAHARASHTRA, INDIA.) ;	A 3 CONE DIFFUSER
242161	COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (RAFI MARG NEW DELHI-110001 INDIA) ;	A BARREL TYPE OIL EXPELLER WITH IMPROVED HEAT REDUCTION FACILITY
198507	JAGDISHCHANDRA VASANJEE KHAJURIA SOLE PROPRIETOR (CHAMUNDA PRODUCTS EST , 2, AALAP NEHRU ROAD, VILE PARLE (EAST), MUMBAI) ;	A BOTTLE WITH A HINGED LID
214724	BHARAT HEAVY ELECTRICALS LIMITED, (A GOVERNMENT OF INDIA UNDERTAKING) (BHEL HOUSE, SIRI FORT, NEW DELHI-110049) ;	A BOTTOM SUPPORT FOR WASTE HEAT RECOVERY BOILER (WHRB) INLET GAS DUCTING.
240097	WEBCO-TVS (INDIA) LIMITED (NO.29 HADDOWS ROAD, CHENNAI) ;	A BRAKE ADJUSTER FOR THE AIR BRAKE SYSTEM OF A MOTOR VECHICLE
200742	M/S. BRAKES INDIA LIMITED (PADI, CHENNAI 600 050) ;	A BRAKING SYSTEM FOR MOTOR VEHICLES
208703	A.R.SHIVAKUMAR (NO.44 SOURABHA BASAVESHWARA, LAUOUT VIJAYANAGAR, BANGALORE 560 040.) ;	A COCONUT FROND SHREDDER
192670	JIPPU JACOB, ASSOCIATE PROFESSOR (KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY, TAVANUR 679 573, MALAPPURAM DISTRICT) ;JOBY BASTIAN (KELAPPAJI COLLEGE OF AGRICULTURAL	A COCOUNT HUSKING TOOL

	ENGINEERING AND TECHNOLOGY, TAVANUR 679 573, MALAPPURAM DISTRICT) ;T	
210204	DR. JOSE THAIKATTIL (PHYSICIAN, UNIVERSITY HEALTH CENTRE, CALICUT UNIVERSITY,) ;	A COOKER WITH A SIGNALING DEVICE INDICATING THE STAGE OF COOKING
207156	SHIRISH BHAILAL PATEL (NANDA DEEP", 2-A M L DAHANUKAR MARG, MUMBAI 400 026, MAHARASHTRA, INDIA.) ;	A COOKING APPLIANCE
232896	TATA ENERGY RESEARCH INSTITUTE (SOCIETY REGISTERED UNDER SOCIETIES REGISTRATION ACT DARBARI SETH BLOCK, HABITAT PLACE, LODHI ROAD, NEW DELHI-110003, INDIA.) ;	A COOKING OVER AND HEAT RECOVERY DEVICE FOR COOKING OF COCOONS
224101	HAWKINS COOKERS LTD. (MAKER TOWER F-101, CUFFE PARADE, P.O.Box 16083, MUMBAI-400 005.) ;	A COOKING UTENSIL
High Tech Crafts		
244752	COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, (RAFI MARG NEW DELHI-110001,INDIA.) ;	A FORMULATION AND A PROCESS FOR THE PREPARATION OF HIGH PROTEIN -HIGH FIBRE WHEAT GERM BISCUITS
242959	DIRECTOR GENERAL, DEFENCE RESEARCH & DEVELOPMENT ORGANISATION, MINISTRY OF DEFENCE (MINSTRY OF DEFENCE, GOVERNMENT OF INDIA, WEST BLOCK-VIII, WING1, SECTOR 1, R.K. PURAM, NEW DELHI-110 066) ;	A MEDICATED HERBAL TEA AND A PROCESS FOR THE FORMULATION THEREOF
239896	G.B.PANT UNIVERSITY OF AGRICULTURE & TECHNOLOGY (PANTNAGAR- 263145, UTTARANCHAL, INDIA) ;	A PROCESS FOR THE PREPARATION OF SPICED WHEAT NAMKEEN
231568	COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (RAFI MARG , NEW DELHI-110 001, INDIA) ;	A BINDER COMPOSITION FOR USE IN FORMING BRIQUETTS FROM FRUIT AND VEGETABLE PROCESS WASTE
239486	DIRECTOR GENERAL,D.R.D.O. , NEW DELHI (DEFENCE RESEARCH AND DEVELOPMENT ORGANISATION MINISTRY OF DEFENCE, GOVT OF INDIA WEST BLOCK-VIII, WING-1 SECTOR-1, RK PURAM NEW DELHI-110066) ;	A BIODEGRADABLE FILM FOR EXTENDING SHELF LIFE OF FRUITS AND VEGETABLES AND A PROCESS FOR PREPARATION THEREOF
240031	DIRECTOR GENERAL,Defence Research & Development Organisation ,New Delhi (DEFENCE RESEARCH AND DEVELOPMENT ORGANISATION MINISTRY OF DEFENCE, GOVT OF INDIA WEST BLOCK-VIII, WING-1, SECTOR-1, RK PURAM, NEW DELHI-110066) ;	A BIOPRESERVATIVE COATING TO EXTEND SHELF LIFE OF TOMATOES AND A PROCESS FOR PREPARATION THEREOF
Innovation in Packs		
210136	M/S. INDIAN SPACE RESEARCH ORGANISATION (ANTARIKSH BHAVAN, NEW BEL ROAD, BANGALORE 560 094.) ;	A PROCESS FOR PRODUCING THERMOSETTING ADHESIVES FROM ACRYLIC COPOLYMERS HAVING PENDANT PHENOLIC GROUPS
242406	COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (RAFI MARG NEW DELHI-110001,INDIA.) ;	A PROCESS FOR PRODUCTION OF BIOGAS FROM BRIQUETTES OF FRUIT AND VEGETABLE PROCESSING WASTE
242916	SECRETARY,DEPARTMENT OF ELECTRONICS, GOVERMENT OF INDIA, (ELECTRONICS NIKETAN,(GROUND FLOOR),6, C.G.O. COMPLEX, LODHI ROAD,NEW DELHI-110 003, INDIA.) ;	A PROCESS FOR PURIFICATION OF COMMERCIAL GRADE HYDROCHLORIC ACID FOR SEMICONDUCTORS'
213517	HI-TECH CARBON (A UNIT OF INDIAN RAYON & INDUSTRIES LTD, JUNAGADH VERAVAL ROAD, P.O. VERAVAL 362 266) ;	A PROCESS FOR THE PRODUCTION OF CARBON BLACK
242954	COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (RAFI MARG, NEW DELHI- 110 001, INDIA) ;	A PROCESS FOR THE SYNTHESIS OF LITHIUM NICKEL VENDATE(LiNIVO4) AS CATHODE MATERIAL FOR ROCKING CHAIR LITHIUM ION CELLS
202603	INDIA INDUSTRIAL ENTERPRISES (2F CAMAC STREET COURT 25B, CAMAC STREET KOLKATA 700016) ;	A PROCESS TO PRODUCE A CONSISTENT QUALITY PRODUCER GAS WITH HIGH CALORIFIC VALUE FOR USE IN FURNACES
Long time-to-prototype		
235769	SERUM INSTITUTE OF INDIA LIMITED (SAROSH BHAVAN, 16-B/1, DR. AMBEDKAR ROAD, PUNE-411001.) ;	A PROCESS FOR PREPARATION OF RABIES VACCINE
239858	COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (RAFI MARG, NEW DELHI-11001, INDIA) ;	A PROCESS FOR PREPARATION OF SHEL-FLIFE EXTENDED TENDER BAMBOO SHOOTS
223124	APPLIED BIOTECHNOLOGY LIMITED (FIRST FLOOR, #15, III AVENUE, INDIRA NAGAR, ADYAR, CHENNAI - 600 020,) ;	A PROCESS FOR PREPARATION OF WATER DISPESIBLE CAROTENOID
207131	NORTH MAHARASHTRA UNIVERSITY (P.O.NO. 80, UMAVINAGAR, JALGAON 425001(MS)) ;	A PROCESS FOR PREPARING A BOTANICAL PESTICIDE FROM SEEDS OF ANNONA SQUAMOSA
241675	DEPARTMENT OF BIOTECHNOLOGY (BLOCK - 2, 7TH FLOOR, C.G.O. COMPLEX, LODHI ROAD, NEW DELHI 110 003.) ;GURU NANAK DEV UNIVERSITY (AMRITSAR 143005) ;	A PROCESS FOR PREPARING LIPOSOMES

