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PATENTING PUBLIC-FUNDED RESEARCH FOR TECHNOLOGY TRANSFER:

A Conceptual-Empirical Synthesis of US
Evidence and Lessons for India

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Contents

Foreword.....	i
Abstract.....	ii
Abbreviations	iii
I. Introduction	1
II. The Bayh-Dole Act: Genesis, Rationale and Consequences	3
<i>II.1 Run up to the Bayh-Dole Act: A Historical Perspective</i>	<i>3</i>
<i>II.2 Rationale for the Bayh-Dole Act.....</i>	<i>6</i>
<i>II.3 Consequences: Trends in Patenting and Licensing Post-Bayh-Dole.....</i>	<i>7</i>
<i>II.4 Consequences: Performance of Universities under the Bayh-Dole Act.....</i>	<i>9</i>
<i>II.4.i Disclosure, Patenting and Licensing</i>	<i>10</i>
<i>II.4.ii Quality of Patents.....</i>	<i>11</i>
<i>II.4.iii Effect on research focus and culture at the US universities</i>	<i>13</i>
<i>II.4.iv R&D expenditure and research funding</i>	<i>14</i>
<i>II.4.v The role of the TTOs.....</i>	<i>15</i>
III. University-Industry Interface & Technology Transfer From Public-Funded Research: The US Experience	17
IV. Bayh-Dole Type Legislations In Other Countries	20
V. Patenting Public-Funded Research: The Debate	24
<i>V.1 Dissemination: Publication vs. Patents.....</i>	<i>25</i>
<i>V.2 Importance of Patents as a Channel of Technology Transfer</i>	<i>26</i>
<i>V.3 Knowledge as a Public Good</i>	<i>27</i>
<i>V.4 IPR and the progress of Scientific Research.....</i>	<i>27</i>
<i>V.5 Unintended Consequences of Patenting Scientific Research.....</i>	<i>28</i>
<i>V.5.1 Financial Motivation and Focus of Research</i>	<i>28</i>
<i>V.5.2 Range of Patentable Outputs.....</i>	<i>28</i>
<i>V.5.3 Secrecy.....</i>	<i>29</i>
VI. Patenting Public-Funded Research In India – Policy Lessons from the US Bayh-Dole Experience	30
<i>VI.1 The Landscape of Public-Funded Research in India</i>	<i>30</i>
<i>VI.2 Public Funded R&D – Expenditure and Outcomes.....</i>	<i>34</i>
<i>VI.3 Streamlining IPR for Public-funded research: Lessons for India</i>	<i>36</i>
<i>VI.3.1 Why IPR Legislation for Public-funded research in India?.....</i>	<i>38</i>
<i>VI.3.2 Why a Bayh-Dole for India?</i>	<i>40</i>
<i>VI.3.3. Why at this juncture in India?</i>	<i>41</i>
VII. Concluding Remarks	43
References.....	46

List of Figure

Figure 1: Network of Public-Funded Science Research in India.....	31
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Foreword

The National Knowledge Commission of India (NKC) recommended a new legal framework along the lines of the US Bayh-Dole Act of 1980, for ownership and licensing of patents on outputs of public-funded research. It is to this effect that a proposed legislation called *The Protection and Utilisation of Publicly Funded Intellectual Property Bill 2008* has been tabled in the Indian parliament.

This paper by Prof. Amit Shovon Ray and Mr. Sabyasachi Saha is a comprehensive and critical review of the patenting and licensing experience of US universities after the Bayh-Dole Act was passed. They also highlight some of the other country evidence with regard to similar legislations. Against the backdrop of the US experience post Bayh-Dole, the paper attempts to draw concrete lessons for public-funded research in India to enrich and inform policy debate in the wake of the proposed Indian version of the Bayh-Dole bill. The authors argue that the expected impact of similar legislation in India will depend on the overall context and the nature and culture of public-funded research in India. The implications, some of which are brought out in this paper could be usefully taken into account before the Indian legislation is passed.



(Rajiv Kumar)
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January 20, 2010

Abstract

The question of protecting intellectual property rights by academic inventors was never seriously contemplated until the introduction of the Bayh-Dole Act in 1980 in the US. The Act allowed universities to retain patent rights over inventions arising out of federally-funded research and to license those patents exclusively or non-exclusively at their discretion. This particular legislation was a response to the growing concern over the fact that federally funded inventions in the US were not reaching the market place. In this paper, we present a critical review of the US experience after the Bayh-Dole Act and argue that the evidence is far from being unambiguous. We discuss the debate surrounding the Act – the extent to which it was successful in achieving its objectives, the unintended consequences, if any, and more generally, the effectiveness of IPR as a vehicle of technology transfer from universities. We also discuss the limited evidence on Bayh-Dole type legislations introduced in other countries. A new legislation, along the lines of the US Bayh-Dole Act – The Protection and Utilisation of Public Funded IP Bill, 2008 – is presently before the Indian parliament. The paper presents an Indian perspective against the backdrop of the US experience in an attempt to draw concrete lessons for India.

Keywords: *Bayh-Dole Act, public-funded research, universities, patents, India*

JEL Classification: *O31, O34, O38, I23, I28*

Abbreviations

AUTM	Association of University Technology Managers
CSIR	Council of Scientific and Industrial Research
DAE	Department of Atomic Energy
DBF	Dedicated Biotech Firm
DBT	Department of Biotechnology
DoS	Department of Space
DRDO	Defence Research and Development Organization
DSIR	Department of Scientific and Industrial Research
DST	Department of Science and Technology
HEW	United States Department of Health Education and Welfare (existed before May 1980, now called United States Department of Health and Human Services)
IACS	Indian Association for the Cultivation of Science
ICAR	Indian Council of Agricultural Research
ICMR	Indian Council of Medical Research
IISc	Indian Institute of Science
IISER	Indian Institute of Science Education and Research
IIIT	Indian Institute of Information Technology
IIT	Indian Institute of Technology
IPR	Intellectual Property Rights
ISRO	Indian Space Research Organization
IT	Information Technology
JNCASR	Jawaharlal Nehru Centre for Advanced Scientific Research
LUP	Law on University Patenting
MCIT	Ministry of Communications and Information Technology
MH&FW	Ministry of Health and Family Welfare
MHRD	Ministry of Human Resource Development
MoA	Ministry of Agriculture
MoD	Ministry of Defence
MoES	Ministry of Earth Sciences
MS&T	Ministry of Science and Technology
NII	National Institute of Immunology
NIPGR	National Institute of Plant Genome Research
NIT	National Institute of Technology
OECD	Organisation for Economic Co-operation and Development
PVA	Patent Valorisation Agency
TLO	Technology Licensing Office
TTO	Technology Transfer Organisation
UGC	University Grants Commission
UKPO	United Kingdom Patent Office
WIPO	World Intellectual Property Organisation

Patenting Public-Funded Research for Technology Transfer: A Conceptual-Empirical Synthesis of US Evidence with Lessons for India

I. Introduction

Public-funded research 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. However, traditionally, the outputs of academic research have always been placed freely in the public domain – to be picked up either by fellow and future researchers for further pursuit of knowledge or by entrepreneurs for industrial or commercial application of the received wisdom. The question of protecting private ownership of intellectual property rights by academic inventors was never seriously contemplated.

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. However, beginning from the 1970s, there was growing concern about the apparent decline in the social value of public research in the US as policy makers began to realise that innovations resulting from public-funded research were not reaching the market place (Mowery, 2005).

This pessimism prompted US lawmakers to seek institutional intervention in the form of new legislations to promote industrial application, coupled with a smooth transfer of technologies generated from publicly funded research. It was with this vision that two consecutive legislations were passed in the US in the year 1980. The first statute, *Stevenson-Wydler Technology Innovation Act* of 1980, made technology transfer an integral part of the research and development responsibilities of federal laboratories and their employees (Eisenberg 1996). The second statute was the *University and Small Business Patent Procedures Act (1980)*, commonly known as the *Bayh-Dole*

Act, which got its name from the two sponsors of the Bill – senators Birch Bayh of Indiana and Robert Dole of Kansas. The Bayh-Dole Act rationalised the patent ownership provisions for outputs of public-funded research, allowing universities and not-for-profit agencies to retain patent titles for all inventions arising out of research sponsored by federal agencies. They were also given the statutory authority to license these patents to industry on an exclusive or non-exclusive basis.

This marked the beginning of a new strand of literature in economics, often with a multidisciplinary perspective, on academic research and IPR. This paper attempts to present a critical review of this rich and focused literature. Although, the major bulk of this literature pertains to the US experience, especially the consequences and implications of the Bayh-Dole Act for public-funded research and technology transfer in the US, there is also evidence from other countries (developed as well as emerging) that have experimented with this type of legislation over the past decade and a half.

Even in India, a new bill (The Protection and Utilisation of Public Funded Intellectual Property Bill 2008), inspired by the US Bayh-Dole Act of 1980, has been introduced in Parliament to stimulate public-funded research for greater industrial application. It is often contended that even though Indian universities and research institutes have been quite active in their research pursuits, their interface with industry has remained sub-optimal. The proposed bill seeks to encourage disclosure and patenting of the results of public-funded research by universities and institutes and uphold their right to license these patents, either exclusively or non-exclusively, in order to incentivise industry to come forward and pick up inventions from government-funded institutes for commercial development. The National Knowledge Commission of India has been candid in stating that such legislation would benefit all stakeholders – the university (generating royalty revenues as incentives for research, patenting and licensing), industry (getting to know about university innovations and to invest in downstream R&D for their commercial application) and the public (enjoying the fruits of public-funded research through commercial applications).

