1.1 INTRODUCTION
An invention can be explained as a creation (product, process, design) resulting from dedicated research activity. However good your invention can be but unless and until it is been accepted by the industry, the novelty of innovation has a little importance. In simple words, any structure intended to promote innovation should be focusing more on the practical implementation of the innovative idea. There is an increasing need in universities and academic research to direct basic inventions/ research to IPR protection rather than publication of the invention. Academic patenting has assumed importance during last twenty-five years in the US universities and patents have been used as mechanisms through which academic inventor shape entrepreneurial firms established to commercialize their scientific idea. This has led to the emergence of patenting culture in university science. This patenting culture has been studied empirically with the increase in commercialization of science. The school of thought is that science-based entrepreneurial firms are a key feature for the growth of modern economy. The intellectual capital contributed by these firms can be converted into financial capital.

The success of US universities has led to thinking in India that above model of US universities in patenting inventions needs to be adopted as it can lead to commercialization of science and promotion of venture thereby benefiting institutions and scientists themselves. Academic institutes are not very aggressive even today to file a patent, though most of the high ranked institutes like IIT, IIM, NIT have set up separate patent cells for encouraging the patent culture in their institutes. Outcome of academic research is based upon factors like researcher’s ability, funds available, time management, and work culture. Once the research work is completed the researchers has a choice to either go for patenting or publication. This has been the culture in Indian academic institutes. This situation has been changing after India signed WTO agreement. Post TRIPS era is compelling the academic institutes to think aggressively about any research work outcome which has potential to get patent ends up in acquiring the same. The execution and acceptance of research ideas, innovations from academic institutes in industries is directly contributing for economic development and supporting industries to be globally competitive.

Still, the prime objective of any academic institute or public funded labs is not only commercialization but much more than that. They are expected to contribute to the fundamental knowledge bank and more importantly create intellectual human resource capital for the society. Considering all these factors, new systems have been set up; legal reforms have been taking place so as to create a positive environment for the research community to share their knowledge and research outcome with the industries. Various efforts are taking place to ensure most of the potential research reaches the market place. With this objective in mind, there is an increasing pressure being put by institutions and funding agencies on Indian scientist to patent their findings before publishing. This is making many of the scientists very much uncomfortable as they feel that their job is to do science and share the results of research with their peers for the advancement of science. They have been brought up in the culture of publishing research work, rather than trying for patenting. They are constantly being told that by not paying attention to patenting, they are sometimes putting valuable information into public domain and it is being used by others to convert into products and processes which are very often patented by others. As a result of which it is believed that the Indian scientist are losing out on opportunity to encash their knowledge.

1.2. Background of the study

The point of whether indigenous minds with innovative ideas are losing out to get incentives needs to be examined from through historical times. A study of the Indian knowledge through ages helps to understand the mindset of the Indian research community. It can be understood that the thought that knowledge is free and should be shared without incentives prevails in history of Indian culture.

1.2.1. J.C. BOSE: Father of modern Indian science and his views on patenting

This is the excerpts from the inaugural speech by Dr J C Bose at the opening of Bose Institute on 30th November 1917. In this speech Dr Bose very clearly takes a stand on what is the future of science and innovation in India. He says" The Discoveries Made Here Will Be Public Property". “Has Her own history and the teaching of the past prepared her for some temporary and quite subordinate gain?"2”

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2 Inaugural speech by Dr C Bose at the opening ceremony of his Bose institute on November 30, The Two Ideals (1917).
“The discoveries made here, which will be demonstrated for the first time before the public.”

“Through the regular publication of the Transactions of the Institute, these Indian contributions will reach the whole world. The discoveries made will thus become public property.”

Bose is one of the original researchers of radio-physics. His research forms a connect between the original discovery by H. R. Hertz and practical use of radio physics by G. Marconi. Marconi was recipient of Nobel Prize for Physics in the year 1909. A US-based Indian engineer claimed that the detecting device (it was called as coherer) named as Italian navy coherer which was used by Marconi, actually was modified version of an instrument that was invented by Bose two years ago. "A combination of factors like negative about patenting, simple misfortune and politics of the modern times went against J C Bose." ³

Europe's encouragement officially supports and recognises Bose's pioneering research as abundant and spontaneous. University of Cambridge offered him a professorship. Sir J C Bose was the first professionally trained mainstream Indian scientist who was elected a fellow of the prestigious Royal Society of London. He was fully aware of the potential financial gains that can be exploited of his radio work but consciously he refused to gain from his research work.

In the year 1895, Bose gave a demonstration to the thrilled people of Calcutta. He exhibited the wireless transmission of radio waves over a distance of 75 feet (25 m) through brickwork wall. Bose's waves were microwaves with lengths in the millimetre range. For long distance travel in space you require longer radio waves. For his detectors, Marconi made use of Bose’s research that was already published. Being in public domain it was a common property. Legally, It is unfair to blame Marconi for his success.

