Leveraging Public Funded Research for India's Economic Emergence: The Role of IPR

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Abstract

India's emergence in the world economy may be largely attributed to its sustained efforts towards technological learning, capacity building and innovation. At this juncture, India's transition to a knowledge economy could be facilitated by harnessing the rich research potential of its public funded institutions. It is in this context that we take a fresh look at India's public funded research for technological advancement focussing on IPR and related concerns. We conclude that a hurriedly implemented IPR law, as envisaged in the 'Indian Bayh-Dole Bill 2008', can hardly be expected to act as an instant magic formula to energise Indian academic research for commercial application.

Index Terms: Public Funded Research, India, Intellectual Property Rights

I. INTRODUCTION

India's emergence as a major player in the world economy over the last decade, has often, in popular discourse, been attributed (at least to a large extent) to its sustained efforts towards technological learning, capacity building and innovation.

India had missed the opportunity to join the other labour surplus Asian economies in the so-called Asian miracle of the 1970s and 1980s to experience a growth process spearheaded by massive expansion of labour intensive manufactured exports based on low labour cost advantages. Fortunately, however, the advantage conferred by low labour costs in India has been pervasive, extending well beyond the realm of traditional labour-intensive goods into new industries and services, like software and IT, biotechnology, pharmaceuticals and long-distance communication-based services, where skills and technological capability play a vital role in shaping competitive advantage. Indeed, it is quite evident from India's economic progress in the last decade or so that knowledge intensive sectors have been driving India's growth, be it IT, Biotech or Pharmaceuticals among many more skill intensive service sectors.[1]

However, as we have argued in an earlier paper [14], India's technological advantages in these skill intensive areas have still by and large remained confined to the domain of minor as opposed to major innovative capabilities. India has demonstrated significant competitive strength in routine (through skill intensive) tasks like coding (in software) or process development (in pharmaceuticals), and perhaps less so in creativity and innovativeness. At this critical juncture when India is imminently poised for a successful transition to a knowledge economy, it becomes all the more important to revitalise India's technological capability building through the most appropriate coupling of creative pursuits leveraging public funded research with applications for industrial R&D.

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[1] See [4].

Indeed, according to National Science Board (2010), governments in many developing countries now consider science and technology (S&T) as integral to economic growth and development, and they have focussed on creating knowledge intensive economies where research and intellectual pursuits along their commercial application would play a critical role. Perhaps India's transition to a knowledge driven economy would also be much easier if the "rich" research potential of its huge pool of public funded institutions could be harnessed for effective commercial application and industrial development. It is in this context that we need to take a fresh look at the public funded research for India's technological advancement. Our objective is to understand the core issues and concerns pertaining to public funded research for technological development in an emerging economy.

We begin with a brief overview of India's technology policy framework and its trajectory of technological learning and catch-up in Section II. Section III presents the broad canvas of public funded research in India. In section IV, we discuss the core debate pertaining to IPR and academic research. Section V contains an econometric analysis of the drivers of university research and patenting in India. Section VI concludes the paper.

II. INDIA'S TECHNOLOGY POLICY AND LEARNING

A. *Technology Policy Framework*[2]

India is among very few, but perhaps not unique, less developed countries (LDCs) that have pursued a well-articulated technology policy providing the broad guidelines for technological development within the country. India's technology policies included both direct policies for indigenous technological development as well as indirect policies for restricting and regulating technology imports and technology transfer. The first *Scientific Policy Resolution* was published as early as 1958 and the latest *Technology Policy Statement* appeared in 2003. Over this half a century, there has been a major shift in India's policy stance towards technology development, roughly coinciding with India's economic reforms and trade liberalisation in the 1990s. Accordingly, India's technology policy environment has been distinctly different in the pre and post-reforms period.

The basic objective of India's post independence technology policy was "the development of indigenous technology and efficient absorption and adaptation of imported technology appropriate to national priorities and resources" as summarised in the Technology Policy Statement of 1983. Attainment of technological competence and self reliance was placed at the heart of India's technological development. The aim was to achieve breakthroughs in indigenous technological development "appropriate to national priorities and resources" (i.e., maximum utilisation of human resources, efficient use of energy, increasing productivity, maintenance of ecological balance).

In fact, prior to 1990, the Indian economy operated within the broad framework of an inward looking policy regime of protection and interventions. Restrictions and regulations on trade and industrial production were pervasive. Against this backdrop

[2] This section draws heavily on my earlier paper [11].

of the overall policy framework, the main focus of India's technology policy was not only to build up *search*-, *selection*-, *implementation*- and *absorptive*- capability, but also to acquire technological capabilities of *adaptation* and *minor innovation* through reverse engineering.