There is now a large body of empirical literature on the impact of Bayh-Dole on university research and technology transfer in the US. The evidence is far from being unambiguous. It is in this context that we intend to present a conceptual-empirical

synthesis of this literature, especially from the US evidence after the Bayh-Dole Act, to draw policy lessons for India.

In section II, we review this US-based literature with a view to exploring the genesis, rationale and consequences of the Bayh-Dole Act. We discuss the various intended as well as unintended consequences of this legislative intervention as reported in the literature, covering a whole range of issues, including the nature and culture of research, incentives for research and disclosure-patenting-licensing. In section III, we present the US experience with university-industry interface and technology transfer from public-funded research. Following the US experience, several other countries, both OECD and emerging economies, introduced similar legislative interventions for protecting IPR on academic research. In section IV, we present a brief overview of the limited amount of literature on these, other country experiences. Section V highlights the core debate regarding patenting of academic research as reflected in the varied literature reviewed in earlier sections. In Section VI, we present a broad overview of public-funded research in India in order to derive policy lessons from the US Bayh-Dole experience. Finally, section VII highlights the some of the key conclusions.

II. The Bayh-Dole Act: Genesis, Rationale and Consequences

II.1 Run up to the Bayh-Dole Act: A Historical Perspective

The introduction of the US Bayh-Dole Act in 1980 has an interesting genesis. The US research culture, which pioneered the advancement of the global frontiers of technology during much of the last century, was seen to be developing some intrinsic mismatches. There was lack of clarity regarding patent ownership of innovations arising out of academic research, which had even partial federal funding. This distanced industry from any public-funded academic research in the majority of areas (Etzkowitz and Stevens, 1998), biomedical research, perhaps, being a notable exception (Cohen et al, 2002).

US universities have been patenting faculty inventions since as early as the 1920s, although prior to the early 1940s, few institutions had developed formal patent policies and most of them seemed ambivalent toward patenting (Mowery 2005).

Interestingly, many of the universities did not manage patenting activities themselves, mainly to avoid the political consequences of conveying the impression of profiting from faculty inventions or to avoid losing their non-profit tax status. Many universities, especially public-funded ones, engaged in patenting of faculty research through the establishment of affiliated, but legally separate, entities like a research foundation. Others engaged third party specialists like the Research Corporation – founded way back in 1912 by Frederick Cottrell – a faculty inventor at the University of California, to manage their patenting and licensing activities (Mowery and Sampat, 2004). Columbia University’s policy maintained that while patenting is the responsibility of the inventor, patent administration is best carried out by the Research Corporation, as “it is not deemed within the sphere of the university’s scholarly activities”. Similar stances were adopted by Harvard, Chicago, Yale, Johns Hopkins etc. Universities like Ohio State and Pennsylvania discouraged or prohibited medical patents.

During the early post-war period in the US, only non-exclusive licenses could be obtained to exploit the results of academic research results by industry. By engaging more than one company to practise a given invention through non-exclusive licenses, the system encouraged competition to keep prices “reasonable”. In the pre-Bayh-Dole era, patenting and licensing of university research was centrally managed by an entity called the National Technical and Information Service (NTIS), under the aegis of the Department of Commerce. This arrangement, however, had serious limitations. Although it was effective for fields such as mechanical devices, electronics and chemical processes that were characterised by short product development durations and reasonably low risks, it was completely ineffective for fields like pharmaceuticals, which have longer development timeframes.¹ Indeed, a study conducted by the federal government in 1968 found that no government-owned patent in pharmaceuticals was ever developed for commercial use.

This ambivalence towards university patenting started changing in the 1960s and the pace of change accelerated later during the 1970s in response to greater federal

¹ Moreover, this system posed procedural hurdles for seeking inventor collaboration during commercial development due to a fundamental disconnect between the inventor (at the university) and the licensing authority (at NTIS).

initiatives in R&D funding. In fact, institutional patent management agreements (IPAs), first implemented by the Department of Health, Education and Welfare (HEW) and later by the National Science Foundation (NSF), may be considered a first response towards resolving this long-standing institutional bottleneck. The IPAs allowed institutions to negotiate title rights to inventions arising out of federally funded research.

According to Etzkowitz and Stevens (1998), these agreements between individual government research funding agencies and universities contributed to the growth of university patenting during the 1970s. Many universities started creating their own technology transfer offices (TTOs). Moreover, this period also witnessed the maturing of fields like biomedical research with patentable outcomes for industrial application. This also acted as a significant factor promoting university patenting. However, according to a Senate Judiciary Committee in 1978, the government owned the title to more than 28,000 patents but licensed fewer than four per cent of them. In fact, the IPAs did not provide an adequate institutional framework for encouraging patenting and licensing of university research for commercial development.

In 1978, Purdue University's attempt to negotiate an IPA to commercialise a promising medical device technology was scuttled by HEW (Etzkowitz and Stevens, 1998). Birch Bayh, the Democrat senator took up the issue. The cause was equally patronised by the Republican senator, Robert Dole. Bayh and Dole jointly initiated the enactment of a legislation to correct these weaknesses. Meanwhile, the Department of Commerce, seriously concerned about the United States' declining international competitiveness, was earnestly looking for ways to bridge the divide between academic research and industrial R&D. Some universities like Wisconsin University and Stanford University also joined the lead with Purdue, supporting this initiative for bringing a change in the existing institutional set-up that required a complex arrangement of individual IPAs. The period coincided with academic research witnessing a number of breakthroughs in the biomedical and biotechnology fields with promises of successful commercial development by industry. It was, therefore, in 1979 that serious efforts were made to formalise the so-called Bayh-Dole Bill – “the

most inspired piece of legislation to be enacted in America over the past half century” according to *The Economist*.²

II.2 Rationale for the Bayh-Dole Act

University ownership of patent titles on inventions generated out of public-funded research under the statutory provisions of the Bayh-Dole Act 1980 was supposed to facilitate patenting and licensing of university research in the US. The passage of the Bayh-Dole Act was part of a broader shift in US policy towards a stronger intellectual property rights regime (Mowery and Sampat, 2004). This law was seen to be the much-needed instrument that would ensure the best development and application of university generated research results.

According to Eisenberg (1996), the earlier institutional framework in this regard in the US, had typically encouraged or mandated federal agencies sponsoring research to make the results widely available to the public through publications made available in the public domain or through government ownership of patent titles for non-exclusively licensing to multiple industry players. However, this same public domain was perceived by many to be a treacherous sand pit, engulfing many potential seed ideas and inventions generated in universities that might otherwise have been put to actual application. Firms, in many cases, did not even get to know about the inventions taking place at universities and, even if they did, they were not willing to pick up these inventions in their nascent stage without exclusive patent license. *The Bayh-Dole Act 1980 was intended to reverse this unfavourable trend in the US by allowing universities to own patent titles on outputs of public-funded research and license them exclusively at their discretion.*

Traditionally, patents are understood to facilitate a market for technology exchange through licensing and other agreements that permit the use of the technology (Gallini 2002). The Bayh-Dole Act of 1980 was principally meant to incentivise industry to come forward, pick up university research results and explore the possibilities of further development into marketable products. The incentive scheme was legally

² “Innovation’s Golden Goose”, *The Economist*, 12 Dec 2002.

routed through the assurance of exclusive licensing on all patented inventions generated out of public-funded research at universities. It was argued that without this assurance, firms could not afford to take the risk of committing enormous expenditures needed to develop university innovation that was often embryonic for commercial application.³In fact, it was particularly emphasised that commercialisation of university inventions was neither the function nor the responsibility of the university and, therefore, industry participation was essential (Stevens, 2004). It was argued that stronger and well-defined intellectual property rights for university research would accelerate their commercial exploitation. (Mowery et al, 2001).

It is not very clear from the literature whether policy makers were also thinking of directly incentivising university research itself through the Bayh-Dole enactment. But the rationale for the Bayh-Dole Act, in popular parlance, is often interpreted as a financial incentive to university researchers not only to stimulate quality research, but also to disclose and patent ‘profitable’ discoveries for commercial use and consider it as a new source of income (Coupe 2003). According to Mowery and Sampat (2005), the theoretical underpinnings of the Bayh-Dole legislation suggest that it is the ultimate expression of faith in the “linear model” of innovation a la Bush (1945) – if basic research results can be purchased by would-be developers, commercial innovation will be accelerated.

II.3 Consequences: Trends in Patenting and Licensing Post-Bayh-Dole

The surge in university patenting in the US in the last couple of decades has spurred research into its cause and effect. The cause may be linked to changes in the research environment resulting from the new IPR framework established by the Bayh-Dole Act 1980. The effects are evaluated in terms of commercialisation of university/laboratory generated, embryonic inventions and research tools along with unintended consequences for university research profile and culture, if any. At the outset, we present some of the findings sketching the overall trends in the profile of university patenting in the US, both before and after the Bayh-Dole Act.