According to Prafulla Chandra Ray, colleague and close friend of Bose, "It appears that he had not then realised the importance of the new line of research he had hit upon and creating possible use of coherer for money-making purposes"⁴.

British navy was first to use the Bose coherer. They used it to set up effective radio connection between a torpedo boat and companion ships.

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³ Did Marconi cheat Bose?: A story in The Telegraph (December 1997) covered a story named "Bose invented Marconi's wireless"

⁴ Prof Rajesh Kocchar, J.C.Bose: The Inventor who wouldn’t patent, Antentop-02, #003 (2003).
In May 1901, Bose wrote a letter to his close friend Rabindranath Tagore: The owner of a well known telegraph company approached Bose carrying along with a Patent form. He offered him fifty percent of the profit and will also invest the business against the patent.

“This multi-millionaire was begging to me. My friend, I hope you would see that awful fondness for money in this nation, that all attracting lucre, that greed for money and more profit. If I get into this trap, it would be point of no return for me.

"Annoyed and frustrated by Bose's "idealistic" attitude towards money, his lady friends, Margaret Noble (Sister Nivedita) who was a British and Mrs. Sara Bull from America without consent from Bose applied for US patent in the name of J C Bose in 1904. But Bose remained firm and refused to commercialise the patent.

See the contradiction here. Bhagini Nivedita a spiritualist stressing the need to go for patents and royalties and professor of science refusing the idea. The reason behind their response to the situation needs to be judged against the backgrounds: Nivedita came from industrial Europe and Bose was a son of the orientalised East.

P.C. Ray told the audience in 1916, to welcome Dr. Bose, that, if Dr. Bose had patented his inventions for the apparatus and instruments, he could have gained heavy commercial returns by their sale. He could have become an Indian icon for commercialization of scientific inventions.

Dr. Bose abandoned radio waves invention and there were no students to take the research ahead and India’s rendezvous with physics came to untimely end.

Research and inventions of Dr. Bose were the proof of what Indian science was capable of and could support modern science. But Dr. Bose was never interested in commercialising his inventions. For western world science was the key to prosperity while Indians thought that science was the reason of its agony and embarrassment. Bose's anti-patent stand in his authorised biography "Simply stated, it is the position of the old rishis of India, of whom he is increasingly recognised by his countrymen as a renewed type and whose best teaching was ever open to all willing to accept it."5

1.2.2. Historical references of Indian knowledge (From Vedic era till Early 19th Century)

India is the mother of all “civilization” is often said by many. But little significant research or reliable writing has ever been done to substantiate this fact. "India’s Contributions to the West"

5 https://techslashdot.org/story/01/01/23/1746245/100-years-of-radio
primarily discusses how India has been a source of knowledge to the West over ages. Even the
growth of modern sciences in the West, called the "Renaissance" was a direct result of flow of
Indian knowledge to the West.  

Kanaka, an Indian scientist from the Sind province of India visited in the court of Caliph
al-Mansur in Baghdad in 773 AD along with Indian scientific manuscripts in Sanskrit. The
Caliph was amused at the scientific knowledge of the manuscripts and immediately ordered
translation. Al-fazari and Yakun ibn Tariq became the first Arab students of Kanaka. Caliphs
sent his researchers to India in search of more manuscripts. Famous mathematician
al-Khwarizmi was sent to study Indian science and mathematics. After returning back he wrote a
book ‘Algoritmi de Numero Indorum’. This book became the beginning of study of mathematics
in Europe. The caliphs started libraries and schools in the areas of Europe under his rule. He
arranged for translation of that scientific literature into Latin. And so books containing writings
of Aryabhat, Brahma Gupta etc. reached Europe. These contained a lot of science including
gravitation. This opened a new era of knowledge in Europe which had been deprived of science.
Although we hardly have any surviving scientific literature from ancient India, the ones which
are accessible proves that physics taught in ancient India since 6th century BCE. This tradition of
teaching ended in the 12th century. Kanada (6th century BCE), mostly been known for his
"atomic theory", wrote the Vaisheshika Sutras. It is a systematic exposition to physics. Kanada
had knowledge of velocity, acceleration, momentum, energy, Newton’s Laws of motion,
potential energy, active and passive work, inertia and Magnetic compass. Prashastapada was
another scientist of this school who lived in sixth century AD.

He wrote the Padarthadharma-sangraha (literally "collection of properties of matter") and
commentary on the Vaisheshika Darshana, the Prashashtapada Bhashya. These are
comprehensive books in physics. Prashastapada discusses properties of motion. The peculiarity
of a single motion affecting a single body at a time, instantaneous velocity, velocity due to
gravity, addition of two velocities in opposing direction, vectorial (digvishishta) representation
of velocity etc. have been analyzed at least a thousand years before these concepts were thought
of in the West. A wide field ranging from general physics up to quantum physics has been
covered in his writings. 