Considerable resources were allocated for this purpose. Indeed, India's share of national R&D expenditure in gross national product (GNP) had increased steadily from 0.17% in 1958-59 to 0.98% in 1987-88, the major share of which was borne by the Government.[3] The overwhelming majority of government R&D expenditure was allocated to various public sector research laboratories, under the auspices of the CSIR (Council of Scientific and Industrial Research) engaged in applied research in a wide range of fields including areas like aeronautics, experimental medicine, environment, oceanography and structural engineering.

Prior to the 1990s, the main thrust of the R&D incentives was to generate indigenous technologies primarily in the institutional sector (public funded R&D institutions) and facilitate effective commercialisation, transfer and absorption of such technologies in the industrial sector. Note that, import of technologies in the form of licensing as well as foreign direct investment (FDI) was severely restricted in order to promote indigenous technology. In-house R&D was encouraged only to facilitate acquisition of technological capabilities of absorption, adaptation and assimilation. Special incentives were given to firms using indigenous technologies developed by R&D institutions.

The decade of 1990s started with the ongoing thrust of integrating the Indian economy with the global economy in the GATT-WTO framework. From 1991, with the liberalisation of the Indian economy, restrictions on imports, FDI and technology transfer have been progressively removed. The technology policy also had to be moderated, and attuned to meet the new challenges of global competition. In fact, the *Science and Technology Policy 2003* states that, *"It is recognised that these objectives* (of S&T policy 2003) *will be best realised by a dynamic and flexible Science and Technology Policy, which can readily adapt to the rapidly changing world order. This policy, reiterates India's commitment to participate as an equal and vigorous global player…."*

The decade of the 1990s saw a departure in terms of a shift of focus from national R&D institutions to R&D carried out by the industry either in in-house R&D units or in the research foundations. Industry captured the lion's share of the incentives provided in 1990s compared to the earlier decade, when the majority of the incentives were directed to public R&D institutions. Indeed, post 1991, the thrust of R&D incentives showed a clear shift away from the institutional sector to technology generation by the industrial sector. In the post reforms period, industrial productivity and technological capability in a more market driven (profit maximising) framework have perhaps been given priority over indigenisation (import substitution) of technology and self-reliance. There has also been a move to encourage collaborative R&D between industry and R&D laboratories.

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[3] Even as late as 1998-99, 75.5% of the national R&D expenditure in India was borne by the Government.

However, during the period under discussion, the government has tried to consolidate R&D efforts of both the public and the private sectors by leveraging the research potential of the public sector. The channels tried out in this regard are basically creating extensive research networks among the public funded research institutions, appropriately interfacing them with the private sector, and exploring certain models of Public-Private Partnership (PPP).

B. Technological Learning and Catch-up

To capture the contribution of technological progress to India's manufacturing GDP growth, there has several studies estimating total factor productivity growth along the lines of Solow [22].[4] Based on these estimates, we may conclude that India's experience with TFP growth post 1980 has been at best modest with periods of stagnation. In other words, technological progress (a la Solow) has perhaps not contributed significantly to India's industrial growth.

However, this does not mean that technology had little role in India's development experience. Neoclassical theory identifies technological progress with major breakthroughs in science and technology resulting in a shift of the frontier.[5] The important contribution to technical progress made in diffusion, adaptation and application of new technologies, which are particularly important in the context of LDCs, has been under-emphasized in the neoclassical tradition. The stages of technological capability acquisition can be described as a process of *path dependent evolution*.[6] It begins with *learning by doing* followed by *learning by adapting*, aiming at augmenting productivity through efficient utilisation and adaptation of technologies at the shop floor. We call this the stage of *production engineering*. Next comes *learning by design* and *learning by improved design*, aiming at replicating processes and designs for better understanding and further improvement of given technologies. This stage is described as *reverse engineering*. All this culminates into *learning by setting up complete production systems* and *learning by designing new processes* which ultimately sets the stage for *basic (frontier) R&D capabilities.*[7]

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4 [1], [2],[16].

5 See, for instance, [20], [21]. Note that Rosenberg [19] has strongly criticized the Schumpeterian usage of the term "innovation" on four grounds: "(1) We confine our thinking about innovations to characteristics which are likely to be true only of major innovations, (2) we focus disproportionately upon discontinuities and neglect continuities in the innovative process, (3) we attach excessive importance to the role of scientific knowledge and insufficient importance to engineering and other 'lower' forms of knowledge, and (4) we attach excessive significance to early stages in the process of invention and neglect the crucial later stages".