220136	INDIAN INSTITUTE OF TECHNOLOGY ( ) ;UNIVERSITY DEPARTMENT OF CHEMICAL TECHNOLOGY ( ) ;THE SECRETARY, DEPARTMENT OF BIOTECHNOLOGY ( ) ;	A PROCESS FOR PRODUCING A SUPPORT FOR EXPANDED BED CHROMATOGRAPHY FOR PROTEIN PURIFICATIONS.
228429	MAHINDRA & MAHINDRA LTD. (GATEWAY BUILDING, APOLLO BUNDER, MUMBAI 400001, MAHARASHTRA, INDIA.) ;	A PROCESS FOR PRODUCING BIO-DIESEL
201822	M/S. INDIAN INSTITUTE OF TECHNOLOGY (IIT P.O, CHENNAI) ;	A PROCESS FOR THE MANUFACTURE OF A NANO COMPOSITE FOR HARNESSING SOLAR ENERGY
218355	COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (RAFI MARG, NEW DELHI- 110 001, INDIA) ;	A PROCESS FOR THE PREPARATION OF A NANOSIZED COLLOIDAL METAL PARTICLE
RD&E		
236516	BHARAT HEAVY ELECTRICALS LIMITED (REGIONAL OPERATIONS DIVISION (ROD), PLOT NO: 9/1, DJBLOCK 3RD FLOOR, KARUNAMOYEE, SALT LAKE CITY, KOLKATA-700091, HAVING ITS REGISTERED OFFICE AT BHEL HOUSE, SIRI FORT, NEW DELHI-110049, INDIA) ;	A PROCESS FOR HIGH-FREQUENCY LONGITUDINAL WELDING OF A TUBE TO A FLAT STEEL FIN
224346	ANIL CHINTAMAN KELKAR (4/1, VRUNDAVAN NO.7, PANCHAVATI, PASHAN, PUNE 411 008.) ;	A PROCESS FOR INHIBITING CORROSION ON METALS AND THE ORGANIC COMPOUND OBTAINED THERE-FROM
233783	STEEL AUTHORITY OF INDIA LIMITED (RESEARCH & DEVELOPMENT CENTRE FOR IRON & STEEL, ISPAT BHAWAN, LODHI ROAD) ;	A PROCESS FOR INTENSIFICATION OF SCRAP MELTING IN AN ELECTRIC ARC FURNACE
230144	TATA STEEL LIMITED (RESEARCH AND DEVELOPMENT AND SCIENTIFIC SERVICE DIVISION JAMSHEDPUR) ;	A PROCESS FOR LOWERING ALUMINA CONTENT OF LUMPY, FRAGILE MANGANESE ORE
195452	STEEL AUTHORITY OF INDIA LIMITED (RESEARCH & DEVELOPMENT CENTRE FOR IRON & STEEL, DORANDA, RANCHI) ;	A PROCESS FOR MAKING HIGH TEMPERATURE WEAR CORROSION RESISTANT ROLLS FOR USE IN STRAND GUIDE SECTION IN SLAB CASTING MACHINE
203309	STEEL AUTHORITY OF INDIA LIMITED (DORANDA, RANCHI-834002) ;	A PROCESS FOR MANUFACTURE OF CORROSION RESISTANT STEEL FOR FUEL GAS PIPELINES
204533	TATA INSTITUTE OF FUNDAMENTAL RESEARCH (HOMI BHABHA ROAD, COLABA, MUMBAI 400 005, MAHARASHTRA, INDIA.) ;	A PROCESS FOR MANUFACTURE OF HALF METALLIC FERROMAGNET WITH CHROMIUM DIOXIDE OR COMPOSITE OF CHROMIUM DIOXIDE AND CHROMIUM SESQUIOXIDE
208197	STEEL AUTHORITY OF INDIA LIMITED (DORANDA, RANCHI-834002, JHARKHAND,) ;	A PROCESS FOR MANUFACTURING A HIGH STRENGTH , FORMABLE AND FATIGUE RESISTANT STEEL .
Safety journeys		
208889	SONIC BIOCHEM EXTRACTIONS LTD (38, PATEL NAGAR, INDORE, MADHYA PRADESH, PIN-452 001) ;	“A PROCESS OF EXTRACTING PURE FOOD & PHARMA GRADEPOWDER LECITHIN FROM CRUDE LECITHIN DERIVED FROMVEGETABLE OIL SEEDS SUCH AS SOYABEANS
207769	MS. RAVITA BEDI (C/O. GUYBRO CHEMICAL, C-58, PIKNIK APPARTMENT, JEET NAGAR, VERSOVA, ANDHERI (W), MUMBAI) ;	“EDIBLE WATER FORPREVENTING DEHYDRATION INcmcxs NAMED AS SPRING”
204591	RELIANCE LIFE SCIENCES PRIVATE LIMITED (CHITRAKOOT, 2ND FLOOR, GANPATRO KADAM MARG, SHREE RAM MILLS COMPOUND, LOWER PAREL, MUMBAI) ;	“METHOD AND DEVICE FOR THE RAPID CLINICAL DIAGNOSIS OFHEPATITIS B VIRUS(HBV) INFECTION IN BIOLOGICALSAMPLES
234308	COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH (RAFI MARG, NEW DELHI-110001,INDIA) ;	2-ALKYL 4,5 DISUBSTITUTED 6- METHOXYPRIMAQUINONE ANALOGUES
212050	ORCHID CHEMICALS & PHARMACEUTICALS LTD (ORCHID TOWERS', VILLAGE ROAD, NUNGAMBAKKAM, CHENNAI - 600 034) ;	2-MERCAPTO-5-PHENYL-1, 3, 4-OXADIAZOLYL-(Z)-4-BROMO-2-METHOXYIMINO BUTYRIC ACID DERIVATIVE AND PROCESS OF PREPARATION THEREOF
238680	RANBAXY LABORATORIES LIMITED (PLOT NOS. 89, 90 AND 91, SECTOR-32, GURGAON, HARYANA-122001, INDIA.) ;	3,6-DISUBSTITUTED AZABICYCLO HEXANE DERIVATIVES AS MUSCARINIC RECEPTOR ANTAGONISTS
241819	SUVEN LIFE SCIENCE LIMITED (SERENE CHAMBERS, ROAD NO. 7, BANJARA HILLS, HYDERABAD - 500034, INDIA) ;	4-(HETEROCYCLYL) ALKYL-N-(ARYLSULFONYL)INDOLE COMPOUNDS AND THEIR USE AS 5-HT6 LIGANDS
System Design & Consulting		
207753	DESAI JAYSUKH PARSHOTAMBHAI (C/O NAVJIVAN CHEMICALS SHED NO. C-1/6822. GIDC. ANKLESHWAR-2, DIST.BHARUCH, GUJARAT, INDIA.) ;	FLOW CONTROLLER