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6 Dr. P. PRIYADARSHI, SATYA PRAKASH SINGH, INDIA’S CONTRIBUTIONS TO THE WEST, Vedic Books, ISBN:
8187471093 (2004).
7 Dr P. Priyadarshi, Seminar on Science & Technology in Ancient Indian Texts, (2010).
Due to attacks on libraries and universities by invaders, by 12th century, most of scientific knowledge was lost forever. We get some information of ancient science from some books which were in private possession of Religious institutes. The scientific literature in these books is substantial. These provide us the information as to what was the status of science. Bhaskara (Bhaskaracharya II; c. 1150 A.D.) was the last great mathematician-physicist of Ancient India. He was one of the best scientists in the world at his time. Bhaskara refined physics to the standard of mathematical accuracy. For example, he calculated that the centre of earth is not the centre of orbit of moon's rotation. Bhaskara gave the concept of tatkalika gati (instantaneous velocity). He gave the formula $v =s/t$. This was the birth of differential calculus, the backbone of all future physics, 600 years before Newton. Bhakara's death in 1185 was end of a very long tradition of Indian physicist. Invaders destroyed all educational institutions, big or small. Burning the famous Nalanda University in 1193 threw India into a Dark Age of ignorance.

However, some mathematicians and scientists fled to the South to establish Kerala school of Indian mathematics. Nilakantha, Mahadeva etc are mathematicians from that school of Kerala. It has been observed that many of the European mathematical discoveries were actually brought to Europe as the translations of the scripts of the scholars of the Kerala School. Pythagoras in the sixth century BCE came to India where he learned Indian mathematics and then went back to Greece to establish the first mathematical school. The Baudhayana Sulba Sutra of the Vedic text Katyayana Kalpatutra is known to us today as the Pythagoras’s Theorem.  

Even the binary number system used in computer science was invented by Pingala. Pingalas book also discusses Permutation and Combination. Panini (600 years before Christ) gave the language theory, which became basis for modern computer language: Backus- Naur form language. It has been renamed as Panini-Backus form.

By the time the British came in power in India, India had lost nearly all memory of her pre-medieval past. Whatever was available comprised only of folklores and some legends contained in the religious texts like the Puranas and the Mahabharata.

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9 Pingala, chhandah-sutra, 8.24-25
1.2.3. Modern India (Till Independence)

A view of historical Indian knowledge can be thought as the base for start of non-patenting culture in India. With progress of science in the next decade, the thought prevailed. Eminent scientists like Dr. J. C Bose (father of modern Indian science) were of the opinion that knowledge should be free and any form of monitory benefits resulting from selling of such knowledge is not acceptable. The issue of non-patenting and commercialization of knowledge in the Indian scientific community was dominant. The scientific community was more engrossed in publishing their inventions rather than patenting them. These inventions/ideas were further commercialised by the western counterparts. This was the beginning of loss of knowledge and resulting in loss of commercial benefits. A detailed analysis below will elaborate on these points.

IACS was influential for ensuring that science is included in the graduate syllabus. Core research in India began after Jagadish Chandra Bose (1858-1937) and Prafulla Chandra Ray (1861-1944) returned back after their studies and work abroad. The early momentum generated by Bose, Ray and the mathematical genius Srinivasa Ramanujan (1887-1920) did carry Indian pure science ahead but no new momentum was ever imparted. The freedom movement gained momentum and science lost its priority at national level.

Science got serious attention after Jawaharlal Nehru (1889-1964) became the face of Indian leadership. As president of the Congress, he declared in 1936: “rapid industrialization of the country will raise the standard of the people substantially and poverty can be fought’. In 1937 at Science Congress he confirmed: 'Even more than the present, the future belongs to science and to those who make friends with science and seek its help in the advancement of humanity'.

1.3. Development of IP law framework in India:
(British Administration till Post Independence Pre-TRIPS Era)

The Legal framework of Indian patent system originated in British Raj. After World Trade Organisation (WTO)-Trade Related Aspects of the Intellectual Property Rights (TRIPS) in 1995, Government of India was compelled to bring drastic changes to its existing patent law of 1970. As a signatory to the TRIPS, India had to amend its entire patent system as part of the agreement. Today, India’s consent to the TRIPS has completed more than 20 years. Even though the patent legislature of India need to bring in few more changes to reach the level of the advanced countries, still post TRIPS Era the introduction of new acts and amendments in existing acts
make Indian IP system almost at par with developed nations IP system. The Indian IP system had the advantage of British administration. The IP acts passed in pre-independence era worked as a foundation for designing post-Independent Intellectual Property law system in India. When we discuss the development of IP law India, we cannot avoid the reference of patents acts passed and executed in British Rule. The impact of acts passed in pre-independence era has a very significant impact on Indian IP system administered in Post independence era. The patent laws/rules passed in India were the direct result of the Acts/rules passed in the British Parliament in those days.