6 [7].

7 Following Lall [8], it is useful to categorise technological capability as "know-how" and "know-why". Know-how is acquired through "not only the assimilation of imported techniques (which itself can be a lengthy and active learning process) but also quality control (which also involves active technical effort), improved plant layout and production practices, slight modifications to equipment and tooling, troubleshooting, the use of different raw materials and so on", all of which can be summarised as production engineering. Such know-how oriented learning brings about rapid and immediate productivity growth in LDCs. Know-why is the next stage of technological learning, which involves the understanding of the nature of the process and product technologies leading to the development of new improved designs. This is absolutely necessary (but by no means sufficient) to create and strengthen the technological foundation of LDCs. By-passing this phase of know-why oriented technological learning, LDCs can never possibly aspire to reach the global frontiers of technology to catch up with the levels of technological advancement of developed countries in the long run. Applied

In an earlier paper [15], we examined the process of technology generation and learning in Indian industry by estimating a comprehensive research production function incorporating the role of learning, using Indian firm-level data for pharmaceutical and electronics sectors. Indeed, the two sectors have followed two distinct trajectories of technological learning, resulting in different kinds of technological capability generation.

In the electronics industry in India (characterized primarily by "screw-driver" technology), assembly operations, production engineering, shop-floor practices and quality control could prove to be the key elements of technological effort. In-depth technological learning of product designs and processes have perhaps been less important for electronics firms in India. Their technological effort lay primarily in gaining operational efficiency and productivity augmentation through shop-floor practices, day-to-day trouble shooting and customer servicing. Hence, it is *know-how* rather than *know-why* that best describes the learning trajectory of electronics industry in India.

The pharmaceutical industry in India, on the other hand, followed a rather different trajectory of technological learning based on reverse engineering.[8] This essentially implies decoding an original process for producing a bulk drug. This involves a detailed understanding of the chemical properties of the active molecule, the excipients used and the chemical process of conversion from the active molecular compound to the final bulk drug. A chemical process incorporates a complex set of parameters, e.g., solvent conditions, temperature, time, stirring methods, use of various chemical and physical substances with different levels of purity etc., all of which have to be simultaneously optimised in order to arrive at the optimum process specification. It is possible to decode all of these parametric specifications of a process through reverse engineering. Indeed, from the decade of the 1970s, the industry acquired substantial technological capability of process development through reverse engineering, both infringing processes for off-patented molecules and non-infringing processes for patented molecules. This phenomenon has been often been referred to as the ***process revolution in the Indian pharmaceutical sector***.

C. Towards a New Paradigm of Technological Development

After a successful phase of learning and catch up described above, India's technological development is now at a watershed, ready to make a steady transition to a truly knowledge driven economy and society. As argued above, an essential pre-condition for this leap forward is the creation of a sound technological foundation based on *know-why* oriented learning and innovations. India has succeeded in creating this foundation, at least in several key sectors, notably chemicals in general and pharmaceuticals in particular, and to some extent in information technology.

Let us take the example of the pharmaceutical industry to illustrate this technological challenge. The industry has played a pro-active role in the process of technological capability acquisition through conscious and concerted in-house R&D. The

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research and frontier R&D leading to major innovations is the final stage of technological capability acquisition, when the country is a poised for a paradigm shift in its technological trajectory.

[8] [12].

proficiency it has acquired in process engineering has been the outcome of several years of process R&D effort by the industry. Clearly, this was facilitated by India's abundance of high-end skills produced through its extensive network of high quality public funded institutes of higher learning and research. Scientists produced by these institutes have been absorbed by the industry, both at the shop-floor and in R&D. These high skilled scientists, employed by the industry and operating within a market driven business model, have been the flag bearers of technological learning and catch up by the Indian industry. The paradigm of technology generation in the Indian pharmaceutical sector remained confined to the principle of "business driven R&D" as opposed to the key mantra of "R&D driven business" followed by those on the frontiers of global technology.

India's policy regime of the 1970s and 1980s was largely responsible for promoting India's technological learning in pharmaceutical through process engineering. The policy environment fostered a corporate strategy of growth, based on non-infringing process development for patented molecules to introduce the *latest* drugs in the Indian market at affordable prices, thanks to the process patent regime adopted by India in 1970. This would no longer remain a viable strategy under the new international economic order introduced in the last decade, where WTO has been a prime architect in designing the norms of a global IPR regime. Of course, reverse engineering on off-patent drugs can, of course, continue to give them an edge in the generic market and some of the Indian pharmaceutical players have indeed entered the global generic market in a big way. However, there are inherent limits to the generic business. First of all, the generic market will become extremely crowded both in India and the world since all non-innovating firms will have to rely on the generic market. Secondly, the high rate of new drug discovery in the 1990s might reduce the life span of existing drugs, implying a high rate of obsolescence in the generic pharmaceutical market.