202532	PROF.DR.SADHAN KUMAR GHOSH (OF MECHANICAL ENGG.DEPT. & COORDINATOR CENTRE FOR QUALITY MANAGEMENT SYSTEM, JADAVPUR UNIVERSITY KOLKATA-700032) ;	IMPROVED ECO-FRIENDLY RECYCLING PROCESS OF POST CONSUMER WASTE PLASTICS AND DEVICE THEREOF
205371	GAUTAM DHARAMDAS GORADIA (2/F LILOUCILLE, WEST AVENUE, SANTACRUZ (WEST) MUMBAI-400 054) ;	INTERACTIVE SYSTEM FOR BUILDING AND SHARING ONE'S OWN DATABANK OF THE TEXT AND OTHER RELATED INFORMATION OF MUSICAL COMPOSITIONS IN ONE OR MORE LANGUAGES
205348	GAUTAM DHARAMDAS GORADIA (2ND FLOOR, LILOUVILLE, WEST AVENUE, SANTACRUZ (WEST), MUMBAI - 400 054, MAHARASHTRA, INDIA) ;	INTERACTIVE SYSTEM FOR BUILDING AND SHARING ONE'S OWN DATABANK OF WISDOM BYTES SUCH AS WORDS OF WISDOM BASIC TRUTHS AND/OR FACTS AND FEATS IN ONE OR MORE LANGUAGES
234733	GAUTAM DHARAMDAS GORADIA (2ND FLOOR, LILOUVILLE, WEST AVENUE, SANTACRUZE (WEST), MUMBAI 400 054) ;	INTERACTIVE SYSTEM FOR BUILDING, ORGANISISNG AND SHARING ONE'S OWN DATABANK OF QUESTIONS AND ANSWERS IN A VARIETY OF QUESTIONING FORMATS ON ANY SUBJECT IN ONE OR MORE LANGUAGES.
204003	SINGH YASHASVI (32, PORNIMA APARTMENTS SIR POCH KHANWALA ROAD, WORLI, MUMBAI,) ;	INTERACTIVE SYSTEM FOR ONLINE COMPLAINT REGISTRATION AND MONITORING AND METHOD THEREOF
Unique Gadgets		
201198	PADMA CHARAN KAR (LALASASON, ASKA 761 110, ORISSA, INDIA,) ;	A BOBBIN ELLIPSOGRAPH FOR DRAWING ELLIPSES
203512	M/S. INDIAN INSTITUTE OF TECHNOLOGY (INDIAN INSTITUTE OF TECHNOLOGY, IIT P.O. CHENNAI 600 036) ;M/S. MIDAS COMMUNICATION TECHNOLOGIES PRIVATE LIMITED (NO. 1 KALYANI NAGAR, KOTTIVAKKAM, THIRUVANMIYUR, CHENNAI 600 041) ;	A BROAD BAND INTERNET CONNECTIVITY SYSTEM
201326	M/S. INDIAN INSTITUTE OF TECHNOLOGY (IIT P.O. CHENNAI 600 036,) ;	A BROMATE 10N SENSITIVE ELECTRODE
230690	LUCAS TVS LIMITED (PADI, CHENNAI 600 050,) ;	A BRUSH ASSEMBLY OF AN ELECTRIC MACHINE
203346	TARA CHAND BANKA (3-B CAMAC STREET KOLKATA 700016) ;	A CABLE SECURITY SEAL ASSEMBLY
214527	CENTRE FOR DEVELOPMENT OF TELEMATICS (9th FLOOR, AKBAR BHAWAN, CHANKYAPURI, NEW DELHI-110021, INDIA.) ;	A CALL IDENTIFICATION SYSTEM
240393	INDIAN SPACE RESEARCH ORGANISATION, (DEPARTMENT OF SPACE, ANTARIKSH BHAVAN, NEW BEL ROAD, BANGALAROE 560 094.) ;	A CATHODE FOR AN AQUEOUS SECONDARY CELL AND METHOD OF MANUFACTURING THE SAME
201416	INDIAN INSTITUTE OF TECHNOLOGY (AN INDIAN INSTITUTE OF KHARAGPUR) ;	A CELLULAR AUTOMATA BASED AUTHENTICATION DEVICE FOR MESSAGE COMMUNICATION SYSTEMS
206867	INDIAN INSTITUTE OF TECHNOLOGY, (KHARAGPUR 721 302, WEST BENGAL, INDIA, AN INDIAN EDUCATIONAL INSTITUTION AND DEPARTMETN OF SCIENCE & TECHNOLOGY, TECHNOLOGY BHAVAN, NEW MEHRAULI ROAD, NEW DELHI - 110 016, INDIA, AN INDIAN GOVERNMENT BODY.) ;	A CHARGING CIRCUIT FOR SUPER CONDUCTING (SC) COIL FOR SUPER CONDUCTING MAGNETIC BASD ENERGY STORING AND UNITERUPTED POWE SUPPLY SYSTEMS.

One of the outcomes of the active and proactive innovation is the patents and is less so when the innovation strategy is reactive. China's innovations range from being *reactive* to *proactive*. The innovations as could be noticed are *reactive* to a large extent, which is reflected in their innovation strategy, in minor improvements of old products and designs. The country is involved in, what could be called an active innovation strategy, in several medium technologies. China is also involved in science based innovation - particular the ones emanating from its universities. The trick in the rapid growth of patent graph is that much of the low technology products, nominal design improvements that are normally not widely appropriated as IPRs have been converted as patents. Protectability of many of them could be an issue, and its intrinsic worth in the market is debatable, apart from addition to the patent count.

A recent study[14] has indicated that R&D investment intensification by China is unlikely to be the primary driving force of China's patenting boom. It argues that the possible motivators could be pro-patent amendments in their IPR laws, international economic integration, particularly FDI flow which has given an opportunity for domestic firms to innovate and imitate, and economic reforms are the reason for the patent growth.

It has also been noted by Thota [9] that China's investment in its technological future by inviting foreign organizations with IP that are in demand by Chinese industry has enormously facilitated innovation through technology transfer, along with its science and technology industrial parks [8] to incubate entrepreneurial companies, both local and the foreign ones.

Israel's strategy is in the continuum of active to pro-active in inventions. In the select core technologies such as software, medical instrumentation, biotechnology and drug development the country is proactive and engaged in cutting edge research. In several other areas the invention is pursued at a level that could be adopted in industry. Active venture capital activities, risk taking behaviour of the inventors / entrepreneurs has served the intellectual property generation very well for the country.

The studies have indicated that R&D intensification contributed to 24% of the patent increase, leaving the bulk of the patent explosion unexplained [14] . So R&D intensification is unlikely to be the primary driving force of China's patenting boom. It is argued that the possible motivators could be pro-patent amendments, international economic integration, particularly FDI flow which has given an opportunity for domestic firms to innovate and imitate, and economic reforms are the reason for the patent growth.

China is investing in its technological future by inviting foreign organizations with IP that are in demand by Chinese industry and facilitating technology transfer. It is also using technology parks to incubate entrepreneurial companies, both local and the foreign ones. The country also uses the channel of conferences where the experts are invited from other parts of the world to facilitate exchange of views by the local experts.

The main difference China, Israel and India, that stands out is the dominance of industry participation in patenting. For the industrial R&D to pick up as a harmonic component, India may have to go in a big way for transfer of technology and broaden the manufacturing base to make room for the related innovations. In the absence of such a situation, growth of intellectual property can come from incentivisation of innovation itself with an intention of licensing the same to the potential users elsewhere. We may have to identify niche areas for such an approach and give substantial thrust, as has been realized by Israel.

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Cultural Dimensions of Innovation

Cultural Dimensions of Innovation

Investment on R&D, S&T and industrial policy, among other factors, could be inferred to account for variation in the innovation and patenting. The study also examined whether the cultural differences account for variations noticed n the innovations. To examine the differences among China, Israel and India on this count Greet Hofstede's 5-D model was adopted. This model readily made available for different countries based on longitudinal studies < http://geert-hofstede.com/national-culture.html > considers variables such as power distance, individualism, masculinity / feminity, uncertainty avoidance, and long term orientation.

National culture of India as per the 5-D Model

If we explore the Indian culture through the lens of the 5-D Model, we can get a good overview of the deep drivers of Indian culture relative to other world cultures.

Power distance

This dimension deals with the fact that all individuals in societies are not equal. It expresses the attitude of the culture towards these inequalities amongst us.

Power distance is defined as the extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally.

India scores high on this dimension - 77 - indicating an appreciation for hierarchy and a Top - Down Structure in society and Organizations. Indian attitude could be summarized as follows: dependent on the boss or the powerholder for direction; acceptance of un-equal rights between the power-privileged and those who are lesser down in the pecking order; immediate superiors accessible but one layer above less so; paternalistic leader; management directs; gives reason / meaning to ones work life and rewards in exchange for loyalty from employees.

Real Power is centralized even though it may not appear to be and managers count on the obedience of their team members.Employees expect to be directed clearly as to their functions and what is expected of them. Control is familiar, even a psychological security, and attitude towards managers are formal communication is top down and directive in its style and often feedback which is negative is never offered up the ladder.

At 80 China sits in the higher rankings of PDI - i.e. a society that believes that inequalities amongst people are acceptable. The subordinate-superior relationship tends to be polarized and there is no defense against power abuse by superiors. Individuals are influenced by formal authority and sanctions and are in general optimistic about people's capacity for leadership and initiative. People should not have aspirations beyond their rank.

Israel takes a unique position in the database of countries with scores on the 5 dimensions. Israel is the only country in the world where the seize of immigrant groups are so large that they influence the dominant values to the extent that new citizens of Israel change the existing values.

With a score of 13 points Israel is at the very low end of this dimension compared to other countries. With an egalitarian mindset the people in Israel believe in independency, equal rights, accessible superiors and that management facilitates and empowers. Power is decentralized and managers count on the experience of their team members. Respect among the people of Israel is something which you earn by proving your hands-on expertise. Workplaces have an informal atmosphere with direct and involving communication and on a first name basis. Employees expect to be consulted.