1.3.1 Trajectory of Patent Act of India (Under British Administration)
1856: The first legislation in India relating to patents was the Act VI of 1856. It was based on the British Patent Law of 1852. Certain exclusive privileges were granted to the inventors of new manufacturing for a period of 14 years. The objective of this legislation was to encourage inventions of new and useful manufactures and to induce inventors to disclose secret of their inventions. The Act was subsequently amended by Act IX of 1857 since it was enacted without the approval of the British Crown.
1859: The Act modified as act XV Patent monopolies called exclusive privileges (making, Selling and using inventions in India and authorizing others to do so for 14 years from date of filing specification).
1872: The Patterns & Designs Protection Act.
In 1872, the Act of 1859 was consolidated to provide protection relating to designs. It was renamed as “The Patterns and Designs Protection Act” under Act XIII of 1872.
1883: The Protection of Inventions Act.
The Act of 1872 was further amended in 1883 (XVI of 1883) to introduce a provision to protect novelty of the invention
1888: Consolidated as the Inventions & Designs Act.
In 1888, an Act was introduced to consolidate and amend the law relating to invention and designs in conformity with the amendments made in the U.K. law.
1911: The Indian Patents & Designs Act.

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The Indian Patents and Designs Act, 1911, (Act II of 1911) replaced all the previous Acts. This Act brought patent administration under the management of Controller of Patents for the first time.

In 1930, further amendments were made to incorporate, inter-alia, provisions relating to grant of secret patents, patent of addition, use of invention by Government, powers of the Controller to rectify register of patent and increase of term of the patent from 14 years to 16 years. In 1945, an amendment was made to provide for filing of provisional specification and submission of complete specification within nine months.

1.3.2 Post Independence: (Pre – TRIPS Era)

The history of patent reform in India suggests a history of decision makers familiar to the appropriate analysis of IP law. This understanding dates to the country’s earliest days as a modern independent nation-state. In 1947 the newly independent India inherited the Indian Patents and Designs Act of 1911, a British law that incorporated definitions, norms, and rules comparable to those that prevailed throughout the developed world. In 1949, a committee was constituted under Justice (Dr.) Bakshi Tek Chand, to review the patent law in India. On the recommendation of the Committee, the 1911 Act was amended in 1950(Act XXXII of 1950). In 1957, the Government appointed Justice Ayyangar Committee. In 1967, an amended bill was introduced and the Patents Act, 1970 was passed which came into force on 20th April 1972 with publication of the Patent Rules, 1972. This Act replaced the 1911 Act however; the 1911 Act continued to be applicable to designs.

For 23 years, various Indian commissions and commentators debated the propriety of such a law to India’s economic needs. The most influential of these commissions, chaired by Justice Rajagopala Ayyangar, emphasized the wisdom of rewarding innovation while nevertheless recommending a narrow scope of innovations eligible for such rewards.\(^{11}\)

The Ayyangar Commission’s report demonstrated careful consideration of the bargain that the public was striking with innovators when it granted them exclusive rights in exchange for their innovations. Ayyangar had studied and reviewed the patent systems of various countries, including Germany, the United Kingdom, and the United States. These inquiries led him to some non standard conclusions and recommendations. In particular, he concluded that Germany’s

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weaker patent laws had helped promote its chemical industry to a position of world leadership—and recommended that India follow Germany’s lead. The Commission asserted that India’s strategic and public policy interests in food and medicines mandated weak protection for innovations in those areas, and proposed allowing patents only for process improvements, not for new products. It also recommended provisions that would make it easy for India to convert the exclusive rights originally (and typically) inherent in a patent grant into a compulsory license, provisions that would require that a patentee work his invention in India to retain the patent, and a patent life as short as 5 years in some cases, and never more than 14 years. India’s Patent Act of 1970 enacted all these recommendations into law. The dawn of the modern patent era in the United States provides another good illustration of appropriate analyses—and one with many lessons applicable to India today. In the late 1970s many observers noted that though the United States retained its global lead in scientific and technological research, it was losing its edge in manufacturing and commercialization. They identified weaknesses in the patent system as one of the causes of this seeming anomaly. Over just a few years—from 1980 to 1984—four major legislative changes and two Supreme Court rulings altered the contours of the U.S. patent system without overhauling the Patent Act of 1952. The six issues that led to these changes are instructive because five of them remain alive and controversial in India today. One inquiry considered the challenge of motivating universities to engage in the sorts of technology transfer needed to leverage their research into marketable products. The Bayh-Dole Act (1980) responded by allowing universities to patent inventions developed wholly or partly through federal research grants. A second inquiry assessed the relationship among branded drug companies, generic drug producers, and their federal regulator, the Food and Drug Administration (FDA). The Hatch- Waxman Act (1984) allowed the branded companies to extend their patents to reclaim some of the time lost to long regulatory reviews, but eased the way for generic producers to experiment and develop products that they could launch as soon as those patents expired. A third inquiry identified inconsistency among appellate courts as a significant source of uncertainty hanging over the entire patent system. The Federal Courts Improvement Act (1982) created the U.S. Court of Appeals for the Federal Circuit and gave it exclusive appellate jurisdiction over all patent rulings, whether administrative or judicial. Meanwhile, the Supreme Court considered two new classes of inventions—laboratory
synthesized microorganisms and algorithms encoded as software—and concluded that both were eligible for patent protection.