Indeed, we find that a handful of firms have already taken a step towards in the direction of R&D driven business, through new product development in the form of novel drug delivery systems (NDDS – controlled/sustained release and targeted release dosage forms). Such advanced product development capabilities (NDDS and analytical methods) paved the way for new drug discovery research (NDDR) in India. The existing skills in chemistry along with strengthening of biology expertise (molecular and structural biology, in particular) required for NDDS research and experience in handling sophisticated equipment facilitated NDDR in India. However, the nature, process and the steps of NDDR in India typically reflect the evolution of technological capability of a typical LDC with limited risk-taking, financial and research capabilities. The 'me-too-type' NDDR in India, predominantly focusing on inventing-around an existing inhibitor for a given target, are far less risky and less expensive than finding a new target itself. It has primarily been driven by *existing* skills and capabilities rather than venturing into new areas of creative and innovative research. No wonder, we are yet to see the launch of a "successful" new molecule by any Indian pharmaceutical firm.

India's transition to a new paradigm of technological development would remain an elusive goal unless without ushering in a new wave of creativity and innovativeness in India's technological effort. We argue that public funded research could perhaps play a critical role in injecting this much needed creativity into the national innovation system at this juncture. This brings us to the core theme of our paper, namely the role public funded research in India.

III. PUBLIC FUNDED RESEARCH IN INDIA[9]

Historically, some of the most important inventions that changed the world had their origins in University laboratories and in the minds of university scientists. Human race has benefited most from the discovery of drugs like saccharine (1879) and insulin (1922) discovered respectively at the Johns Hopkins University and at the University of Toronto. Some more in the endless list are penicillin, streptomycin, polio vaccine and Hepatitis B vaccine originating from the University of Oxford, Rutgers University, University of Pittsburg and the University of Pennsylvania. Similar impressive discoveries at universities in the field of medical and other technologies (Ultrasound, Pacemaker, CAT Scan and MRI), material sciences (Plexiglass and LCD), and high-end electronics have made this planet a better place to live.

It is in this context that public-funded research (in universities and institutes) is expected to play a key role in ushering in innovations for competitiveness and economic growth, and influence a country's technology trajectory. In the USA, public-funded research has always been an integral part of the national economic strategy. Many US innovations, especially in the areas of pharmaceuticals and computer systems, had their origins in federally funded research conducted at universities and laboratories. The USA, the leading global economic power of the previous century, had reached the highest standards (in both quality and quantity) of academic research, largely funded by public resources, by the decades of the 1960s and the 1970s. This had potentially enormous spillover effects on the industrial and strategic technological capability of the nation. The importance of university generated research ideas in promoting innovations for economic growth and competitiveness of industrialised economies is now well acknowledged in the literature ([6], [9]).

India's post-independence vision of home-grown science and technology was in perfect consonance with its broader policy goal of self-reliance in practically all spheres of economic activity. Although India's economic performance under this broad policy regime during the first four decades after independence is highly debated, there is little disagreement that it was only because of India's post-colonial policy thrust on higher education and S&T that it could actually take-off during the 1990s.[10]

At present, in India, we see public-funded institutions at various levels, comprising of academic institutions (universities and other institutes of higher learning) as well as public funded research laboratories and other autonomous organisations. Naturally, the network of institutions, universities and organisations that ideally represent public funded science research in India is vast and impressive.

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[9] This section draws upon our earlier paper [18].

[10] See, for, instance, [13].

In the academic sector, we notice that there is co-existence of the traditional university system (with some very good central and state universities) along with competently designed apex institutions for technical education like the IITs. Alongside broad-based technical education and research, it has always been felt that research in basic sciences is equally important for India and it is, therefore, equally important to produce scientists of the highest calibre from its own institutions. This required institutes with highly competent research faculty and excellent infrastructure. India was fortunate to have institutes like the Indian Institute of Science (IISc), Bangalore, established under private patronage of Jamshetji Tata in the early decades of the last century. After independence, IISc has been publicly funded, and recently given a privileged status by the central government. The objective is to help the institution reach the highest echelons of cutting-edge scientific research. The central government has very recently set up five Indian Institutes of Science Education and Research (IISERs) on the lines of IISc.[11]

On the other hand, the Council for Scientific and Industrial Research (the CSIR) under the Department of Scientific and Industrial Research of the Ministry of Science and Technology covers an extensive network of 40 public-funded research laboratories and 100 field stations spread across the country. These are dedicated to R&D in well-defined areas for industrial application and are solely aimed at achieving technological self-reliance and facilitating technology transfer. There are several other high-calibre autonomous S&T organisations, primarily funded by the department of science and technology and department of biotechnology, many of whom engage primarily in research in basic sciences and enjoy international repute.