Individualism

The fundamental issue addressed by this dimension is the degree of interdependence a society maintains among its members. It has to do with whether people´s self-image is defined in terms of "I" or "We".

In Individualist societies people are supposed to look after themselves and their direct family only. In Collectivist societies people belong to 'in groups' that take care of them in exchange for loyalty.

India, with a score of 48 is a society with clear collectivistic traits. This means that there is a high preference for belonging to a larger social framework in which individuals are expected to act in accordance to the greater good of one's defined in-group(s). In such situations, the actions of the individual are influenced by various concepts such as work group and other such wider social networks that one has some affiliation toward. For a collectivist to be rejected by one's peers or to be thought lowly of by one's extended and immediate in-groups leaves him or her rudderless and with a sense of intense emptiness. The employer/employee relationship is one of expectations based on expectations - Loyalty by the employee and almost familial protection by the Employer. Hiring and promotion decisions are often made based on relationships which are the key to everything in a Collectivist society.

At a score of 20 China is a highly collectivist culture where people act in the interests of the group and not necessarily of themselves. In-group considerations affect hiring and promotions with closer in-groups (such as family) are getting preferential treatment. Employee commitment to the organization (but not necessarily to the people in the organization) is low. Whereas relationships with colleagues are cooperative for in-groups they are cold or even hostile to out-groups. Personal relationships prevail over task and company.

The Israelian society is a blend of individualistic and collectivistic cultures (54). Small families with a focus on the parent-children relationship rather than aunts and uncles are common. And at the same time extended families, with many children and close ties to all other family members are a part of society as well. There is a strong belief in the ideal of self-actualization. Loyalty is based on personal preferences for people as well as a sense of duty and responsibility. Communication is direct and expressive.

Masculinity / Feminity

A high score (masculine) on this dimension indicates that the society will be driven by competition, achievement and success, with success being defined by the winner / best in field - a value system that starts in school and continues throughout organisational behaviour.

A low score (feminine) on the dimension means that the dominant values in society are caring for others and quality of life. A feminine society is one where quality of life is the sign of success and standing out from the crowd is not admirable. The fundamental issue here is what motivates people, wanting to be the best (masculine) or liking what you do (feminine).

India scores 56 on this dimension and is thus considered a masculine society. Even though it is mildy above the mid range in score, India is actually very masculine in terms of visual display of success and power. The designer brand lable, the flash and bling that goes with advertising one's success, is widely practiced. However, India is also a spritual country with millions of deities and various religious philosophies. It is also an ancient country with one of the longest surviving cultures which gives it ample lessons in the value of humility and abstinence. This often reigns in people from indulging in Masculine displays to the extent that they might be naturally inclined to. In more Masculine countries the focus is on success and achievements, validated by material gains. Work is the center of one's life, and visible symbol of success in the work place is very important.

At 66 China is a masculine society -success oriented and driven. The need to ensure success can be exemplified by the fact that many Chinese will sacrifice family and leisure priorities to work.

With a score of 47 Israel is neither a clear masculine nor feminine society. Some elements point at more masculine features. Performance is highly valued. Managers are expected to be decisive and assertive. Status is often shown, especially by cars, watches and technical devices.

Uncertainty avoidance

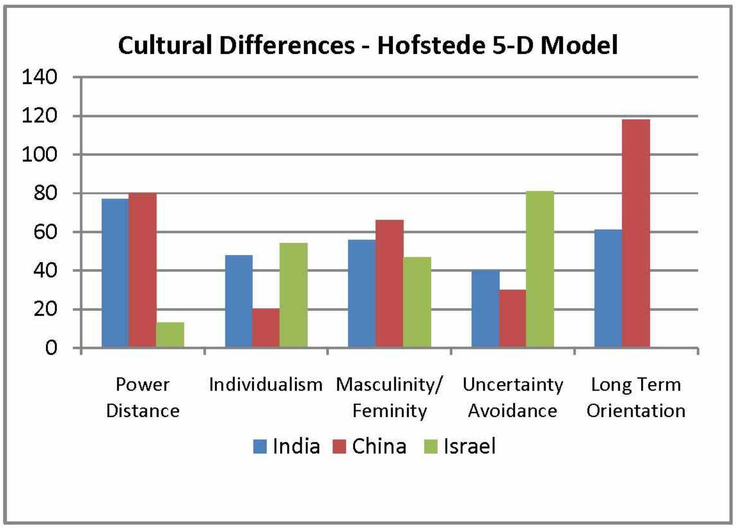
The dimension Uncertainty Avoidance has to do with the way that a society deals with the fact that the future can never be known: should we try to control the future or just let it happen? This ambiguity brings with it anxiety and different cultures have learnt to deal with this anxiety in different ways. The extent to which the members of a culture feel threatened by ambiguous or unknown situations and have created beliefs and institutions that try to avoid these is reflected in the UAI score.

India scores 40 on this dimension and thus has a medium low preference for avoiding uncertainty. In India there is acceptance of imperfection; nothing has to be perfect nor has to go exactly as planned. India is traditionally a patient country where tolerance for the unexpected is high; even welcomed as a break from monotony. People generally do not feel driven and compelled to take action-initiatives and comfortably settle into established rolls and routines without questioning. Rules are often in place just to be circumvented and one relies on innovative methods to "bypass the system". A word used often is "adjust" and means a wide range of things, from turning a blind eye to rules being flouted to finding a unique and inventive solution to a seemingly unsurmoutable problem. It is this attitude that is both the cause of misery as well as the most empowering aspect of the country. There is a saying that “nothing is impossible” in India, so long as one knows how to “adjust”.

At 30 China has a low score on uncertainty avoidance. Truth may be relative though in the immediate social circles there is concern for Truth with a capital T and rules (but not necessarily laws) abound. None the less, adherence to laws and rules may be flexible to suit the actual situation and pragmatism is a fact of life. The Chinese are comfortable with ambiguity; the Chinese language is full of ambiguous meanings that can be difficult for Western people to follow. Chinese are adaptable and entrepreneurial. Majority (70% -80%) of Chinese businesses tend to be small to medium sized and family owned.

Israel is among the stronger uncertainty avoidant countries (81). In these cultures there is an emotional need for rules (even if the rules never seem to work), time is money, people have an inner urge to be busy and work hard, precision and punctuality are the norm, security is an important element in individual motivation. Cultures with a high score on this dimension are often very expressive.

	India	China	Israel
Power Distance	77	80	13
Individualism	48	20	54
Masculinity/ Feminity	56	66	47
Uncertainty Avoidance	40	30	81
Long Term Orientation	61	118	NA



Long term orientation

The long term orientation dimension is closely related to the teachings of Confucius and can be interpreted as dealing with society's search for virtue, the extent to which a society shows a pragmatic future-oriented perspective rather than a conventional historical short-term point of view.

The Indians score 61, making it a long term, pragmatic culture. In India the concept of "karma" dominates religious and philosophical thought.Time is not linear, and thus not as important as to western societies which typically score low on this dimension. Countries like India have a great tolerance for religious views from all over the world - Hinduism is often considered a philosophy more than even a religion; an amalgamation of ideas, views, practices and esoteric beliefs. In India there is an acceptance that there are many truths and often depends on the seeker. Societies that have a high score on Long Term Orientation, typically forgive lack of punctuality, a changing game-plan based on changing reality and a general comfort with discovering the fated path as one goes along rather than playing to an exact plan.

With a score of 118 China is a highly long term oriented society in which persistence and perseverance are normal. Relationships are ordered by status and the order is observed. Nice people are thrifty and sparing with resources and investment tends to be in long term projects such as real estate. Traditions can be adapted to suit new conditions. Chinese people recognize that government is by men rather than as in the Low LTO countries by an external influence such as God or the law. Thinking ways focus on the full or no confidence, contrasting with low LTO countries that think in probabilistic ways.

There are no scores for Israel on the 5th dimension based on the VSM and Chinese Value Survey.

As we can see in all the 5 - Dimensions China is relatively more conservative compared to India. Israel exhibits a different set of values on most of the dimensions. Israel's innovativeness compared to India and China can be easily explained on cultural terms also.

China's achievement is inspite of the cultural constraints as we can observe in the model. So much so that relatively better innovativeness, as reflected in patents obtained by them, is due to careful policy directions. Chinese have created a sub-culture through deliberate way, where innovation is seen as a desirable and rewarding. Innovativeness is not a natural trait in the society. Yet, the trait is harnessed through force and incentives. These measures could bring in the correction in the behaviour in the long run.