These five issues—university technology transfer programs, the balance between drug innovators and low-cost drug producers, the internal consistency and predictability of patent law, the patentability of microorganisms, and the extension of patent law to software and algorithms—all remain alive today, and all remain subjects of controversy and debate in India and around the world. The U.S. experience at addressing these issues should inform India’s debate, but not dictate its outcome. India needs to be asking similar questions. The particulars of India’s economy will help guide it to its own set of answers.

The sixth significant issue that the U.S. addressed in the early 1980s is relevant to India, at present only indirectly. At that time, the United States identified its microchip industry as a source of particular concern; it was a critical, strategic industry that appeared ill served by the standard patent regime. In response, the U.S. drafted a sui generis IPR for semiconductors. In India today, a parallel concern arises when thinking about traditional knowledge. Such knowledge plays an important role in the Indian economy, as well as in its sense of national pride. It also comprises a body of knowledge whose possessors are in desperate need of development assistance. Many Indians (and others in the developing world) have expressed an interest in developing an IPR to help convert such knowledge into a viable revenue stream—and once again, conventional patent rights seem ill suited to the task. Just as the United States invented a new IPR to protect semiconductors, India is contemplating the creation of a new IPR to protect traditional knowledge. Because TRIPS is silent on the creation of new IPRs, any system that Indian law treated it as a distinct IPR subject to its own legislation rather than as an adjunct to its patent system subject to provisions of India’s Patent Act would likely be TRIPS compliant.

Parallels aside, these illustrations show the sorts of analyses that countries should undertake when contemplating IP reform. Appropriate analyses are no guarantees of success, as both the Indian and U.S. experiences demonstrate. India’s Patent Act of 1970 led to some notable successes—particularly in the growth of India’s generic drug companies into global leaders and important players in the pharmaceutical industry. But it failed to promote widespread innovation, industrial development, and growth. The U.S. reforms of the 1980s led to successful technology transfer programs, faster releases of generic drugs, and increased consistency in patent law. At
the same time though, it did little for the semiconductor industry and unleashed an ever-growing morass of questionable software patents unlikely to have increased innovative software development. The recent amendments to India’s patent laws suggest that India undertook an appropriate analysis when drafting its new legislation, and that it learned many empirical lessons from both its own experiences and those of the United States. The remaining challenges all relate to India’s ability to leverage these analyses beyond legislation and into a fully functioning patent system.

1.4. Indian regulatory framework (Post TRIPS Era)

Patents (Amendment) Act, (1999) came into force from 01-01-1995. An ordinance was issued in 1999. This ordinance was subsequently replaced by the Patents (Amendment) Act, 1999 that was force with retrospective effect from 1st January, 1995. The 3rd amendment to the Patents Act 1970 was introduced through the Patents (Amendment) Ordinance, 2004 w.e.f. 1st January, 2005, which was later replaced by the Patents (Amendment) Act 2005 (Act 15 of 2005) on 4th April, 2005 which came in force from 1-1-2005.

Indian Regulatory Framework among other comprises of^{12}:–

- The Trade Marks Act, 1999
- The Geographical Indications of Goods (Registration and protection) Act, 1999
- The Designs Act, 2000
- The Semiconductor Integrated Circuits Layout-Design Act, 2000;
- The Protection of Plants & Varieties and Farmers Rights Act, 2001; and
- The Biological Diversity Act, 2002
- The Copyright Act (Amendment), 2012

The Trade Marks Act, 1999

The Trademark Act 1999 deals with registration and protection of trademark. It provides the right to transfer and assign the right to others as well as get penalties for infringements and apply

^{12} History of Indian Patent System- Controller General of Patents, Design & Trademarks - http://www.ipindia.nic.in/history-of-indian-patent-system.htm
for remedies that are available in case there is infringement. The 1999 Act was enacted to comply with the provisions of the TRIPS.

**Geographical Indications of Goods (Registration and Protection) Act, 1999**
The Geographical Indications of Goods (Registration and Protection) Act, 1999 is a sui generis (unique) Act of the Parliament. India, as a member of the World Trade Organization (WTO), enacted the Act to comply with the Agreement on Trade-Related Aspects of IPR.

**The Designs Act, 2000**
In order to comply with the articles 25 and 26 of TRIPS agreement, India's Design Act, 2000 was enacted for the protection of design. The act does not include any trade mark as defined of the Trade and Merchandise Marks Act, 1958 or property mark as defined in section 479 of the Indian Penal Code or any artistic work as defined in the Copyright Act, 1957.