Looking at the output profile of public funded research in India, we note that patenting is not very common among academic researchers in India. However, some of the S&T institutions, particularly the CSIR network, have put in place an institutional framework to encourage patenting of their research output. The number of US patents granted to CSIR jumped to 196 in 2005 from just six in 1990-91. Although, there appears to have been a spurt in patenting activity from a handful of laboratories, very few of these patents have actually been licensed to industry.

On the publication front, the scenario appears to be more encouraging. Based on core databases, DST reports that the total number of papers from public sector R&D institutions increased from 59315 in 2001 to 89297 in 2005. The distribution of the publications according to research areas show that, in 2005, physical sciences accounted for 11 per cent (9574), agricultural sciences 18.5 per cent (16526), biological sciences 14 per cent (12491), chemical sciences 26.5 per cent (23668), engineering 13 per cent (11,945), and medical sciences 14 per cent (12142). Overall, India’s contribution in world publications has increased marginally from 2.1 per cent during the 1995-2000 to 2.3 per cent during 2000-2005. With this increase, the effective contribution of Indian scientists in the international scientific community has also risen. Although India's impact factor (average number of citations per paper) is not yet at par with the world average in most scientific fields, it has made significant gains in physics, with an average of 3.13 cites per paper for the period 2003 to 2007.

[11] Information obtained online on the MHRD website

IV.PATENTING PUBLIC FUNDED RESEARCH[12]

Until recently, scientists in India, in universities and public funded research laboratories, have not shown much keenness in obtaining patents on their research outputs. There did not exist any institutional/organizational mechanism to facilitate patenting and licensing of public funded research. Only from the decade of the 1990s, a few select institutes have started putting in place such institutional structures. By and large, dedicating research outputs to the public domain through copyrighted publications has been a standard practice in public-funded research in India. However, this has often been viewed as 'lethargy' towards active participation in commercialisation of inventions on the part of the Indian academic community. This is not to suggest that Indian policy makers did not realise the importance of publicly funded scientific research and the possible role it could play in boosting industrial competitiveness. But university-industry interface has remained sub-optimal and institutional research has failed to adequately contribute to industrial catch-up in India [13].

At this juncture, there is a considerable policy debate on whether inadequate and loosely defined IPR provisions for academic research in its present form in India have indeed posed a serious bottleneck in facilitating successful commercialisation of public-funded inventions. In India, unfortunately, much of the inventions generated out of public-funded research remain unnoticed by industry, and even when noticed, not picked up by them due to heavy development costs and uncertainties. It is argued, therefore, that industry is reluctant to make this investment unless the embryonic innovations are protected by secured intellectual property rights (IPR) owned by the university with exclusive licensing provisions. Accordingly, there is now a concerted effort to put in place institutional framework for IPR on public-funded research in India. This is why a proposed legislation called The Protection and Utilisation of Publicly Funded Intellectual Property Bill 2008 has been tabled in the Indian parliament.

This bill has been designed on the lines of the U.S. Bayh-Dole Act of 1980. At present in India, public-funded research is carried out (in many cases with extramural funding from government agencies) without any express contract specifying ownership over the intellectual property generated. The forthcoming bill proposes to streamline IPR provisions in these cases by allocating patent rights to universities and research institutions (identified as 'recipients' in the bill) over inventions arising from government research grants. Disclosure norms appear to be strong given the fact that the recipients shall not be allowed to publicly disclose, publish or exhibit the public-funded intellectual property till patent applications are formally made in India or abroad.[13] If the recipient university or institute fails to do so within a stipulated period, the funding government agency will retain the rights to apply for a patent. The bill also allows exclusive licensing at the discretion of the patent holder to anyone who manufactures products using such public-funded intellectual property within India.