India could learn from this experience to give a boost in this activity.

Learning from the others' Experience:

Innovation cannot happen in a vacuum. In our plan to enhance this activity we could realistically consider the desirable social, economic and political environment, along with S&T factors to facilitate technology development and patenting. Improvement in the S&T policy is the easiest of them all. Much of the desirable measures have been already articulated in the latest Science, Technology and Innovation policy of 2013. Perhaps we may have to look for the solutions in our economic strategy in general and industry domain in particular.

While we examine our relative strength, we can notice that there is a need to increase the inventor base. We are lagging behind both in terms of sheer number and also in the productivity of the existing stock. We also have to broaden the subject coverage in the range of innovation activities. The innovation plan must enthuse to engage with the peculiar local needs going with our socio-cultural background and the way of living while preparing technology wish list and idea generation. Though such innovations may not be cutting edge, we would not face foreign competition on such ventures and such technologies would also cater to the market needs.

The country already has several schemes to encourage research and innovation. They cater mostly to science based research and development. These include:

- ✓ Industrial R&D Promotion Programme;
- ✓ Technology Development and Demonstration Programme;
- ✓ Technopreneur Promotion Programme;
- ✓ Technology Management Programme;
- ✓ International Technology Transfer Programme;
- ✓ Consultancy Promotion Programme;

- ✓ Technology Information Facilitation Programme;
- ✓ Technology Development & Utilization Programme for Women.

There are also various such programmes under different union ministries to encourage extra-mural research. Considering that these schemes are already in vogue for several years, there is a need to evaluate their efficacy.

Immediate attention could be given to some of the following:

- ✓ A proper appreciation of what is ‘patentable innovation’. We seem to have a different notion on what is patentable. This is reflected in our focus on lab-based innovations.
- ✓ Broad basing the R&D grants to accommodate technology development risk and failure as is done by Israel. S&T grants could be administered through regional offices for better inventor spotting, immediacy of innovators, and project monitoring.
- ✓ A re-look at the tax-based incentive for R&D.
- ✓ Encouraging the schools for industrial designs and education with this focus.
- ✓ Examine the adequacy of the support base for prototype development activities, which are essential components of innovation eco-system.
- ✓ Broadening the inventor base through incentivising patenting in a major way.
- ✓ Strengthening the local patent offices and bringing in an element of professionalism in their activities.
- ✓ Encouraging hands on innovation activities and the importance of new ideas and products at the school level.

Summary and Conclusions

Summary and Conclusions

Innovation refers to exploiting new ideas leading to the creation of a new product, process or service. Innovativeness has become a major factor in the context of science and technology (S&T). Prominent among the measures of innovativeness of a country or an organization is the patents assigned to the same.

The current study examines the patents granted to China, Israel, and India by the USPTO, one of the three important patent offices in the world. The United States of America is the biggest economy and any worthwhile idea/ technology would have to succeed in that market, and hence, in most cases, would be patented in the country. Apart from this, confining the study to the USPTO also ensures a common benchmark for the comparative study.

The objectives of this study were the following:

to examine the patents granted to China, India, Israel by USPTO during 2001-2010 in numerical and qualitative terms;
to Identify the core areas of innovation activities and its growth;
to analyze the information on innovator as also assignee affiliation and collaboration;
to present a few cases that would take a closer look into the technologies patented within a given focus;
to infer the patenting trends, active components of the national innovation system and strategies adopted by the countries for obtaining the patents, and also elicit possible learning from the same, and finally
to analyze patents granted to Indian entities by Indian Patent Office during the years 2001-10.

Methodology & scope

The study considered all the patents assigned by the USPTO during the years 2001-10 to the selected countries. All the patents were examined individually and the same were categorized as appropriate to the context. The variables considered include, assignees, innovators, subject focus, and broad grouping of patents on technology level, time lapse in grant of patents, apart from growth trends of patents during the period. Technology levels of the patents were broadly classified into high, medium and low. High technology was defined to include cutting edge technologies originating from the lab-based research. These include nanotechnology, drugs and pharmaceuticals, semiconductor related research, and a host of related ones. Low technologies are those that are soft innovations or ones belonging to commonplace products. These also include soft innovations such as ornamental designs and the like. Medium technologies are the ones which do not fall in either group and cover innovation on a wide ranging products and processes. The classification broadly corresponds to embryonic, growth and maturity stages of technology S curve.

Economic and S&T Backdrop

China:

During the 2001-10 period China tripled its GDP(PPP) and it was US$ 10,170 billion in 2010. Its per capita income also tripled during the period and stood at US$ 6,846 in 2010.

Whether it is the science and engineering papers that China's researchers publish in international journals, the amount of investment made in R&D or the number of patents obtained, statistics indicate that their S&T capabilities are developing rapidly. China has the stated ambition to be an *innovation-oriented country* by 2020, and one of the world's leading science powers by 2050.

China has been taking great strides on the R&D investment, which has grown from US$ 6.5 per capita in 1999 to over US$ 63 in 2010. It has also registered a steady growth in the expenditure on R&D as percent of their GDP. Business expenditure on R&D has grown ten-fold during the decade. Interestingly the number of R&D personnel has also grown four-fold during the same period. The country has the second largest workforce of scientists and engineers, second only to the U.S.

Israel:

Israel is 100th smallest country with population of seven million. During the 2001-10 period the country registered promising economic growth and its GDP (PPP) stood at US$ 218 billion in 2010. In the same year the country's per capita income stood at US$ 28,298.

Israel's S&T tradition predates formation of the country. The country has the highest ratio of university degrees to the population in the world, and has one of the highest per capita rates of patents filed.

Israel's expenditure on R&D and per capita expenditure on R&D is way ahead at 4.41 percent of its GDP and US$ 1242, respectively, in 2010. However, considering Israel's population is small, per capita measure does not add up to big numbers. Israel has seven R&D personnel for every 1000 people.

India:

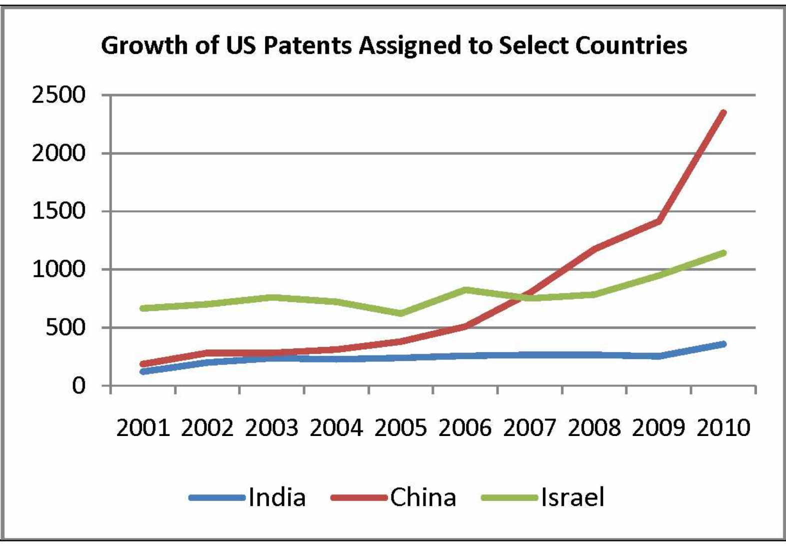
During the 2001-10 period India registered a promising economic growth resulting in almost four-fold increase its GDP (PPP), which stood at US$ 1,648 billion in 2010. Our per capita income during the same year was US$ 3,523.

Excepting for the size of the economy, India is comparatively on the low end as to the parameters relating to R&D. Business expenditure on R&D has registered an increase in the recent years, though it is too meagre to make a considerable impact. R&D expenditure as percentage of GDP stands at 0.85, and the per capita R&D expenditure was $ 11.77 in 2010. Business expenditure on R&D has also registered a four-fold increase during the 2001-10 period and was US$ 2,800 million in 2010. Total R&D personnel, as per the data available, works out to be as small as one in every 5,000 people.

Analysis of Patent Growth

Growth of US Patents

	India	China	Israel
2001	121	186	665
2002	199	283	701
2003	237	282	760
2004	227	312	722
2005	239	380	621
2006	257	508	825
2007	266	800	750
2008	266	1174	783
2009	253	1414	947
2010	**358**	**2350**	**1142**



China:

China has registered a steep increase in the patent productivity in recent times. During the 2001-10 period of US patents assigned to China has increased over 12 times.