**The Semiconductor Integrated Circuits Layout-Design Act, 2000**
With the advancement of Information Technology, a new branch in the field of intellectual property flourished, called as the Layout-Design or the semiconductor integrated circuits. The semiconductor integrated circuit is an integral part of every computer chip. The fifth generation computers are using Very Large Scale Integration (VLSI) where numerous transistors are accommodated on a single chip, cutting down the size of the chip and at the same time increasing its processing power significantly. This ultimately translates into smaller and more powerful computers. Hence, the development of the layout-design on a semiconductor integrated circuit as an intellectual property is quite significant. India being a signatory of the WTO passed an Act in conformity with the TRIPS agreement called the Semiconductor Integrated Circuits Layout-Design Act (SICLDA) passed in the year 2000. "Semiconductor Integrated circuits Layout-Design Act 2000" is a supplement act to designs. It fulfils the obligations of TRIPS agreement (Art.35 to 38) regarding the protection of semiconductor integrated circuits layout-designs.

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13 The Designs Act, 2000 - WIPO
**The Protection of Plants & Varieties and Farmers Rights Act, 2001**
The Protection of Plant Variety and Farmers Right Act, 2001 (PPVFR Act) is an Act to provide for an effective system for protection of plant varieties, the rights of farmers and plant breeders, and to encourage the development and cultivation of new varieties of plants.

**The Biological Diversity Act, 2002**
The Biological Diversity Act, 2002 is an Act of the Parliament of India for preservation of biological diversity in India, and provides system for fair sharing of benefits arising out of the use of conventional biological resources and knowledge. The Act was enacted to meet the obligations under Convention on Biological Diversity (CBD), to which India is a party.

**The Copyright (Amendment) Act, 2012**
The Copyright Act, 1957 (as amended by the Copyright Amendment Act 2012) governs the subject of copyright law in India. India is a member to international conventions governing the area of copyright law, including the Berne Convention of 1886 (as modified at Paris in 1971), the Universal Copyright Convention of 1951, the Rome Convention of 1961 and the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS).

The above thought that knowledge dissemination should be free in the Indian culture prevails from Vedic period. The traditional knowledge and expertise of the indigenous minds were used by the western counterparts. The tradition continued through Dr. Bose, who was against the thought of protecting knowledge through law. With the progress in law, as described above, from British Raj to date, intellectual property gained importance. Patent law came into existence to protect that was new and innovate. This not only helped the innovator, but the society at large to gain benefits. The activity of patenting has improved to some extent in India with advent of IP laws, but there still remains a point to study- whether to patent first or publish. Do the Indian research community still have the mindset of their forefathers to set knowledge free or is there a need to protect this knowledge and commercialize the same. With this thought in mind, the present research theme was designed to understand whether the Indian research is losing out opportunity to encash their inventions. What other issues and challenges the research community might be experiencing to convert their science into technology. All such points have been
addressed in the research work. With advent of Digital platforms Intellectual property issues and challenges need to look beyond the framework of Law. Are there any new IP management trends which facilitate technology conversion to market products and any special laws reforms related to the same. Can the research community think beyond commercial aspects and share their research outcomes for the development of human race?

1.5. Importance of research theme
In order to understand how the custom of prioritization of publication over patenting emerged and whether the issue of non-patenting still prevails, what other factors other than the belief that ‘knowledge should be free’ could be affecting the modern researcher to publish his research and not patent; there is a need to understand the issues, challenges and legal factors, if any, affecting the process of transforming science into technology. The need to understand issues of non-patenting or non-commercialization of inventions, led to the development of the present research topic. Case studies that establish a link between Indian research publications’ core idea being used for patenting by others was studied. Dr R A Mashelkar in his speech delivered at Sam Manekshaw Memorial Lecture series at Symbiosis Institute in 2010 (Annexure II) had addressed the importance and relevance of this research theme. He emphasised on the need of research in this area to find whether choice of publication over patenting is not a good idea but we are losing out on opportunity to en-cash the Indian research and generation of revenues by the research community of India. These case studies help to understand how the inventions published have been patented by others.

To start the research work, primary study was carried out with the research publications of India’s most renowned research scientist Prof. CNR Rao.

1.5.1 The case of patents referring the work of Prof. C N R Rao (Pilot case study)
Professor C.N.R. Rao is a world-renowned authority in the field of Chemistry. He is Honorary President of the JN Centre for Advanced Scientific Research at the Indian Institute of Science, Bangalore. He has published over 1000 research papers and edited or written 35 books in a career spanning over 40 years. A study of patent literature was carried out, which revealed that

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there were 14 US patents that referred to Prof. C N R Rao’s research publications. To elaborate, an example can be cited. A patent US6146602 describes an invention on "Mesoporous oxide molecular sieves for absorbing nitrogen oxides in oxidizing engine exhaust gas" The patent cites publication by Prof. C N R Rao titled "High Catalytic Efficiency of Transition Metal Complexes Encapsulated in a Cubic Mesoporous Phase". This publication reveals the specificity of the metal complexes encapsulated in mesoporous aluminium phase. This study demonstrates the high catalytic potential of transition metal complexes encapsulated in mesoporous aluminium phase in oxidation reactions. The patent US6146602 reveals catalyst comprising a mesoporous aluminium complex. The catalyst is useful to absorb nitrogen oxides from lean-burn engines when the exhaust gas is oxidizing, which may be gasoline or diesel engines. Thus the patent is based on the concept of catalyst comprising of mesoporous metal complexes in oxidation reactions. Prof. Rao has demonstrated the idea of the patent in the research publication “High Catalytic Efficiency of Transition Metal Complexes Encapsulated in a Cubic Mesoporous Phase”. It can be observed that the research publication is dated 1998 while the patent was applied on 08/02/1999, a year after the research publication. This is just an indication and one may be able to establish a connection between the content of the paper and the concept being used in the patent and the significance of the patent in terms of its industrial applicability can be further studied.