³ This was highlighted by Birch Bayh in his Senate speech to introduce the Bill on 13 September 1978

There has been a phenomenal expansion of university patenting in the US over the last three decades of the last century. Comparing the rates of growth of university patents vis-à-vis total US patents (domestic and overall) between 1965 and 1988, Henderson et al (1998) observed that university patents grew more rapidly than overall US patents and much more rapidly than US domestic patents. Mowery (2005) reports that the share of university patents in total US patents with domestic assignees, increased from less than 0.5 per cent in 1970 to nearly 4 per cent by 1999, and the rate of growth of this share began to accelerate just before 1980.

This process was facilitated by new organisational structures whereby universities assumed a more prominent role in managing their patenting and licensing activities through the establishment of technology transfer offices (TTO). The number of TTOs increased from 25 in 1980 to 200 in 1990 and, by the end of 1990s, TTOs became an integral part of virtually all US universities (Nelson 2001). According to Henderson et al (1998), there has been a significant increase in the number of universities taking out patents – from 30 in 1965 to nearly 150 in 1991. However, the study reports that university patenting remained highly concentrated with the top 20 institutions accounting for 70 per cent of the total number of patents. MIT, the most prolifically patenting institution, alone commands about eight per cent of the total.

Interestingly, the surge in university patenting has been largely limited to a few specific fields. According to Henderson et al (1998), between 1965 and 1988, universities are seen to be more inclined towards patenting drug and medical technologies and less towards patenting mechanical technologies. Fields like chemical and electronic technologies were in between in this regard. The study by Mowery et al (2001) shows that biomedical patents outnumber non-biomedical patents in three of the top US universities (Columbia, Berkeley and Stanford). This dominance of biomedical patents is perhaps a reflection of the fact that this area of research carries greater commercial promise.

Along with a surge in university patenting in the US after Bayh-Dole, commercialisation of university innovations and technology transfer to industry through licensing has also gone up. According to the report of the Association of University Technology Managers (AUTM) in 1998, there was a 75 per cent increase

in licenses executed between 1991 and 1997. Although this reflects the positive attitude of universities towards appropriating returns from faculty research, it does not unequivocally establish a success story for commercialisation of university research as a result of the Bayh-Dole Act. Indeed, Thursby and Thursby (2002) show that the rise in the number of university licenses executed is definitely not commensurate with the massive increase in the number of university patents. Mowery et al (2001) reports that biomedical inventions accounted for the lion's share of revenues generated from licensing of university patents. For the three universities studied by them, this share exceeded 80 percent of revenue generated from their respective top five inventions during 1985-1995. University generated innovations require substantial "development" after licensing. Based on a survey of 62 universities, Jensen and Thursby (2001) show that over 75 per cent of the licensed inventions were at the proof of concept stage and only 12 per cent were ready for commercial use.

II.4 Consequences: Performance of Universities under the Bayh-Dole Act

The observed surge in US university patenting and licensing was not necessarily a post-Bayh-Dole phenomenon. There were two categories of universities in the US prior to the enactment of the Bayh-Dole Act. The first category included universities like the University of California, Stanford University, MIT and University of Wisconsin, which had the culture of patenting and licensing university inventions even before the Bayh-Dole Act; the other group (which included prominent universities like Harvard, Columbia and Yale) were less active in this regard. Mowery et al (2001) observe that Columbia University started to actively patent and license only after 1980.

The growth in the numbers of patents across US universities after the Bayh-Dole Act is evidence of its success in generating university research for commercialisation. However, there are other aspects that quite justifiably attracted serious research attention. We now discuss some of this literature based on a more disaggregated profile of US evidence, focusing specifically on issues of commercialisation of university research, patent quality, research culture and focus, research funding and the role of the TTOs.

II.4.i Disclosure, Patenting and Licensing

Commercialisation of university inventions arising out of public-funded research is a multi-step process. It begins with the inventor realising his invention to be patentable (in terms of novelty, inventive step and commercial application) and willingly seeking intellectual property rights protection through disclosure. The next step involves the award of patent. According to the provisions of the Bayh-Dole Act, once the patent is granted, the patent title for all inventions arising out of federally funded research would be owned by the university itself. Naturally, in the third step, the responsibility of licensing these patented inventions would now rest with the university. It is presumed that the expected revenue gains from royalty would drive the university towards licensing their patents. Thus, broadly speaking, there are three steps leading to commercialisation of university inventions – disclosure, patenting and licensing. In this sub-section, we focus on these three activities of universities to understand the possible consequences of the Bayh-Dole Act for commercialisation of university research.

Thursby and Thursby (2002) model disclosure, patenting and licensing as a three-stage production process involving multiple inputs at each stage. Faculty disclosure is modelled as a function of several inputs, both observable (including faculty size,⁴ research funds and the size of the technology transfer office) and unobservable (propensity to disclose). In the second stage, patent application is considered to be the output determined by observable inputs (like number of disclosures, TTO size and a measure of faculty quality) and an unobservable input (the propensity to patent, indicative of the commercial aggressiveness of the university administration). Finally, in the third stage, licensing is modelled as a function of observable inputs (including the number of disclosures, number of patent applications, the size of the TTO and faculty quality) and unobservable inputs (propensity to license reflecting the ability, knowledge and aggressiveness of the TTO in determining the fate of a patent).

⁴ This is represented by three separate variables capturing faculty size in biological sciences, engineering and physical sciences, keeping in mind the differences in methods and marketability of research in these areas.

Using a sample of 64 universities, Thursby and Thursby (2002) estimated total factor productivity (TFP) growth for each of the three production functions using data envelopment analysis (DEA). The estimated TFP growth rates were 12.1 per cent in the patent stage as compared to 2.7 per cent for disclosures and -1.7 per cent for licenses executed. From these estimates, Thursby and Thursby (2002) conclude that disclosures have gone up essentially due to the increase in direct inputs (like faculty size) and once we control for these inputs, the increase in disclosures due to unobservable factors like rising propensity to disclose is only marginal. However, it is patenting that has shown a phenomenal rise even after controlling for direct inputs, including number of disclosures. Finally, licensing has effectively declined once we control for the massive increase in patenting, although the number of licenses executed might have gone up in absolute terms. This perhaps reflects a decline in the commercial appeal of the rising number of disclosures and patents.

In another paper exploring the nature of inventions licensed by universities, Colyvas et al (2002) presented case studies of inventions licensed by Columbia and Stanford. The inventions covered fundamental techniques, biotechnology research tools, biological processes, medical devices and software programs. While most of the cases fell in the category of “embryonic” inventions, some of them were “ready-to-use” technologies. The paper suggests that intellectual property rights and exclusivity are likely to be most important for ensuring industrial development of “embryonic” inventions.

II.4.ii Quality of Patents

It follows from the discussions presented in the previous section that US universities had experienced a surge in patenting after 1970 with a marked upward movement after 1980. Whether this growth in patenting could have been sustained without the Bayh-Dole Act remains an inconclusive debate in the literature (Mowery et al, 2001). However, a pertinent issue that has been extensively researched and debated in this context is whether the massive rise in the number of university patents has been accompanied by any changes in the overall quality of such patents.

Patent quality is judged in terms of both its importance as well as its generality. The index of importance constructed in terms of patent citations, discounting for second generation citations, is a measure of the technological impact of an invention as reflected in the number and importance of its descendants. The second index formalises the generality of patents in terms of citations to capture the extent to which follow-up technical advances are spread across diverse technological fields, rather than being concentrated in just a few of them.

Citation-based studies of US patents, notably by Henderson et al (1998), suggest that, before the mid-1980s, university patents used to receive more citations compared to patents from other sources and university patents were more widely cited in a diverse range of fields. Regressing the measures of importance and generality on a series of dummy variables capturing application years, technological areas and patent origin (university versus non-university), Henderson et al (1998) found that university patents received almost 25 per cent more citations on an average and were 15 per cent more general (both these differences being highly significant statistically). The regression was done controlling for possible field-specific effects and time effects. This difference was seen to be the largest in electronics and mechanical patents, and smallest in the drug/medical ones. However, this difference in the patent quality for university and non-university patents seemed to narrow down after 1983. This was attributed to the decline in the relative importance and generality of university patents, since there was no evidence of rising importance and generality of non-university patents. The declining quality of university patents triggered off apprehensions about the possible accumulation of low quality university patents in the US.

However, Mowery et al (2002) show that the fall in patent quality after the Bayh Dole Act was not true for all universities. They argued that the poor performance of the entrants, as opposed to the incumbents, explains the overall decline in the quality of university patents in the US.⁵ The results from negative binomial and probit regressions suggest that the entrants' patent importance was significantly lower than that of the incumbents for the period 1981-86. However, these differentials were

⁵ These two terms are appropriately defined by Mowery et al (2002) – incumbents being those universities with at least six patents granted during 1975-80, while entrants as those having less than six patents during the same period.

statistically insignificant for the period 1987-1992. Non-biomedical patents, for which the incumbent-entrant importance differential was the most pronounced during the 1981-86 period, showed convergence during the later period. These results confirm that entrants' patents quality has improved over time, while there has been no decline in the quality of incumbents' patents.

The convergence of patent quality reflects a gradual learning process for the universities to patent their research outputs. Their experience and familiarity with the patenting process itself do matter. In the US, prior to the Bayh-Dole Act, it was the Research Corporation that was primarily engaged in managing the patenting and licensing activities of nearly 200 universities – a task which later on became the responsibility of the technology transfer offices of the respective universities. One possible explanation is that TTOs established by earlier (incumbents) were more efficient because of their links with bodies like the Research Corporation. The entrants did not have much links with the erstwhile Research Corporation and, therefore, had little by way of learning through their own patenting experience (Mowery et al, 2002). However, the entrants did enjoy the benefit of learning from the experience of successful incumbents through various direct and indirect spillover effects that might have accounted for improvements in the importance of entrant university patents during the late-1980s and the 1990s.