There is a distinct trend of industry dominating the patenting activity in China. They make up 90 percent of the total patents granted to China. Research institutions and universities have also registered a steady growth of patents in numerical terms, though as a proportion to total they have crossed double digits in only one year. Also to be noted is the significant increase of patents by universities, which has registered a twenty-fold increase during the decade. Patents by research institutions have tripled during the 2001-2010 period, though the numbers are relatively small. The trend is indicative of all round growth in innovation activities. China had 2,079 distinct patent assignees during the period

Chinese patents are increasingly an outcome of collaborative R&D investment and these have moved from 09 to 45 percent of the total during the ten year under study.

China also has benefited from international collaboration at assignee level. Starting with a mere 2.2 percent of the total patents in 2001 it increased to 37 percent of the total in 2010.

Sole inventor patents dominated in China in 2001. This trend has corrected itself over the more recent years. The changing trend could be an indication of increasing sophistication of innovation. It has changed from 70:30 - Seventy being single inventor - in 2001 to 67:33 - Sixty-seven, in the latter case, being collaborative - with more than one inventor - in 2010.

A little over eleven percent of the Chinese patents have exclusive foreign innovators, (i.e., invention carried out completely by non-Chinese) over the 2001-10 period. On a year-wise analysis this figure shows a steady decline from 23 to 7 percent of the total.

On the whole 12 percent of the Chinese patents could be classed as high technologies; 47 percent as medium, and 41 percent as low.

A closer look at the annual trends reveal that Chinese high tech patenting is on a gradual rise from 22 patents in 2001 to 242 in 2010, all along registering an increase. Chinese medium technology patents have risen from 17 to 57 percent of the total. The corresponding figures for low technology ones show a decline from 70 to 30 percent. However, the low tech patents have increased in actual numbers.

China seems to have benefited from filing the low technology patents in ensuring a quick grant of the same. Over 62 percent of the low technology patents taken by Chinese are ornamental designs and the rest are minor modifications of one or the other commonly used products. It could be observed that Chinese seem to have rapidly increased their patent count with an emphasis on low technology and low-end innovations. Analysis shows that a large portion of Chinese patents is granted by the USPTO with in a year or two.

China had initially depended on outsourcing the innovation in toto. They graduated into international collaborative research, more in medium technologies. The high technology patents are increasingly local in all its collaboration. Chinese seems to work with an intention to showcase an increasing innovation trend, as reflected in patent growth, and the plan seems to be holding good so far.

Chinese patents for the years studied fell under more than 359 distinct main classes of the US patent subject classification. China had 10,125 successful inventors as per this study and per capita patent per inventor works out to 0.76.

Major subject focus of Invention by China:

Designs patents (23 classes from D19 through D99)	1977
Electricity & Electrical machinery (US PTO Subject classes 361,439,324,60)	578
Textiles (US PTO Subject classes 94,141,19,26,58,28,57))	774
Office systems / supplies (US PTO Subject class D19)	164

China has defined its S&T objectives in various plans categorically, channeling the resources and efforts. Increase in the country's innovation base is also a result of China's emphasis on manufacturing oriented export trade. China has also taken the route of rewarding successful innovators through prize money at various levels, among other things, for moving towards its declared goal of innovation-based economy.

Israel:

Israel was ahead of India and China in 2001 and, in numerical terms, has been holding steady during the ten-year period. In fact, a look into the total patents assigned to Israel during the previous years shows that the number has been growing over the last ten years and from 2001 onwards it has been around 700. This number has shot up during the last three years of the decade.

Industrial sector dominate the patent scene in Israel. This sector has obtained nearly 87 percent of the total patents granted by the USPTO to the country, during the first decade. Absolute number of patents going with the universities and research institutions are also relatively high, considering that the country has only eight universities and 55 research institutions. Universities and research institutions have also carved a niche for themselves in innovation activities in Israel. Both universities and research institutions have annexed business organs to deal with the IPR and technology transfer issues. The country has earned considerable revenue through the technology transfer.

As a rule Israeli patents are mostly inventions by single entities (96%) and collaboration of two or more entities is a minor affair, both in actual numbers and as a proportion to the total. Foreign collaboration, as reflected in patents jointly assigned to the country, is below two percent of the total. Collaboration, however, is present at the inventor level. Eight percent of the patents have resulted from foreign inventor collaboration and 4.2 percent of the total had exclusive foreign inventor(s). One-third of the Israeli patents are also technologies developed by single inventors.

Low technology patents form a small proportion with less than 10 percent of the total. Medium technology patents, including those relating to software procedures, plants - mainly cultivars, cryptographic methods; engineering and electrical equipment make up almost two-thirds of the total. The rest of the patents grouped as high technology and add up to 10 percent of the total.

Foreign inventor collaboration could be noticed both in medium and high technology patents. It is more so in the high technology, amounting to 13 percent of the total in that category.

Israel has clearly earmarked sectors like software, biotechnology, pharmaceuticals, medical instrumentation, and agriculture, among others, for innovation activities. They seem to have made best of the available technical manpower, considering it is a small country with smaller population base. In support of this Israel has vigorously administered the government grants for R&D, and even encouraged MNC collaboration in R&D through official grants.

Israel's patents could be categorized under 217 main classes of USPTO classification. However, a few major categories make up a half of the patents. In all, there were 2,400 unique assignees in Israel and 9,475 unique inventors were identified from the data. Per capita patent per inventor works out to 0.84.

Major areas of innovation by Israel

Subjects	Patents
Communication - Multiples / Digital (US PTO Subject classes 370, 375, 340, 379)	675
Drugs (US PTO Subject classes 514, 424)	629
Medical Equipment (US PTO Subject classes 600, 604, 606, 623)	673
Optical systems (US PTO Subject classes 356, 359, 385)	419

India:

India was along with China in the number of patents in the year 2000 and also, even as late as, 2003 in utility patents. India's annual patent count has been around 250 during the ten years under review. The composition of Indian patents granted by USPTO is interesting. The share of research institutions, which was as high as 63 percent in 2001, has reduced to 23 percent in 2010. The decline has been steady and it has occurred, both as a proportion of the total and also in actual numbers. As opposed to this, the industry has registered a growth from 37 to 74 percent of the total over the same period. The relative contribution of industry and research institutions has changed, almost depicting a scene vice versa of the one in 2001. The universities show a dismal picture all through the period. The picture is not rosy when we consider the actual numbers. There is a considerable decline in the patents granted to the research institutions. The annualised growth is only marginal during the decade.

Indian patents are increasingly outcome of non-collaborative R&D investment both for industry and research institution. Even among the academic bodies - universities and research institutions the trend in India has been to 'go alone'. Inter institutional collaboration, be it between more than one research institution, more than one university, or research institution and university, is negligible. Also, there is no noticeable international collaboration in innovation in our context.

The patents, however, have increasingly come from collaborative teams of inventors and such instances have remained above 80 percent all through the years for India. Around 4,800 inventors obtained 2,420 patents, making it about a patent for two inventors over the decade. India had 386 distinct patent assignees during the study period. Indian patents falls under 181 US patent main classes.

Relatively greater proportion (56 percent) of Indian patents comes under high technology, and low technology innovations are less than ten percent of the total. This distribution reflects our patenting priorities, which tend to be less of low end products and more of lab based processes and the like.

Major areas of innovation by India

Chemistry of organic & inorganic compounds (US PTO Subject classes 160, 423, 435,536, 540, 544, 546,560, 562, 568, 548, 549,	798
Drug, bio-affecting and body treating compositions (US PTO Subject classes 514,424)	517

Due to the presence of MNCs with their R&D laboratories in all the three countries they have lost their local innovation to other countries. That is, invention by Chinese, Indians and Israelis, as the case may be, but the patents assigned to an entity other than the respective countries. In fact, during the decade China and India have lost more innovations to others than the countries have as their own. It is also almost the case with Israel. This trend exists despite the growth in number assigned to countries during the period. What is alarming is that this trend has consistently increased for India and has declined for China in recent years.

Case Studies:

Case study of the patents in the US Patent Class 370/641- thermal conduction of electronic equipment - reveal that China took up to patenting on the technology when the innovation on the technology was on the decline elsewhere. China learnt the technology through collaboration with Taiwan and later continued on its own. Most of the patents they obtained in the process were based on fine-tuning at the sub-component level. These patents could be categorized as either exploitative innovation or creative imitation. The new patents provided a learning opportunity for China and also helped in brining in small improvements in the electronic products they were putting together. It would have also helped in avoiding license fees to other IPR holders on the technology.