[12] This section also draws heavily on our earlier paper [18].
[13] http://rajyasabha.nic.in/legislative/amendbills/Science/protection_utlisation.pdf

The principal arguments favouring such an enactment in India are based on expectations of an increase in industry interest in exploring commercially applicable, public-funded research output. The increase is expected to be driven by greater clarity on who owns these patents and who to negotiate with. The exclusive licensing provision is expected to incentivise industry to come forward and invest in the development of university-generated prototypes. Enthusiasts argue that the present bill, when made into law, will lead to greater university-industry collaborations by reducing the transaction costs of IPR negotiations. It is also believed that this bill would enhance the revenue prospects of an individual university through licensing of patented inventions. One can infer from these arguments that institutional intervention in this case is meant to rejuvenate the process of technology transfer from Indian universities and research institutes to industry. However, the process may not be as simple and linear as portrayed.

There is now a large body of empirical literature on the impact of the Bayh-Dole Act on university research and technology transfer in the United States, but the conclusions are far from being unambiguous. Till date, nearly three decades after this legislation, we are still unsure about the consequences and implications of such kinds of targeted IPR legislations. Of course, there was a spurt in university patenting in the US after the Bayh Dole Act, but there has not been a commensurate rise in licensing of federally funded university patents. Moreover, there is ambiguity as to whether there has been a fall in the general 'quality' of university patents after Bayh-Dole, their rising numbers notwithstanding. Another issue that has received considerable research attention pertains to the culture and focus of a university being shaped by the financial incentives embedded in IPR. The US evidence, however, allays fears of any permanent shift in research focus of universities away from basic research, although biomedical and other applied research fields emerged in the research portfolio in a big way. The US literature also fails to confirm that financial incentives drive academic scientists in any major way. Nevertheless, studies do suggest that excessive emphasis on patenting as the only (or a major) channel of technology transfer might blinker our vision and lead us to ignore other very important channels of effective university-industry interface.

For deriving lessons for India, based on the conceptual-empirical synthesis of the U.S. evidence, we highlight some of the key issues involved. On the question of energising India's public funded research, streamlining IPR would help only if we believe that the promise of private appropriation of research results drives creativity and innovation. But is there any evidence to suggest that extrinsic motivations indeed dominate the pursuit of knowledge? According to Thursby and Thursby (2007), there may be little need for patents to provide academic scientists the appropriate incentives to invent or disclose, since the rewards associated with the norms of science itself encourage both invention and public disclosure. This is in perfect consonance with the *prima facie* impression about the mental frame of Indian academic scientists, who have never been quite concerned about patent ownership or financial incentives for their research pursuits. Hence, how far IPR legislation will help energise research in India remains a matter of debate.

Apart from incentivising public-funded research itself, the IPR legislation is also expected to incentivise industry to come forward and pick up ideas and inventions (often embryonic) arising out of public-funded research by assuring them exclusive licensing rights of these ideas with a clear patent ownership title. In fact, this, perhaps, is the primary objective of such legislations. However, as already discussed, public-funded research in India has not succeeded much in contributing adequately to the process of technological learning and catch up by Indian industry. While Indian industry is considered immature, myopic and risk averse, university research in India is allegedly too tangential to have direct commercial application. It, therefore, remains to be seen if industry would be incentivised to come forward and pick up novel ideas from university labs just because they are assured of IPR protection.

Finally, it has been also been argued that an IPR law may result in better regulation of patenting activities at universities through a judicious auditing of patent disclosure, application and licensing. In fact, the draft of the Indian bill clearly spells out its intention to guide public-funded research organisations to establish a mechanism to promote the culture of innovation and public-funded intellectual property generation. In the United States, although patenting of university research was viewed with some sort of ambivalence earlier, a major organisational change was the creation of TTOs in the wake of the U.S. Bayh-Dole Act of 1980. However, there is clear evidence to show that most of the TTOs in U.S. universities spent more on their operations than they received as income from licensing and other activities. This raises serious doubts as to whether they have indeed been able to regulate university patenting and licensing activities viably and judiciously. In India, so far, only the top tier institutes have established TTOs and, at this juncture, one cannot envisage making them self-sustaining through successful licensing of university patents. Indeed, an IPR legislation may result in establishing such TTOs indiscriminately across all public-funded institutes and become another futile public-policy exercise, resulting in filing and maintaining a large number of unutilised government patents at the cost of the public exchequer!

The US Bayh-Dole Act, by assigning clear IP rights in the hands of the universities/institutions, in a way wanted to do away with the operational hassle that existed in the form of unwarranted tensions between funding agencies and institutions over IP ownership. Such operational bottlenecks were considered the most crucial barriers to technology commercialisation in the United States. But, this is certainly not the case in India. Government funding agencies hardly stake their claims, perhaps with some exceptions in the case of funding by the Department of Biotechnology. In most cases, the CSIR retains the right to patent and license all research conducted at their laboratories. IITs, on the other hand, have both inventor as well as institution owned patens. Research in Indian academia has so far been known to promote flexibilities in research scope and modes of dissemination. Terms and conditions from government funding agencies have never been perceived as a serious problem. Hence, the basic tenet of the arguments for introducing the Bayh-Dole Act in the United States is not valid in the case of Indian public-funded research.