II.4.iii Effect on research focus and culture at the US universities

The survey of three universities conducted by Mowery et al (2001) comes up with interesting insights on the focus and culture of university research. Nelson (2001), drawing upon this survey, says that the allocation of university research effort between fundamental and applied research did not alter significantly after the Bayh-Dole Act and there has not been any shift away from fundamental research. In other words, according to Nelson (2001), university research has not become any less fundamental at these three universities after the Bayh-Dole Act. However, as far as research portfolios of US universities are concerned, there has been a definite shift towards biomedical research, and this could partly explain the rise in university patenting and licensing after Bayh-Dole. However, it is not clear if the act itself has anything to do with this shift (Mowery et al 2001).

With regard to research culture and motivation, the 11 case studies from Columbia University and Stanford University by Colyvas et al (2002) failed to find any evidence to support the hypothesis that expected financial gains shape scientists' motivation to do research. According to this study, one cannot conclusively determine if scientists were indeed directed towards less fundamental or less "deep probing" research because of the policy changes, notably the Bayh-Dole legislation. As a matter of fact, in many cases, the main objective of research was to make fundamental advances in research techniques and methods and the results of such research not only proved to be useful for other researchers in a wide range of areas and applications, they also had significant commercial appeal.

Indeed, the very fact that over 75 per cent of the licensed inventions required further interactions between the inventor and the licensee to develop commercially viable products (Jensen and Thursby 2001) was a clear indication that university research continued to be fundamental in nature, the increased licensing activity notwithstanding (Rafferty 2008). This perhaps suggests that more areas within university science could now be accessed through the market mechanism.⁶

There has been a long-standing debate on whether industrial development of university research outputs through the proprietary route (patenting and licensing) actually stimulates scientific and technological progress. Studies on the post Bayh-Dole experience seem largely inconclusive with regard to a broader debate on privatisation of scientific commons. Scientific commons, largely promoted by public-funded research, has broadened the knowledge base of modern science and created a culture of open science, encouraging competition among potential innovators (Nelson, 2004).

II.4.iv R&D expenditure and research funding

Given the fact that the Bayh-Dole Act made it easier for universities to license patents from public-funded R&D projects, it is likely that the Act actually affected the way

⁶ Nelson (2004) suggests that, post Bayh-Dole, there had been profound changes in the ways universities gave access to their research results, with dissemination taking the patent route in more areas of science than it used to. On the other hand, US court rulings allowing patents in some areas of basic research increased incentives for for-profit firms to engage in areas of basic research.

these projects were financed. Rafferty (2008) seems to be one of the few studies that use national level data on university R&D expenditure and activity (according to the character of research activity, namely, basic, applied or development) to analyse the impact of the Bayh-Dole Act. This paper considers aggregate R&D expenditure for basic research, applied research and development and models each of them as a univariate autoregressive process, checking for structural breakpoints during the period 1953-2002. The results suggest structural breaks for basic R&D in 1964, for applied R&D in 1976 and, surprisingly, no structural break for development. The Bayh-Dole enactment apparently does not seem to coincide with either of the observed breaks. Hence, there is no reason to believe that the act played any role in promoting development R&D at the cost of basic R&D. The paper also finds rising industry funding of university research right from the 1970s, pre-dating the passage of the Bayh-Dole Act. Rafferty (2008), therefore, concludes that the passage of the Bayh-Dole Act cannot be associated with any statistically significant change in university R&D activity or expenditure.

Coupe (2003) analyses the direct real effects of university R&D expenditure in terms of patents generated. An estimated Poisson regression of patent numbers indicates that academic R&D production has constant returns to scale at the university level, with some indications of increasing returns at the aggregate level. For instance, universities as a whole applied for about 20 patents per billion US dollar spent on R&D in 1972, 40 in 1985 and more than 100 in 1994. However, at the level of individual universities, such expenditure generally results in constant or even decreasing returns to scale. This conclusion has clear policy implications for optimal allocation of federal research funds among competing recipients – whether or not to concentrate resources among selected institutions or universities or to spread it thinly across.

II.4.v The role of the TTOs

The Bayh-Dole Act led to the creation of new organisational structures within the universities through the establishment of technology transfer offices (TTO). The TTOs were meant to facilitate patenting of university research and its commercialisation. The number of universities with technology transfer offices increased from 25 in 1980, to 200 in 1990 and, by the end of the century, virtually all

US universities created their TTOs. The TTOs were supposed to act as the interface between individual inventors, the university and the market for technologies. Since the TTOs were self-financing, they were presumably functionally autonomous.⁷

It has been contended that the spurt in university patenting and licensing post Bayh-Dole was essentially spearheaded by the initiatives of the TTOs. Coupe (2003), based on maximum likelihood estimations, finds that a typical university, spending the mean expenditure on R&D, will have an expected number of patents that is about 45 per cent higher if it has a TTO compared to one without a TTO. Moreover, universities that established TTOs in response to the Bayh-Dole Act are most likely to experience increased licensing activity compared to those that did not establish one. This shows that the Bayh-Dole Act could actually play its intended role through a two-step process of creating TTOs in the first place and patenting and commercialising university research thereafter.

Jensen and Thursby (2001), through a survey of technology managers of 62 US universities, concluded that technology managers viewed themselves as balancing the interests of university administrators with those of the inventors. While the former considers revenue generation to be the most important, the latter is essentially inclined towards sponsored research. For TTOs, generating royalty fees was extremely important, followed by activities leading to actual commercialisation of inventions. Facilitating sponsored research was found to be only moderately important, while the number of patents awarded seemed to be the least important. Using the Kendall's τ , Cohen's κ and McNemar's test to test for the association between the nature of responses from TTOs, university administration and faculty, it was concluded that for most of the outcomes, TTO managers' objectives were more closely aligned with that of university administrators.

⁷ "Few (13 per cent) of the TTOs reported that their office is a part of a foundation, and 20 per cent reported that the university has a foundation that provides support for the TTO. Only 15 per cent of the TTOs are corporations that are separate from their universities, and 4.8 per cent are for-profit. On average, 42 per cent of the support for the TTOs is based on a *line item* in the university budget and 43 per cent comes from royalties/license fees. Most (80 per cent) of the TTOs report directly to an academic university official (typically, the vice president for research) rather than a university business or finance official. More than 40 per cent use brokers or consultants to aid the TTO." Thursby et al (2001).

III. University-Industry Interface & Technology Transfer From Public-Funded Research: The Us Experience

The outcomes of public-funded research, spanning from knowledge and knowhow to technologies and prototypes, need to be transferred to agencies that would put in the necessary effort required to develop them further for scaling up and commercial use. Public-funded research has evidently played a significant role in generating fundamental ideas (or techniques) that have contributed to the overall technological progress in a society,⁸ while private in-house R&D has been driving specific product and process innovations that boost productivity, competitiveness, economic growth and welfare. Therefore, it is crucially important that the industry-university interface happens in a manner that ensures best utilisation of university generated research results. However, such interactions are far from being linear in spirit or singular in approach. This brings us to a discussion of the possible channels of university-industry interface, their effectiveness and the implications for university-industry technology transfer.

Industry might consider public-funded research as a breeding-ground of forward-looking ideas that they could possibly harness for further development.⁹ However, as we understand in the case of the US, such university-industry interface was not visible to the extent possible and desirable during the 1970s for various reasons – the lack of a proper IPR framework being the most frequently noted. Indeed, this slack in university-industry technology transfer is what is believed to have fuelled the legislative intervention in the form of the Bayh-Dole Act, 1980.

Santoro and Chakrabarti (2002) identify technology transfer as one of the four main forms of industry-university interaction. The other three forms are identified as research support, co-operative research and knowledge transfer. Research support refers to contributions by industry to universities in the form of research funds and equipment. Co-operative research is supposed to be more interactive than research

⁸ Indeed, the key role played by universities and public research institutes in the process of *technological* catch-up has been highlighted by Mazzoleni and Nelson (2007). Jaffe (1989) had earlier found a significant effect of university research on corporate patents in the areas of drugs and medical technology, electronics, optics and nuclear technology.

⁹ A somewhat less ambitious expectation by industry is guided by their more specific and immediate needs (both with respect to minor trouble shooting and problem solving as well as major product and process development) through leveraging public-funded research and its associated talent pool.

support and includes contract research with individual investigators, consulting by faculty, and group arrangements to address specifically immediate industry problems. Knowledge transfer broadly refers to formal and informal interactions, co-operative education, curriculum development and personnel exchanges, extending to research consortia, co-authoring of research papers by members of a university and industry and employing university graduates. Therefore, knowledge transfer may be considered to have a far-reaching and long-term impact while technology transfer serves more specific and immediate industry needs. It is under technology transfer that public-funded research provides both basic and technical knowledge along with the technology patent and/or licensing services, while the industrial community provides a clear problem statement related to market demand in a specific applied area. The other most common forms of technology transfer have been identified as technological consulting arrangements, sponsored extension services and joint ventures.