Case study on design of pens, which could be categorized as soft patents, reveals that initially Chinese firm co-opted with Taiwan by outsourcing the innovation. After this learning it took up to patenting new designs. A careful study of the trade figures show that through these exercises, along with the cost advantage, China could garner substantial world export share on the product within a short span of time.

Case study on medical device patenting by Israel show that the country promoted innovation on the technology in the late 1990s and carried on during the next decade. As there were well-established players in this technology market with patent wall in place, Israel's innovation could at best plug the hole in the technology. The patents obtained were in group B and C category technologies, which fall in low-moderate and moderate-high risk group of products. More recently Israel has moved into innovation in Cryosurgery - relatively new technology, with limited players. This way, the strategy seems to be in the forefront on the technology. This approach contrasts with that of Chinese method of coming late in the process and innovating at the margins.

Indian Patents Granted by Indian Patent Office

Analysis was also carried out on the patent records obtained from the public access database of the IPO. As per the available records Indian patents obtained from the Indian Patent Office shows a more promising trend. The patent growth shows a prominent upward trend and reached an annual grant of 2056 patents in the year 2008.

This number declined in the last two-years of the decade. Over all the number adds up to a substantial 7,899 for 2001-2010 period.

Unlike Indian patents in the US PTO, within the country industrial firms have assumed a leader role with 45 percent of the total for the decade. Considerable number of patents is also assigned to research institutions and universities. Universities make up six percent of the total, with 465 patents in all for the decade. Included in this list are IITs and other such institutions of national importance. An unusual pattern in our local patents is the dominant presence of the unaffiliated assignees. These are individual inventors who have also mantled the role of assignees. This category makes up almost one-fifth of the total patents for the decade. This phenomenon reflects lack of awareness and low importance given to IPR by some institutions where the patented idea was worked on. Despite considerable increase in the overall numbers, there is no consistent trend of growth for any of the major assignee groups.

Three-fourths of the local Indian patents were obtained by single entities; collaborative research at the organizational level is relatively less. Inventor collaboration, on the other hand, is widely noticeable with two-thirds having two or more inventors. Assistance taken from foreign inventors either through exclusive outsourcing or innovation through collaboration is meager.

Medium technologies dominate the patented innovations, as opposed to the patents obtained in the USPTO. These innovations broadly fall in the category of products in one or the other engineering fields. Only 20 percent of the total could be classified as high-tech, which includes innovations involving laboratory based research or the new areas such as nano-technology and the like. There were only 16 patents that could be categorized as low tech. Absence of soft patents such as designs under our patent law could be one of the reasons for this low number.

Subject-wise classification shows that our innovations are skewed towards chemistry based processes, (including pharma products) and mechanical engineering, (including auto-components etc.). These are followed by innovations in metallurgy, electronics, electrical goods, food technology based products and medical devices. Relegation of electronics to the secondary level and medical devices that are only in the Group A (low risk) category does not speak highly of our innovation priority, considering the market potential for these products.

Indian innovator base, as per the IPO records, is strong with 11,855 individuals who have obtained one or more patents. Assignee base is also strong with 2,663 entities in the IPR game. CSIR owns nearly 20% of the total patents granted, followed by Hindustan Unilever (643), BHEL (199), SAIL (165) and the IITs (162).

Patent granting process in Indian Patent Office is slow and on an average it has taken nearly six-years for the grant and in an extreme case the figure stands at 17 years.

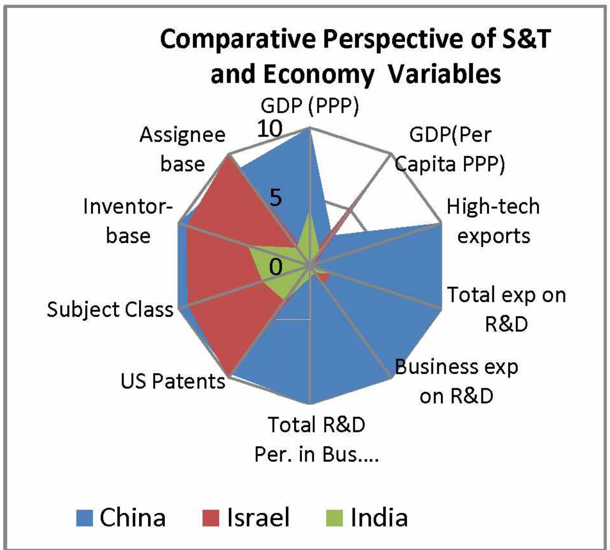
Innovation trend on the whole indicates the availability of the talent and eagerness to patent. There is a need to strengthen the institutional base for IP protection, including providing a credible database of the patents in the public domain. There is also a need to spread greater awareness of the patentable innovations.

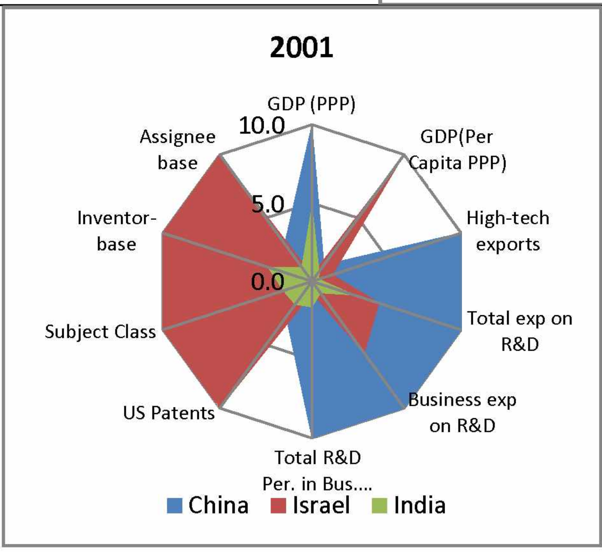
Summary table of R&D and US patent data 2001-10

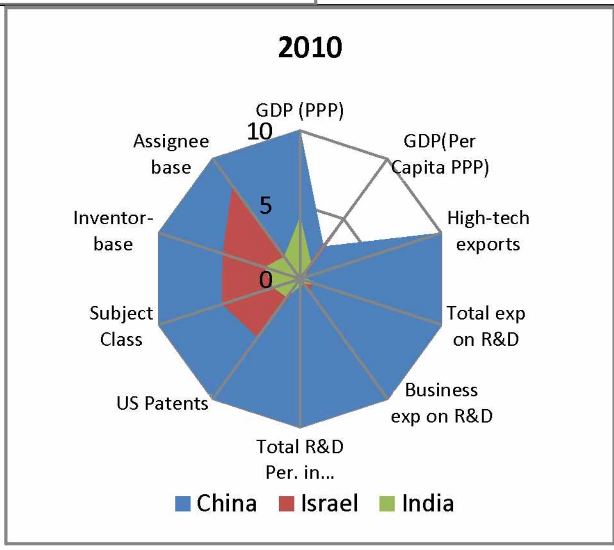
	GDP * (PPP)	GDP(Per Capita PPP)*	High-tech exports*	Total exp on R&D*	Business exp on R&D*	Total R&D Per. in Bus. Ent.*, **	US Patents 2001-10	Subject Class 2001-10	Inventor-base 2001-10	Assignee base 2001-10
China	10169.52	7583.54	223795.39	44252.10	31450.85	1046.13	7679	4717	10125	2079
India	4194.86	3523.04	5427.31	7354.42	2001.39	87.25	2420	1681	4794	386
Israel	217.84	28298.66	6067.36	6973.54	5457.38	44.57	7916	4372	9475	2400

- Annual average for the period 2001-2010 (US $ million)