Thus, in the absence of any comprehensive or in-depth systematic research on this issue, there was a need to carry out a detailed study focusing on the research work and publications of highly cited and recognized Indian researchers by looking for citations of their publications in issued patents.

1.5.2 Rationale and significance of the study

The objective of the research detailed below is to examine whether the scientific publications of Indian scientists are used and designed around to apply new concepts for patented products and or processes. Intellectual Property Rights-related concerns did not bother Indian scientists for long. Dedicating research output to public domain for free use and follow-on research has been a standard practice. Publications facilitate dissemination of research results in the public domain.

\[^{15}\text{CNR Rao, M. Eshwaramorrthly, High catalytic efficiency of transition metal complexes encapsulated in a cubic mesoporous phase, Chemical Communications, Issue 5, (1998).}\]
and establish natural copyrights. Patents protect Intellectual Property Rights on university inventions as a conscious and concerted effort to facilitate technology transfer. 75% of all patents granted in India are to foreign citizens (2006-2007)\textsuperscript{16}. It is observed that though public funded system of higher learning has been successful in generating adequate scientifically trained manpower, it has not contributed significantly to usher in competiveness and technological learning by the Indian industry. Despite active research pursuits, industry interface has remained sub-optimum as reflected in patenting, licensing and commercialization of university research. In a sample study less than half of the faculty members have engaged in patenting activity, only a handful of university patents have been licensed. Examples of successful commercialization of these licensed innovations are hard to come.

1.6 Research methodology

In the light of above, the research methodology was developed. It clearly explains the research objectives, an appropriate methodology to attain those objectives, relevance or need of the study, research limitation, research gap and scope for further search in this field. This section further provides the details of the research methodology used for the current research work. The research methodology is a combination of various methods. The major approach of research methodology was exploratory research. Doctrinal research method was used while gathering and analysing the library-based, web-based primary and secondary data. Empirical research method was used with the tools of questionnaires sent to research community

1.6.1 Research objective

Objectives

- To analyse/study
  - The scientific publications, of highly cited Indian scientists, cited in patents
  - To demonstrate how Indian research is losing out opportunity to drive incentives by not obtaining patents
  - Identify issues and challenges that affect the transformation of science to technology
  - To suggest recommendations for policy changes to address issues and challenges related to transformation of science to technology from lab to market.

1.6.2 Research Questions:

- What is the nexus between inventions of highly cited Indian Scientists, patenting and good technology and ultimately the social and industrial development in India?
- Should patenting be prioritized over publication for inventions carried out by Indian scientists?
- What are the legal protection mechanisms and what are the reforms and approaches required to protect the inventor in the transition of science to technology?

1.6.3. Research Design

The research design used here is descriptive and exploratory due to the nature of this study which is based on qualitative data.

- The major type of research methodology is exploratory research.
- Doctrinal research method is used for library research on various literature, primary data and legal aspects including the protection and utilisation of public funded intellectual property bill, 2008 and National IPR Policy 2016.
- Empirical research method was used to gather data from the research community at two levels. At the first level, research community responses were gathered using questionnaires as the tool of data collection. The research community was identified on the basis of analysis of information on active research including lead research institutes such as IIT, NCL, and Conference at IIT- Mumbai-2012. At the second level, focus group case studies were undertaken comparing the central idea of publication of highly cited scientists and related patents.

Exploratory research methodology is selected when research is based on a theoretical idea. In such a scenario, the researcher has a belief or has observed the issue and want to gain better insights about it. An exploratory research is expected to create the groundwork for future studies. Exploratory research, as the title suggests, just focuses on exploring the research questions and has no intention to arrive at conclusive solutions to the problem.

It has been stated that "an exploratory study may not have rigorous methodology compared to conclusive studies. The sample cannot be large. But it helps to conduct the exploratory research as systematically as possible, if it is impacting decisions about the future course of study". 17

Advantages of exploratory Research\textsuperscript{18}:

- It is a valuable approach for picking up foundation data on a specific subject.
- It is flexible.
- Provides a chance to characterize new terms and enlighten existing concepts.
- It is often used to define formal hypotheses and specify more precise research problems.
- In the policy matters, exploratory studies can help to define priorities and allocation of resources.