Santoro and Chakrabarti (2002), based on a firm level survey in the US, shows that larger (more mechanistic) firms use knowledge transfer and research support relationships to build competencies in non-core technological areas. By contrast, smaller firms, particularly those in high tech industrial sectors, focus more on problem solving in core technological areas through technology transfer and co-operative research relationships.

Cohen et al (2002) use data from the Carnegie Mellon Survey on industrial R&D to evaluate the influence of “public” (i.e., university and government R&D lab) research on the US manufacturing sector and explore the pathways through which that effect is exercised. They have identified the following pathways of technology transfer (or sources of university information) – patents, informal information exchange, publications and reports, public meetings and conferences, recently hired graduates, licenses, joint or co-operative ventures, contract research, consulting, and temporary personnel exchanges. The paper reveals that 41 per cent of the respondents rate publications/reports as at least moderately important; it, therefore, forms the dominant channel. Informal information exchange, public meetings or conferences, and consulting are next in importance, accounting for 31 per cent to 36 per cent of the responses. Channels like recently hired graduates, joint and co-operative ventures and

patents constitute 17 per cent to 21 per cent of the responses. Licenses and personnel exchange are found to be the least important channel with a share of less than 10 per cent. These results clearly indicate that for most industries, patents and licenses are not nearly as important as other channels of transferring public research results to industry, especially publications, conferences, informal information exchange, or consulting.

The above studies look at university-industry technology transfer from the demand side, i.e. the industry perspective. There are studies that look at the issue from the supply side, i.e. the university perspective. The new knowledge that is created through public-funded research is generally the outcome of laboratory experiments or theoretical analysis and is generally published in peer-reviewed journals and/or patented. University professors have traditionally been transferring knowledge through mentoring students' research, through conference presentations and notably through publications placed in the public domain.

Agrawal and Henderson (2002) suggest that patents only represent a small proportion of all work being conducted within academia and may not be the representative mode of what we have so far been calling technology transfer. Their study of technology transfer from MIT is focused on the departments of mechanical engineering, electrical engineering and computer sciences. Their results show that on an average, only about 10 to 20 per cent of faculty members in their sample patent their research in any given year and only three to seven per cent license their invention. However, more than 50 per cent of them publish at least one paper in any given year. In a startling revelation, they conclude that half of their sample population have never patented at all. Clearly, publishing academic papers appears to be a far more important activity than patenting. The paper has also tried to give important insights regarding the channels of university-industry technology transfer drawing upon the perceptions of faculty. The relative importance of the channels of technology transfer, as perceived by the faculty, is summarised as: publications 18 per cent, conferences 5 per cent, consulting 26 per cent, conversations 6 per cent, collaborative research 12 per cent, co-supervising 9 per cent, recruiting graduates 17 per cent and patents and licenses 7 per cent. These results suggest that a focus on patenting as a measure of the impact of university

research must be carefully qualified, given the fact that patenting seems to play a relatively small role in the transfer of knowledge.

IV. Bayh-Dole Type Legislations In Other Countries

Notwithstanding apprehensions regarding its possible unintended consequences, the Bayh-Dole Act has been credited with having pulled the United States out of the slump that it had gone through in the 1960s and the 1970s. However, it took a while for the rest of the world to get enthused by the idea. It was only in the late 1990s that this US legislation was used as a guide to formulating IPR policies in some of the other nations – with significant influence on their innovation systems.

Countries like Austria, Denmark and Norway changed their employment norms for academic staff by abolishing faculty rights on university-generated research results. Some OECD countries like Japan and Germany by now have legislations along the lines of the Bayh-Dole Act to energise the process of technology transfer from their universities. Most interestingly, the idea did appeal to the emerging economies as well. Countries like Brazil, China and South Africa already have similar legislations in place, while in India the process of enacting a similar law is underway.¹⁰ In this section, we present an overview of the experiences of selected countries with a Bayh-Dole type legislation, to further our understanding of how patenting of public-funded research may be used as an effective instrument of public policy.

Historically in Europe, patents arising out of academic research were either assigned to firms that may have funded the researchers, or were taken by the academic inventor. In any case, there never was a strong tradition of patenting and licensing of university research in Europe. Some technology transfer did occur through patents produced in universities, but these were mostly owned by companies (Bacchiocchi and Montobbio, 2009). Elaborating on the long standing European practices of technology transfer from universities, the study reports that in Germany (like in

¹⁰ But this is not to suggest that this bandwagon has been pervasive. Countries like Sweden have not abolished professor's privilege and Canada still does not have a separate legislation similar to the Bayh-Dole Act. However, there has been consistent effort in Canada towards harmonising divergent rules of IP ownership by universities, at least with respect to R&D funded by the federal government (WIPO).

Denmark, Sweden and Austria), there was the so called professor's privilege allowing university professors to retain the property rights on their research results. In the UK, France and Italy, however, universities and research centres maintained that employers retain intellectual property rights over their research. In France, some universities (in particular the CNRS) did pay serious attention to the issue of intellectual property ownership. However, Italian universities did not bother much about intellectual property rights and private companies were allowed to retain patent ownership (Balconi et al 2004).

Although similar in nature to the US policy framework, recent policy developments in some of the European countries with respect to patenting of university research are perhaps less extensive than the Bayh-Dole Act (Guena and Nesta, 2006). Prominent European nations, which initiated changes in their provisions for intellectual property ownership in the case of public-funded research, include Denmark and France (in 1999), Germany (in 2001), Norway (in 2003) and Italy (in 2005).

Germany in 2001 introduced reform of the Employee Law whereby IPRs were transferred to the university from individual inventors. This led to the establishment of patent valorisation agencies (PVAs) in Germany, mandated to manage the patenting activities of one or more German universities (OECD 2003, Mowery and Sampat 2004). In Norway, policy changes in this regard took place in 2003 though there is little by way of evidence on the consequences of these policy changes. The Italian case is very interesting. They assigned the ownership rights of university generated patents to researchers in the first place in 2001, but reversed it in 2005. At present, Italian universities are allowed to hold patents for all inventions coming from externally funded research, with certain exceptions in the case of research undertaken with sole institutional funding.

A detailed study on Denmark by Valentin and Jensen (2006), focusing on some of the consequences of such policy moves (Sweden, with no such policy changes, was taken as the control), suggests that the Danish Law on University Patenting (LUP), which came into force in January 2000, transferred the right to patent any university invention to the concerned university even if the research was undertaken through collaborations with industry. Sweden on the other hand, continued with their older

system of professor's privilege. The study attempted to assess and compare the contribution of university scientists to inventions patented by dedicated biotech firms (DBFs) specialising in drug discovery in the two countries. Denmark initiated such legal and procedural norms in the wake of growing participation of university scientists in industry-owned patents. The study confirms that, post-LUP, there has been an observable increase in the total number of patents held by universities in Denmark compared to Sweden. However, on the flipside, they find that the previous trend of academic participation in company-owned patents (here, drug discovery research) has suffered in Denmark because of the introduction of the LUP. Such an adverse effect has been attributed to the fact that a typical joint university-DBF research project does not fit well into LUP's requirement of ex-ante allocation of IPR to universities. The core hindrance for firms to engage in a joint (collaborative) exploratory work in drug research with universities was that they were not willing to invest in the transformation phase leading to an actual drug without having secured the patent rights themselves. It must also be noted that this variant of the Bayh-Dole, implemented in Denmark as the LUP, is rather strong in terms of its reach – it extends to university-industry collaborative research and not merely public-funded research.

In the UK, much of technology transfer in the public research system has been achieved without intellectual property ownership laws like the Bayh-Dole Act. It is evident from the UK Patents Act, 1977, that the ownership of intellectual property rights was clearly allocated to universities for all research undertaken within a university. Universities in the UK firmly advocated employer status over their research staff and retained the discretion to patent research outputs. This is in contrast to the pre-Bayh-Dole provisions in the US, which were unclear on who owned the rights to inventions generated out of public-funded research. Some indicative figures for the state of commercialisation of university research from the 1996 report of the Parliamentary Office of Science and Technology suggests that the total number of patents held by 34 UK universities was 510. The highest number held by any one establishment was 60. Out of the 10,000 patents granted by the UKPO per year, universities are only a small contributor. UK universities, on average, earn income from patents equivalent to between one and two per cent of their total research expenditure. The British Government came up with new policy guidelines for IP ownership in academic research, following the publication of the Baker Report in

August 1999.¹¹ The new policy reaffirmed that the ownership of IP generated by public-funded research would reside with the research provider as the body best placed for such exploitation unless compelling factors like national security, dissemination of information, aggregation of work, purchasers' own standards, regulatory responsibilities or the research provider's lack of resources came in the way (The Patent Office UK).

Apart from some of the European countries discussed so far, Japan has also introduced its version of the Bayh-Dole Act in 1999 to shift intellectual property rights from individual inventors to the organisations they worked for (<http://www.nsftokyo.org/rm04-05.html>). Collins and Wakoh (2000) explain this policy move in the light of the IPR arrangements that existed earlier and the very limited technology transfer that took place from Japanese universities to industry through patenting and licensing. In fact, they find little evidence to support any significant licensing activity on the part of Japanese universities; royalty incomes for these universities were reported to be negligible. It has been also shown that the total number of patent applications made by universities had actually declined after the late 1980s. Even in the case of industry-university research collaborations, the Japanese experience was not very encouraging prior to 1999. The earlier system of assigning intellectual property rights to the inventor implied added procedural and bureaucratic hurdles due to the involvement of intermediary organisations in the process of IPR management, like the Japan Society for Promotion of Science (an advisory body to the Education Ministry). These considerations prompted Japan to adopt the Bayh-Dole styled legislation in 1999. Alongside this legislative intervention, Japan also focused on reforming organisational structures for intellectual property management by creating technology licensing offices (TLOs) in universities to facilitate the process of commercialisation of university research.