** (FTE thousands) (Indian figures were calculated on the basis of 2006 figures)



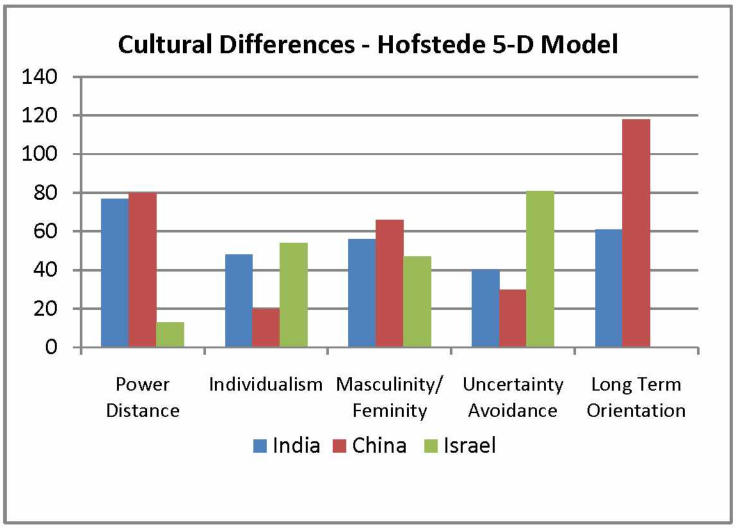




2001	GDP (PPP)	GDP(Per Capita PPP)	High-tech exports	Total exp on R&D	Business exp on R&D	Total R&D Per. in Bus. Ent.	US Patents	Subject Class	Inventor-base	Assignee base
China	3334.18	2612.44	49409.51	12595.14	7611.82	532.10	186	156	259	122
Israel	130.39	20059.38	6741.83	5661.84	4318.19	39.14	665	595	1227	411
India	1616.45	1571.30	2286.51	3610.85	697.81	87.25	121	114	361	46
2010	GDP (PPP)	GDP(Per Capita PPP)	High-tech exports	Total exp on R&D	Business exp on R&D	Total R&D Per. in Bus. Ent.	US Patents	Subject Class	Inventor-base	Assignee base
China	10169.52	7583.54	406089.69	########	76592.23	1873.91	2350	1606	3997	653
Israel	217.84	28298.66	7978.96	9566.84	7635.00	49.35	1142	886	2191	505
India	4194.86	3523.04	10086.63	14015.21	2803.25	87.25	358	303	993	119

Cultural Dimensions

To examine the possible cultural difference in innovations comparative national scores on variable such as power distance, individualism, masculinity/ feminity, uncertainty avoidance, and long term from Greet Hofstede's 5-D model was compiled. Innovativeness is known to correlate with communication across hierarchy in organization, risk taking behavior, individualism, among others. The data for the three countries indicate that Israel is distinctly different on several dimensions. There is a considerable overlap between India and China on all the five dimensions. On power distance, individualism and uncertainty avoidance, China scores relatively low compared to India. In its record growth in patents during the decade, China has fared well despite some of the possible cultural obstacles. The success points to a host of policies China adopted to enhance their performance.



http://geert-hofstede.com/national-culture.html

Innovation Strategy of China, Israel:

Strategy is the art of devising and employing plans towards accomplishing a goal. Patent or IPR strategy is a part of the larger technology management strategy.

Technology management strategy includes:

- Recognition of technological threats and opportunities,
- Exploitation of existing technologies,
- Identifying and evaluating alternative and emerging technologies,
- Involve in innovation activities,
- Protect and exploit IPR.

An innovation strategy guides decision on how the resources are to be used to meet a firm's / country's objective for innovation and thereby build value and competitive advantage. It entails judgment about what kind of innovation process is more appropriate for the circumstances and ambitions. The strategy identifies technologies and markets it should best develop and exploit, to capture and create value.

Patenting strategy involves mechanics of achieving exclusivity in a technology area. At the firm level these include:

- Broad or narrowly claimed patents
- Patent flooding or blanketing around an original patent.
- Wall strategy, in which the firm knows that the patented technology would be surpassed in functionality. The gain is in the time delay imposed on the competitor.

Patent strategy at the national level is part of -

- S&T policy, which may sometimes include an exclusive innovation policy
- Industrial policy, which may include growth strategies desired, such as export led growth or focus on internal market through protection mechanisms, and
- Industrial manpower policies, which could include capacity building, among other things.

Israel has consciously opted for technology and innovation led growth model. Considering the relatively small population base, the technologies opted by the country are the high end ones such as medical devices, IT, drugs and pharmaceuticals etc. The government has also devised ways for risk absorption in innovation process, through grant programmes at all levels of technology development process, namely embryonic, growth and maturity stages. It has also encouraged formation of technology-based enterprises through venture capital mechanisms and funds operated for the purpose. International and bi-national interactions for technology development are facilitated through specific programmes intended for the purpose. The results of this are reflected in the patents obtained by the country.

China has the explicitly stated goal of transforming the country in to an innovation-based economy by 2020. Among the strategies adopted towards that goal are -

- Manufacturing export led growth;
- Import of technology to facilitate manufacturing, mainly through open door policy for trade and industrial establishment;
- Protection of local markets through appropriate IPR legislation, such as

    - Utility model patent;
    - Making local patenting mandatory for MNCs engaged in R&D within the country;

- Changing labor laws to make the manufacturing process competitive;
- Encouraging local innovators through incentivization at various levels;
- Restructuring the S&T organizational set up to make them competitive;
- Selectively developing universities to achieve the best standards and establishing benchmarks;
- Adopting a slew of measures, such as venture funding, tax based incentives, to facilitate innovation and patenting;
- Continuously revising the national policies, which have also earmarked a set of technologies to focus on in the coming decades.

The outcome of these measures in terms of innovation and patenting is immense. These have resulted in new innovators and firms harnessing the IPRs.

Four levels of innovation strategy are recognized. These are: **Reactive** - where the innovation is entirely incremental; **Active** - wherein the innovation, though is not first to market, but are well prepared to follow; **proactive** - in which the innovation is mainly radical in nature; and **passive** - in which case the product improvements take place only on customer requirement.

One of the outcomes of the active and proactive innovation is the patent rights and is less so when the innovation strategy is reactive. China's innovations range from '*proactive to* '*reactive*' '. They are, however, skewed towards '*reactive*'. This is reflected in their innovations, which are minor improvements of old products and designs. The country is also involved in an '*active*' innovation strategy in certain medium technologies. China is also engaged in science-based inventions - particularly the ones emanating from its universities. The trick in the rapid growth on patent graph is that much of the low technology products, nominal design improvements that are normally not widely appropriated as IPRs have been converted as patents. Protectability of many of them could be an issue, and its intrinsic worth in the market is debatable.

Nonetheless, this exposure to patenting has broadened the innovator base, spread awareness of IPR, its commercial importance, and generally prepares for a wider innovation culture. China, through its policies, is aiming for such a change.

Israel's strategy is to engage in '*pro-active*' to '*active*' inventions on select technologies. In technologies such as computer software, medical instrumentation, biotechnology and drug development the country is proactive and engage in cutting edge research. In several other areas invention is pursued at a level that could be adopted directly by the industry. Active venture capital firms facilitate the inventors / entrepreneurs. The government also facilitated in lowering the R&D risks through imaginative programmes. This has served the intellectual property generation very well for the country.

Indian patents largely fall in the categories '*active*' and '*reactive*' inventions, the bouquet, however, is small.

Learning from the others' Experience:

Innovation cannot happen in a vacuum. In our plan to enhance this activity we could realistically consider the desirable social, economic and political environment, along with S&T factors to facilitate technology development and patenting.

While we examine our relative strength there is a need to increase the inventor base. We are lagging behind both in terms of sheer number and also in the productivity of the existing stock. We also have to broaden the subject coverage in the range of innovation activities. The innovation plan must enthuse to engage with the peculiar local needs going with our socio-cultural background and the way of living while preparing technology wish list and idea generation. Though such innovations may not be cutting edge, we would not face foreign competition on such ventures and such technologies would also cater to the market needs.

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- ✓ International Technology Transfer Programme;
- ✓ Consultancy Promotion Programme;
- ✓ Technology Information Facilitation Programme;
- ✓ Technology Development & Utilization Programme for Women.

There are also various such programmes under different union ministries to encourage extra-mural research. Considering that these schemes are already in vogue for several years, there is a need to evaluate their efficacy.

Immediate attention could be given to some of the following:

- ✓ A proper appreciation of what is 'patentable innovation'. We seem to have a different notion on what is patentable. This is reflected in our focus on lab-based innovations.
- ✓ Broad basing the R&D grants to accommodate technology development risk and failure as is done by Israel. S&T grants could be administered through regional offices for better inventor spotting, immediacy of innovators, and project monitoring.
- ✓ A re-look at the tax-based incentive for R&D.
- ✓ Encouraging the schools for industrial designs and education with this focus.
- ✓ Examine the adequacy of the support base for prototype development activities, which are essential components of innovation eco-system.
- ✓ Broadening the inventor base through incentivising patenting in a major way.
- ✓ Strengthening the local patent offices and bringing in an element of professionalism in their activities.
- ✓ Encouraging hands on innovation activities and the importance of new ideas and products at the school level.