Limitations of exploratory Research:

- The exploratory research cannot arrive at specific conclusions. It can give insight but not definitive conclusions.
- The research process is flexible and unstructured, thus can arrive at tentative results that may have limited value to policy makers.
- It lacks standards set for data collection and analysis since one of the area for exploration may decide which methodologies can address the research problem.
- Exploratory research works with very small sample and, so outcome cannot be standardise for general population.

Therefore, this method was deemed fit for this research.

1.6.3 Research plan

1.6.3a. Expert / Experience Surveys:

Expert surveys allow us to gather data from experts in the area. When researcher is less qualified and knowledgeable in the research area than the experts, then it is advisable to go for expert survey.

Experience surveys:

A questionnaire was sent to more than 100 India’s top scientist working with various research laboratories, CSIR Labs, IIT's, Universities to understand their views on the proposed research problem. Interviews were conducted with scientists to gain the insights in the topic. 125 scientists were send questionnaires as a part of experience survey. Out of them 13 scientists replied to the questionnaire. Interview was conducted using the responses received.

experience survey was helpful in defining and more importantly understanding the Indian research scenario. The experience survey confirmed the primary hypothesis and provided insights about approaching the research problem in a more systematic way. The scientists working with research labs were found more concerned about security and secrecy of research. Most of them accepted about the probability of research problem being in existence but were not willing to disclose the case studies. The major focus was found to be on publishing than patenting. The reasons cited for preferring publication over patenting are discussed in chapter 4. The survey outcome is required to give more emphasis on creating focus group case studies to validate the finding.

1.6.3b. Secondary data:
It is very rare to conduct the research on unexploited topic. All research plans can gain from reviewing similar research conducted and studying from the outcomes. It also helps in bettering the research design. Beyond reviewing existing work, social media like blog and discussion forums can add different dimension to the problem and insights about opinions and behaviours about the research topic.
Among the numerous methods of determining and assessing the interface of science and technology, citation analysis approach for achieving the purpose of this research, was used. The secondary data was obtained using various sources like Books, Research Papers, Patent Regimes and Laws (USA /Europe / India), Journals and Periodicals, Scientific Literature, Patent Search tools, Google Citations, Thomson Reuters, USPTO, European Patent sites. The Patents Citation Index (PCI - File 342), produced by Thomson Reuters (Scientific), provides access to 54.5 million patent and literature citations found in 7.8 million patent families. India's most cited scientist list was prepared using the sources like Thomson Reuters list of highly cited eminent scientists, list of world’s most influential minds, Patent citation index, Science citation index (web of science).
1.6.3c. Focus group case studies¹⁹:
A focus group consists of 10 to 12 people fulfilling the requirement of the sample group. Focused questions are being asked in the area of research. Focus groups maintain its important position and integral part of exploratory research. It provides researcher an insight about the current scenario and opinion of the experts on the research problem. For effective and flawless data collection, survey and case study methods were used in this study. Focus group case study methods are used for an in-depth investigation of a single individual, to gauge proper assessment of the same. It provides a systematic way of collecting data, analyzing information and finally reporting the findings. Hence, these methods have been extensively used to extract the most relevant information and help in better analysis of the data. As this research is based majorly on secondary sources so the survey of literature comprises a broad spectrum of books, articles, reports, working papers, narratives of experts, internet based resources and most importantly USPTO, European Patent Site, WIPO, Google Citations and Thomson Reuters to cover all possible and primarily, the dominant perspectives to examine the patent citations of Indian scientists publications and relevant patents who have cited them.

The following diagram captures various phases, tools and process of the exploratory research design used in this study:

**Fig1. Scheme of research process**

**Case Studies:**
Focus groups continue to be one of the most common uses of exploratory research, providing researchers with a great foundation on where people stand on an issue. The list of India's most cited scientists was prepared with the help of experience survey and various secondary data sources. Once the focus group was ready, their publications were cited. Granted patents related to the highly cited scientist / publication was searched on the official government patent sites. The patent results obtained were studied to understand the invention in terms of the initial idea of invention & central idea disclosed in the publication. The patent with a disclosure that appear close to the published idea were analyzed critically to understand how the patented invention was designed around/ or was obvious over the central idea of the publication.
Scope and limitation:

1. The scientific community is very large – from university research to private and public funded organisations and individual researchers (SMEs). Due to the large volume, it becomes difficult to tap each sector.

2. Highly cited Indian researchers were considered. Many others who are not highly cited but provided impetus to patent not included

3. Questionnaire sent 125 respondents, but received very few responses.

4. Focus group confined to Indian scientists working in India. Views of Indian scientists residing abroad, not taken due to non-accessibility

The next chapter is a literature review of the various aspects related to the research theme. It highlights the nexus between science and technology and unveils many related concepts. The chapter 2 discusses the importance of publications and patents as indicators of technology growth and highlights methods for evaluating science and technology interaction as well as impact. The technology transfer and licensing strategy of public funded research organization-CSIR- India have also been discussed.