Emerging economies like Brazil, China, and South Africa have, of late, refrained from being silent onlookers to the development trajectories of the early industrialised nations and their periodic experiments with public policy towards competitiveness. On July 5, 2004, the House of Representatives of the Brazilian Congress approved an

¹¹ "Creating Knowledge Creating Wealth – Realising the Economic Potential of Public Sector Research Establishments" Published by HM Treasury August 1999

innovation law that is meant to provide incentives to increase innovation activity and facilitate scientific and technological research. China passed its amended S&T law on December 29, 2007, which became effective from July 1, 2008. Seemingly, this law is flexible in terms of favouring patent ownership of either the scientist or the institution in the case of publicly funded research. Effectively, this law was passed to redefine the range of patentable research outputs in China. South Africa enacted its Intellectual Property Rights Bill in December 2008. The specific object of this legislation is to ensure that intellectual property resulting from publicly financed research and development should be commercialised for the benefit of all South Africans and protected from misappropriation.

Among policy makers, especially in emerging economies, Bayh-Dole type legislations are generally thought to be a *panacea* to solve all problems regarding incentivising innovation and technology transfer. Some of these countries (like Brazil or India) have been spending large amounts on public sector R&D as a matter of policy for several decades now. However, these initiatives have often failed to generate enough momentum for cutting-edge innovations from public-funded research, notwithstanding the large number of experimental and sponsored research projects in the universities and research laboratories. However, one is not sure if institutionalising IPR in academic research would indeed energise the quantity and quality of research for economic growth and progress to the extent desired.

The literature on other country experiences, not surprisingly, is somewhat limited, given that the legislative interventions in these countries have been a relatively recent phenomenon. Unlike in US literature, we fail to find much evidence-based analysis of the implications and consequences of such Bayh-Dole type legislations in these countries.

V. Patenting Public-Funded Research: The Debate

The empirical literature so far discussed contains rigorous analyses of the consequences of the Bayh-Dole Act (1980) in the US. Evidently, there is a strong lobby of policy makers and stakeholders across the world, which believes in the positive influence of such legal interventions in stimulating the process of technology

transfer from university research. However, the policy debate is not as unidirectional and linear as might appear at first glance. The key issues that form the discourse in this regard are rather broad and complex.

First, it is unclear whether the outputs of government-funded research projects are more effectively disseminated through publications (available in the public domain) than through patenting. Second, it is debatable whether patenting and exclusive licensing should assume the most important mode of university-industry interface, ignoring other important and, perhaps, more effective channels. Third, such public policy to promote exclusive licensing of public-funded research has its flip side in terms of monopoly rent-seeking on publicly funded research outputs by industry. This effectively implies double-taxation of taxpayers (Eisenberg, 1996). Finally, it is yet to be ascertained whether intellectual property rights can actually incentivise scientific research.

Moreover, there are serious concerns regarding possible, “unintended” consequences of Bayh-Dole type legislations Act. For instance, the excessive thrust on monetary incentives (beyond the traditional norms of academic rewards) might shift the focus of public-funded research away from basic to more applied (and commercially oriented) fields and thus hamper the pursuit and progress of “science” (Nelson 2004, Mowery et al 2001). Another issue arising out of the Bayh-Dole Act relates to expanding the scope of patentable research to include a wide range of output in areas of basic research and research tools. It is also argued that the culture of patenting might lead to an uneasy environment of secrecy and may impede and delay the process of information sharing. Remotely though, such tendencies come in the way of potential collaborations crucially important for large-scale scientific research.

V.1 Dissemination: Publication vs. Patents

There is a fundamental philosophical domain of intellectual debate that addresses concerns related to the privatisation of scientific commons. According to Nelson (2004), Bayh-Dole endorsed the notion that dedicating research results to the public commons discourage the use of these results. However, he strongly believes that university research is most effectively disseminated to users if they are placed in the

public domain. Indeed, exclusive (or restricted) licensing may deter widespread use at considerable economic and social cost. Nelson (2004) also points out that the current zeal of universities for patenting represents a major shift from universities' traditional support of open science. The paper highlights the potential downside of exclusive licensing of university research results. This may be particularly relevant in the case of research tools, medical remedies etc that are meant for wider application. Nevertheless, initially the argument supporting Bayh-Dole focused primarily on pharmaceuticals where patent protection continues to be justified.

Dasgupta (2000) analyses the choice between 'disclosure and publication-priority' versus 'secrecy and patents'. He argues that inventors are often faced with such choices where the urge to disclose their findings to the world at large clashes with the compulsion to restrict their spread to earn commercial rents from them. Taking into account the principal arguments behind the Bayh-Dole act, Mazzoleni (2006) tries to theoretically model R&D competition to determine conditions under which IPR and exclusive licensing induce an increase in downstream R&D and explores the implications of "open access" versus "university patenting" in terms of social welfare. He shows that under "university patenting", the equilibrium number of firms engaged in the development of embryonic inventions is clearly less than the optimal level. He argues that in the case of a transition from an "open access" to "university patenting" regime, if the aggregate R&D spending is below the socially efficient level under "open access", then university patenting decreases social welfare unambiguously. However, if a patent race takes place among firms engaged in down-stream R&D under "open access", then university patenting may either decrease or increase social welfare. Even when the "university patenting" regime brings about an increase in social welfare, it does so only at the expense of consumer surplus.

V.2 Importance of Patents as a Channel of Technology Transfer

To understand the importance of patents as a means of technology transfer from academic research, we take a look at some factual evidence provided by Agrawal and Henderson (2002). They suggest that patents represent only a small proportion of all research being conducted within academia and may not be the representative mode of technology transfer. Publishing academic papers is far more important an activity for

university faculty than patenting. Even from the perspective of the industry, as shown by Cohen et al (2002), patents and licenses are not nearly as important as other channels of transferring public research results to industry, especially publications, conferences, informal information exchange, or consulting.

V.3 Knowledge as a Public Good

Encouraging patenting of university research to the extent of enacting laws (Bayh-Dole Act) may be in direct conflict with the “public good” nature of university R&D. Government subsidised academic research is based on the premise that the benefits or knowledge derived from these scientific discoveries would remain in the public domain (Devaney 2004). Eisenberg (1996) is critical of the Bayh-Dole Act on the ground that it was actually counterintuitive to provide incentives to patent and restrict access to discoveries made through public funding in institutions that have traditionally been the principal performers of basic research. There is a possibility that this might result in shrinking the public domain of scientific research on the one hand and taxing the general taxpayer twice before they can actually enjoy the fruits of such research by purchasing the follow-on patented product from the market at the rent seeking price charged by the patent holder.

V.4 IPR and the progress of Scientific Research

Whether IPR promotes research at universities has also been highly debated. It has been argued that if the discoverer or the developer of a knowledge output can control its use, it acts as a major incentive for them to carry out research (Nelson 2004). Post Bayh-Dole, many members of the academic and scientific fraternity in the US began to think of their discoveries as private, valuable, and licensable products or processes (Slaughter and Rhodes 1996). Theoretically, one can also argue that when research is sequential and builds upon previous discoveries, stronger patents may discourage subsequent research on valuable, but potentially infringing, follow-on inventions. In debating the usefulness of patent enforcement, it is argued that stronger patent rights are both a blessing and a curse. Such provisions protect the patent holder in terms of future infringements but it also makes the same inventor vulnerable to charges of

infringement of the work of previous inventors. Thus, the link between patent strength and innovation incentives is highly ambiguous (Gallini 2002).

V.5 Unintended Consequences of Patenting Scientific Research

Apart from the issues highlighted so far, there may be several other “unintended consequences” as evident from the US experience. We discuss some of them.

V.5.1 Financial Motivation and Focus of Research

Nelson (2001) comments on the possible conflict of interest when faculty members have overlapping financial and scientific interest in certain areas of research like those related to new medical treatments. Several American research universities have established faculty committees to deal with such conflicts as and when they are reported. However, concerns that the expectation of financial gain could adversely affect the motivation for university research have been allayed by Colyvas et al (2002). Based on case studies, they concluded that financial returns do not appear to have played a significant role in motivating research among scientists.

Gallini (2002) makes an important observation regarding the possible redirection of research effort from basic research to potentially ‘lucrative’ applied research because of the Bayh-Dole Act. Mowery et al (2001) found that while there is a perceptible change in the research portfolio of US universities towards biomedical research, there is no evidence of any significant shifts away from fundamental research.

V.5.2 Range of Patentable Outputs

The objective of the Bayh-Dole Act was to facilitate utilisation of patents resulting from university research, without changing the range of output that universities patent (Sampat 2006). However, several court decisions in the US after the Bayh-Dole Act expanded the patenting provisions beyond ‘technologies’ to include elements of basic research and research tools. Thus, research output on an increasingly wider range of subject matter could be patented (Gallini 2002). Nelson (2004) argues that the potential problems associated with expanding the scope of patents into the

conventional realms of science could be alarming. Conventionally, scientific facts or principles or natural phenomena are not patentable. However, the Supreme Court judgment in the famous *Diamond vs. Chakrabarty* case (1980) upheld the US principle to define patentable subject matter to “include anything under the sun that is made by man”. The Bayh-Dole Act did not distinguish between patents on basic versus applied science, although ignoring this subtlety might have serious consequences. While patents on commercially viable inventions foster product development, patents on basic scientific discoveries may impose serious costs on entrepreneurial science that have no economic justification (Devaney, 2004).