The mode of licensing also has implications for market competition in product development. After the World War II, only non-exclusive licensing of public-funded research was allowed in the United States to promote competition. However, faced with the competitiveness crisis of the 1970s and the large pool of unutilised government patents, it was thought that non-exclusive licensing did not provide adequate incentives to private industry to come forward and pick up university technologies for commercialisation. Therefore, the Bayh-Dole Act for the first time allowed exclusive licensing of federally funded research at the discretion of the institution. In India, licensing of public-funded research has always been a strategic decision on a case-by-case basis. Generally, the option of exclusive licensing is practiced only in areas that run high risks during development and where the transaction costs associated with the transfer of technology is fairly high. As we have mentioned, Indian institutions and universities have taken steps (and some of them for quite sometime now) to put in place organisational structures to facilitate technology transfer. These have been done following models adopted by the West, particularly the United States, as a matter of institutional policy and not because of any law. Thus, it is unclear why one needs a replication of the Bayh-Dole Act in India, explicitly accommodating possibilities of exclusive licensing, when the provision for such licensing already exists.

How could such a law help public-funded research in India *now* is a substantially nuanced question. Whether the law achieves its objectives, namely, facilitating commercialisation of public-funded research output as well as ushering in creativity in public-funded research, depends crucially on the existing research culture in India and the way both academia and industry responds to such a legal intervention. When the Bayh-Dole was introduced, the United States had already attained the highest standards of scientific research. The only aim now was to rejuvenate the process of technology transfer from public-funded research, which had slowed down during the 1970s. U.S. industry was the world leader in generating cutting-edge technologies with frontier R&D effort. Many of them have been actively interfacing with the academic world through various modes and channels, including sponsored research and consultancy agreements. Hence, they were perhaps in a position to explore university patents for commercial development once an appropriate incentive structure was put in place through legal intervention.

Perhaps this is not quite the case in India today. On the academic front, India will have to take its scientific achievements to a higher level through greater creativity and innovation. Science in India, pursued in public-funded research institutions since independence, has now received renewed focus through this impending bill. However, as already argued, whether such a law provides the right kind of incentives for science research and innovation *per se* is an open question. Apart from the state of academic research, industry in India is also perhaps not mature enough to engage in effective university-industry interface. Both have remained shy of each other for a long time.

The other two issues that should possibly be taken into perspective are – first, the existence of a large pool of unutilised government patents already in India, something very similar to the situation in the United States before the Bayh-Dole Act but with very different implications, and the second, the heterogeneity in the quality of academic research across the spectrum of public funded institutions in India.

The CSIR, which is the largest repository of government held patents in India, is a prime example of an institution with a large number of unutilised patents. To the best of our knowledge, the structure of patent ownership and the licensing clauses in this set up are very similar in spirit to that being proposed by the new Indian legislation. Indeed, the CSIR holds the right to patent all public-funded research output and license them exclusively. Hence, any bottleneck in the process of commercialisation of unutilised patents cannot be directly linked to IP ownership *per se*.

The last issue is that of the heterogeneity in the quality of academic research across the spectrum of public-funded institutions in India. Universities, institutes and laboratories, which are the pillars of public-funded research in India, do not uniformly perform in terms of the quality of research or human resource generation. Only a handful of premier institutes and universities can compare themselves with international standards. Such skewed research performance may be linked to the concentration of good minds in the top tier institutions only. Therefore, it remains to be seen how a uniform IP law can be tailored to suit every tier of the quality spectrum in India, if at all. Different constituencies are expected to respond differently to a new institutional framework triggered by a new law. It is here that one fears that a 'one size fits all' approach could prove to be counter-productive.

Ultimately, then, the expected impact of a Bayh-Dole type legal intervention in India will clearly depend on the context and environment, i.e. on the nature and culture, of public-funded research in India. This brings us to the final section of our paper, where we attempt to capture the ground realities of the academic research environment, culture and levels prevalent in India.