V.5.3 Secrecy

To establish the link between the ‘culture of patenting’ and ‘secrecy’, one may argue that, typically, the financial incentives embodied in patents may discourage academics from sharing knowledge, data and other material with their peers. However, Walsh et al (2007) find that while access to knowledge inputs is largely unaffected by patents in biomedical research, access to materials used may be restricted because of scientific competition. Pineda (2006) discusses rather the far-reaching influence of the Bayh-Dole Act in affecting the mood and spontaneity of international scientific collaborations. Although international collaborations are recognised as a common scientific endeavour, economic and institutional obstacles might prevent access to both codified and tacit knowledge. The legislative initiatives in developed countries (led by US through the Bayh-Dole Act in 1980) changed the academic research environment by implementing special secrecy provisions to protect the patentability of research in progress. This has adversely affected the culture of hosting foreign research scholars. Pineda (2006) also cites cases where it is seen that such legislative frameworks have prompted developed country universities to adopt an extremely aggressive stance when negotiating collaborations with their developing country counterparts in a bid to stake claim on the intellectual property arising out of joint research.

To conclude, it is conceded that commodification of science-based intellectual knowledge through patenting will lead to greater contract-based regulations and bureaucratisation in research universities (Slaughter and Rhodes 1996). Specifically,

it has been observed that universities' efforts to enhance the commercial value of life sciences research have serious consequences that include politicisation of government research funding, disparity across universities and changes in the culture of academic research (Powell and Owen-Smith 1998).

VI. Patenting Public-Funded Research In India – Policy Lessons from the US Bayh-Dole Experience

Over the past decade and a half, India has emerged as a major player in the world economy. According to Ray (2008), if one looks at India's economic progress in the last decade or so, it is quite evident that knowledge intensive industries have been driving India's growth, be it IT, biotech or pharmaceuticals among the many skill intensive sectors. The role of technology and high-end human capital in India's economic success cannot be overemphasised, thanks to its post-colonial policy thrust on higher education (specifically scientific and technical) and public-funded S&T.

VI.1 The Landscape of Public-Funded Research in India

Science in India, as understood from the perspectives of research, technology generation and human resource generation primarily through government initiatives, posits an interesting evolutionary picture. The edifice of science in India stands on a very complex but appropriately integrated network of public-funded institutions at various levels, comprising of universities, research laboratories and various other autonomous organisations. Although these institutions are differently identified, based on pre-conceived mandates for their research focus and skill generation, they might not operationally be very different from one another. Arguably, in most cases, their activities overlap in the primary disciplines of scientific research and modes of human resource generation – divergences in the institute specific expertise, facilities and infrastructure notwithstanding. However, science research in India reflects enormous heterogeneity in terms of quality and in many cases has experienced a rather slow pace of change.

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.¹²

The network of institutions, universities and organisations that ideally represent science research in India is vast and impressive. To sketch the entire map of the S&T landscape in India and portray the broad co-ordinates of the role of different organisations in the S&T landscape of India, we use the following diagram categorising the entire network of science research in India as we find it at present.

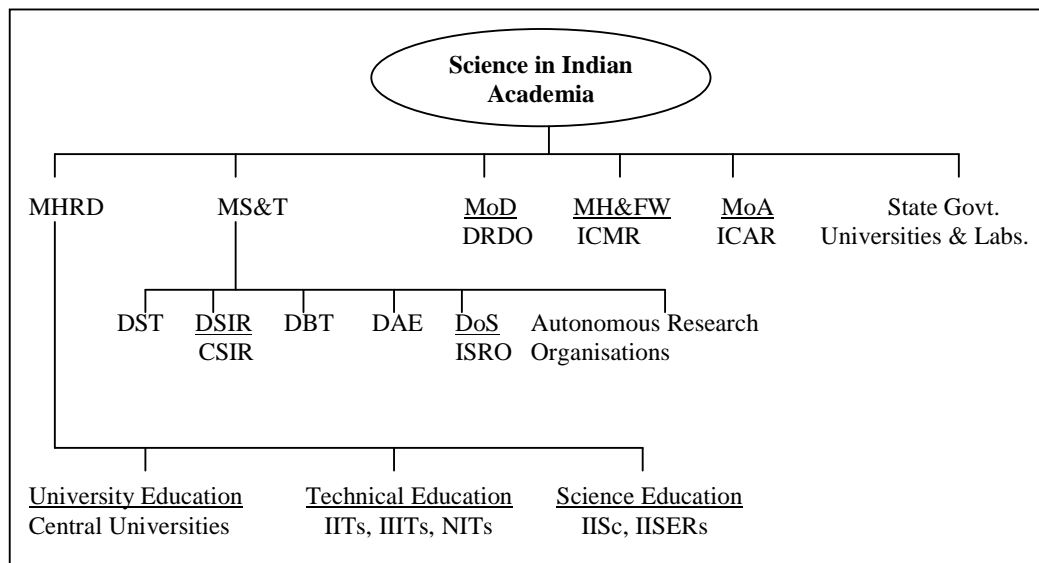


Figure 1: Network of Public-Funded Science Research in India

As the figure above shows, the canvas of India’s science research and education is very broad and complex. The task of building up a nation-wide infrastructure for higher education in science and technology rests with the department of higher education under the Ministry of Human Resource Development (MHRD). The MHRD has constituted the University Grants Commission (UGC) and several professional bodies to overlook the functioning of the otherwise autonomous universities and institutions. Universities in India are understood to perform research in various core disciplines of science and engineering along with training students up

¹² See, for, instance, Ray (2006).

to the doctoral and post-doctoral levels. The number of central universities at present is 39 and the number of state universities stands at 251. Note that at the time of independence there were just 20 universities in all in India. Of late, the UGC has also built inter-university centres at various places (like the Inter-University Accelerator Centre, New Delhi and the Inter-University Centre for Astronomy and Astrophysics, Pune) as specialised centres with highly sophisticated facilities and infrastructure for common use. Out of the 39 central universities, 12 were established only this year (2009) under the Central Universities Act, 2009.

For technical education, MHRD has set up the Indian Institutes of Technology (IITs), followed by the Indian Institutes of Information Technology (IIITs) and the National Institutes of Technology (the NITs). Today, there are seven IITs located at Bombay, Delhi, Kanpur, Kharagpur, Madras, Guwahati and Roorkee. There are proposals to open eight more. The IITs are governed by the Institutes of Technology Act, 1961 and are principally responsible for churning out high quality engineering graduates and to conduct research in relevant fields. IITs have also ventured into research and teaching in basic science disciplines like physics, chemistry and mathematics. Thus, we notice that there is co-existence of the traditional university system along with competently designed apex institutions for technical education (IITs) under the MHRD.

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.¹³

¹³ Information obtained online on the MHRD website

Having discussed the primary role played by the poster-boys of higher education in India, we come to the second group of S&T organisations, primarily under the Ministry of Science and Technology (MST), which have evolved parallel to the IITs and other institutes of higher learning. Some of them command equal prestige and recognition.

The Council for Scientific and Industrial Research (the CSIR) under the Department of Scientific and Industrial Research of the MST 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. CSIR today boasts of a diverse portfolio of research, which includes biotechnology, chemicals, aerospace etc. Many of the CSIR laboratories have designed their own doctoral programmes in various applied and multi-disciplinary areas. However, in most cases, these programmes are run closely in association with a central university for the award of the degree and evaluation.

There are several autonomous S&T organisations, primarily funded by the department of science and technology under MST. Some of them engage primarily in research in basic sciences and enjoy international repute. These include the Indian Association for the Cultivation of Sciences (IACS, established way back in 1876), Bose Institute (established by Sir Jagdish Bose), S. N. Bose National Centre for Basic Sciences (all in Kolkata), Indian Institute for Astrophysics, Raman Research Institute and Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) (all in Bangalore). All these research institutes run their doctoral programmes and consider training research students an integral part of their research mission.

The Department of Bio-technology (DBT), established in 1986, has been a relatively new addition to the existing structure within the MST. This department takes a two-pronged approach to boost modern biotechnology and biomedical research in India. It funds premier autonomous institutes dedicated to focused areas of research within the broader ambit of biotechnology. It also awards sponsored research projects as well as network projects to various institutes, research laboratories and university departments. Biotechnology research in India is today carried out in most S&T

organisations, IITs and universities. This speaks of the vigour and enthusiasm with which biotechnology is being pursued in India for industrial applications, drug development and agricultural innovations. The prominent institutes working in this field include the National Institute of Immunology (NII) and the National Institute for Plant Genome Research (NIPGR), both in Delhi.