V. DRIVERS OF ACADEMIC RESEARCH AND PATENTING IN INDIA[14]

It has been observed that research goes hand in hand with teaching, especially in the premier academic institutions in India. In fact, faculty members are expected to perform the multiple tasks of teaching, research and research supervision, stretched to personal initiatives of industry interface and (in many cases) administrative responsibilities. It might, therefore, be rather difficult for them to define their priorities to meet diverse institutional obligations. [15] However, within a broad mandate to carry out teaching and research simultaneously, faculty in premier institutions do enjoy a certain amount of freedom in setting their own work agenda and ultimately participate in shaping the institute's organisational character.[16] Accordingly, we may reasonably expect research inputs by a faculty member to be an outcome of his/her own decision-making process, which in turn determine the research outputs produced. In fact, academic research may ideally be viewed as a research production process where research inputs (like research time and number of research scholars) are transformed into research outputs in the form of publications and patents. University faculty and researchers are the primary actors in this research production process and ultimately it is *their* behaviour, perception and performance that determine the co-ordinates of academic research.

The results show that the more experienced faculty devote greater research inputs in terms of research time and the number of research scholars. Further, full professors supervise more research scholars. Interestingly, faculty who have become full professors at a relatively early date engages more in patenting activities. Perhaps they have the dynamism of the younger generation to appreciate the need for commercial

[14] This section draws upon [17].
[15] Formal microeconomic models of multiple principals and multiple agents, following Holmstrom and Milgrom [5] for instance, may be helpful in understanding such complex matrix of incentives determining faculty decision making.
[16] [3]

application of university research as well as the professorial maturity to identify the patentable components of their research agenda. Further, they fail to find any evidence to suggest that faculty trained abroad have greater research drive than their counterparts trained in India, although the former again appears to be more active in patenting their research. Perhaps the general academic milieu in the premier institutions in India is not very different from that in the West, however, different exposures help them bring in a culture of patenting to Indian universities. Surprisingly, career considerations appear to be actually counterproductive for publications, since faculty who publish with career advancement in mind end up with a lower publication rate.

The study also explicitly addressed the question of how far sponsored research acts as a driver of academic research in India. We fail to find a satisfactory answer to this question. Faculty with a larger portfolio of sponsored research will supervise more scholars but end up devoting a lower share of time to research, perhaps due to the demands of project administration over and above pre-determined teaching obligations. Interestingly, larger portfolio of sponsored research does not ensure that faculty will publish more or be more active in patenting.

Finally, a key objective of our econometric analysis was to explore some of the less understood relationships that could explain faculty inclination towards patenting in Indian universities to derive concrete policy lessons. If indeed, the policy objective is to encourage academic researchers in India to come forward and patent their research results, it is important that we take cognisance of the drivers of patenting activity among Indian academics. *First*, we find evidence in support of our hypothesis that faculty with a doctoral degree from abroad and those with work experience in industry are more inclined to patenting. Their different exposures have helped them bring in a culture of patenting to Indian universities. It may therefore be important to encourage short and medium-term exchange programmes for faculty to get exposure abroad and in industry. *Second*, we found that the dynamism of the younger generation of faculty combined with the academic maturity at the professorial level proves to be the ideal combination for encouraging university patenting. This group should be encouraged to take the lead in creating a demonstration effect among the rest of their faculty colleagues. *Third*, given that faculty with a positive attitude towards research supervision and a larger team of research students engage more in patenting their research, research supervision must be given due credit when evaluating faculty performance. *Finally*, we did not find IIT faculty to be more inclined towards patenting than JNU faculty, the long established organisational structures for facilitating IPR management in IIT notwithstanding. This clearly suggests that putting in place institutional structures will not serve the purpose without addressing the fundamental issues of research environment, culture and attitude in the first place. In a sense, therefore, a hurriedly implemented IPR law, as envisaged in the 'Indian Bayh-Dole Bill 2008', can hardly be expected to act as an instant magic formula to energise Indian academic research for commercial application.

VI. CONCLUSION

India has successfully gone through a phase of technological learning and catch up over the past three or four decades. Having created a sound foundation of *know-why* oriented learning and innovations, India's technological development is now at a watershed, ready to make a paradigm shift towards the global frontiers of technology. We have argued how public funded research in India may be harnessed to usher in the much needed creativity and innovativeness in India's technological trajectory. Although, the contribution of public funded research has been traditionally remained sub-optimum in India, there is ample scope to energise innovations from such research for effective industrial application. This would require putting in place appropriate institutional structures and legal framework (if required) along with addressing fundamental issues pertaining to the research culture, environment and attitude both in the academia as well as in the industry. This entails a thorough understanding of the drivers of academic research so that in the enthusiasm of promoting innovations for direct industrial applications, one does not lose sight of the broader mandate and objective of public funded research to further the frontiers of knowledge. There need not be any inherent conflict between the two.

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