The two other important departments under MST, namely the Department of Atomic Energy and the Department of Space, engage in strategic areas of S&T research in India. Both have been successful in carrying out cutting-edge research in their fields and have benefited from international collaborations. Apart from the MHRD and MST, the other key ministries of the central government which patronise research in related areas of science and technology include the ministries of defence, health and family welfare and agriculture. These have their own flagship organisations responsible for core research tasks – the Defence Research and Development Organisation (DRDO), the Indian Council for Medical Research (ICMR) and the Indian Council for Agricultural Research (ICAR) respectively. These bodies have an organisational structure similar to that of the Council for Scientific and Industrial Research (CSIR) and consist of a network of public sector research laboratories, each of which is devoted to a particular type of research in their respective fields.

VI.2 Public Funded R&D – Expenditure and Outcomes

Research and Development expenditure as a percentage of GNP in 2005-06 stood at 0.89 per cent.¹⁴ In 2005-06, the government incurred 74.1 per cent of total R&D expenditure with the remaining 25.9 per cent being accounted for by the private sector. Of the total government expenditure, the central government accounts for the lion's share (57.5 per cent of total R&D expenditure). The bulk (86 per cent) of central government expenditure on R&D gets distributed among the major scientific agencies listed in the previous section, namely CSIR, DRDO, DAE, DBT, DST, DOS, MOES, ICAR, ICMR, MCIT etc. DRDO gets the highest share (about 34.4 per cent). Apart from providing the core funding for its own agencies and laboratories, the

¹⁴ A quick international comparison reveals that developed countries on an average spends over two per cent of their GDP on R&D, a cut above India's spending. China spends 1.42 per cent of its GDP on R&D, again ahead of India. However, another emerging economy, Brazil, is somewhat close to India with 0.82 per cent of GDP being spent on R&D.

central government also allocates project-specific funds to the academic sector. This is known as extra-mural funding and the three departments (DST, DBT and the Ministry of Communications and Information Technology (MCIT)) together disbursed the highest extra-mural support during 2005-06.¹⁵

The pool of patents generally represents tangible R&D outcomes for S&T efforts by a particular country. It is believed that these patents hold the key to innovations and competitiveness. Out of the total number of patents granted in India in 2006-07 (7539), 74.7 per cent were in the name of foreign citizens and only 25.3 per cent were assigned to Indian citizens. Although patenting is still not very common among academic researchers in India, some of the S&T institutions, particularly the CSIR network, have put in place an institutional framework to encourage patenting of their research output. It may be noted that the number of US patents granted to CSIR jumped to 196 in 2005 from just six in 1990-91 (Kaul, 2006).

Though 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. It has to be kept in mind that public sector R&D in India did not contribute significantly to improve industrial competitiveness and encourage technological learning by Indian industry. Even though Indian universities and research institutions have been quite active in their research pursuits, their interface with industry has remained sub-optimal (Ray, 2003). It is now felt that India's transition to a knowledge-driven economy would be much easier if the available research potential of its huge pool of premier universities and institutions could be harnessed for effective commercial application and industrial development.

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

¹⁵ It may be noted that the government also spends on industrial R&D through its public sector industries. In case of industrial R&D, defence industries in the public sector accounted for 38.8 per cent of R&D expenditure followed by the fuels industry in the public sector with 24.2 per cent in 2005-06. Private sector industrial R&D expenditure was primarily concentrated in drugs and pharmaceuticals with 45.1 per cent followed by transportation with 16.7 per cent.

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.

VI.3 Streamlining IPR for Public-funded research: Lessons for India

Intellectual Property Rights (IPR) related concerns did not bother Indian scientists for a long time. Dedicating research outputs to the public domain for free use and follow-on research was a standard practice in public-funded research. However, this has often been viewed as 'lethargy' towards active participation in commercialisation of inventions on the part of 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 (Ray, 2006).

There is considerable policy debate on whether inadequate and loosely defined IPR provisions for academic research in its present form in India has 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. Indeed, the National Knowledge Commission of India (NKC) came up with a strong recommendation for a new legal framework for ownership and licensing of

intellectual property rights (patents) of the output of public-funded research. 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 US 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.¹⁶ 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.

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.

¹⁶ http://rajyasabha.nic.in/legislative/amendbills/Science/protection_utilisation.pdf

Against the backdrop of this proposed Indian legislation, we now attempt to draw concrete lessons for India from the critical review of the US experience presented earlier. The US evidence with regard to the acclaimed consequences of the Bayh-Dole Act is far from unambiguous. Moreover, the expected impact of a similar 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. Despite the absence of a clear understanding of the potential impact of such legislations, the way the Bayh-Dole legislation has been emulated in many of the developed as well as emerging economies has increased its appeal to policy makers. However, at the policy making level, at least in India, the original US Bayh-Dole Act, rather the variants adopted by other countries, remains the benchmark to be cited in support of the move to implement this law in India.

For deriving lessons for India, based on the conceptual-empirical synthesis of the US evidence, we pose three distinct sub-questions:

- a) Why IPR legislation for public-funded research in India?
- b) Why a Bayh-Dole for India?
- c) Why at this juncture?

VI.3.1 Why IPR Legislation for Public-funded research in India?

It has often been felt that public-funded research in India needs to be re-energised. One channel is through a legal framework protecting intellectual property to incentivise public-funded research. This is essentially a re-assertion of the age-old conviction of the efficacy of the IPR system in creating innovation incentives in the framework of the so-called linear approach to innovation. This approach is based on the understanding that the promise of private appropriation of research results drives creativity and innovation. Interestingly, the opposite viewpoint is equally strong and it considers knowledge as a public good (non-rivalrous and non-excludable) where market-based private incentives like IPR would lead to socially sub-optimal levels of knowledge creation. However, even from the perspective of individual scientists, there is a pertinent debate on whether their motivation for research is ‘extrinsic’ or

‘intrinsic’ in nature. If indeed scientists respond to extrinsic motivations, IPR would incentivise research.

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 US, 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 US Bayh-Dole Act of 1980. However, there is clear evidence to show that most of the TTOs in US 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!

VI.3.2 Why a Bayh-Dole for India?

The US Bayh Dole Act 1980 was perhaps the first uniform IP legislation that sought to assign IP rights to universities and institutions for all federally funded research. As discussed earlier, this was felt to be necessary at that juncture to save public-funded inventions from the clutches of the funding (and other government) agencies that held the primary stake. This unnecessarily delayed the process of technology commercialisation. These agencies were sometimes obstructive. The consequences were visible in terms of the minimal technology commercialisation that took place out of federally funded research and the US losing out on industrial competitiveness during the 1970s.

If we seek to replicate such a law in India, it becomes important to understand the preconditions that bind us to do the same thing here as well. The Bayh-Dole, 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 US. 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 patents. 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 US 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 US 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 US, 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.

VI.3.3. Why at this juncture in India?

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 US 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. US

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.

Although it is evident that university-industry technology transfer can actually happen through multiple channels, intellectual property protection in academic research has been in focus for quite sometime now, even in India. It is true that scientists in Indian universities have been patenting their research, albeit to a very limited extent, but the confusion regarding a possible conflict between publication and patenting, both in operational as well as in philosophical terms, still persists. In fact, ethical issues about IPRs in academic research connected to norms of “disinterestedness” of the academic profession have always been a common sentiment in Indian academia. This is not to suggest that such issues were fully resolved among the US academic community at the time the Bayh-Dole Act was introduced. However, perhaps the US academic world was more attuned to the idea of patenting their research and far more aware of IPR provisions, compared to what we observe among Indian academia now. Therefore, the introduction of the law at this juncture may at best be a little premature.

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 US 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. Therefore, 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.

VII. Concluding Remarks

In this paper, we have reviewed the economics literature on the implications and consequences of institutionalising intellectual property rights in academic research. In the USA, the culture of patenting in universities and institutions existed for a long time. However, it was only in the 1970s that US policy makers felt the need for a legislative intervention to promote university patenting in order to facilitate the transfer of technologies generated out of federally funded research at universities. This led to the introduction of the Bayh-Dole Act in 1980, which assigned patent ownership to universities for all publicly funded research outcomes.

Today, nearly three decades after this legislation, we are still unsure about its consequences and implications. 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 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.

Later, from the latter half of the 1990s, many OECD countries (including France, Denmark and Japan) along with several emerging economies (like Brazil, China and South Africa) have enacted Bayh-Dole type legislations to promote university-industry interface and technology transfer. However, there is little by way of concrete empirical evidence from these countries of the consequences of such legislations.

At present, India is also contemplating a similar legislation to stimulate public-funded research for greater industrial application. The landscape of public-funded research in India is vast and impressive, although diverse and heterogeneous and its contribution to society has remained far below its potential. It is expected that public-funded research in India will be energised for more effective technology transfer through streamlining the IPR provisions. It is in this context that the proposed Indian legislation is discussed against the backdrop of the conceptual empirical synthesis of US literature on Bayh-Dole to draw lessons for India. We argue that an IPR law will perhaps not act as a magic formula to achieve the intended goals of rejuvenating India’s public-funded research and encourage greater industry applications.

Of course, we have seen how universities in the West have assumed new roles in the innovation process by codifying knowledge through patenting and licensing of their research, by actively supporting the creation and development of spin-offs and by engaging in contract research and joint ventures. They tried out various operational business models to encourage university scientists to become entrepreneurs with equity share holding in spin-offs. This worked very well in some cases – the Silicon Valley around Stanford University and the Route 128 around MIT are two prominently successful examples of this attempt. However, if we try to replicate these models in Indian universities simply by institutionalising IPRs for academic research, ignoring the realities of the differences in context, environment, culture and levels of scientific achievements, we may end up putting the cart before the horse!

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