Commercializing technologies from universities and research institutes in India: some insights from the US experience

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Translating research done in universities and research institutes to products and services in the market takes considerable and sustained effort. Dedicated technology transfer offices (TTOs) and supporting systems are required to achieve this. Starting from attracting the right people, devising flexible models to work with various commercial partners (like large and small companies, start-ups), bringing in external funding to further the technology goals, TTOs can perform a crucial role in commercializing academic technologies. Various strategies followed by TTOs in the US universities are analysed and suggestions to improve the technology transfer process in the Indian context are presented.

Keywords: Commercializing technologies, research institutes, technology transfer offices, universities.

WHAT do nicotine patches, modern magnetic resonance imaging machines and the human growth hormone have in common? All these products have their roots in the technologies developed in university campuses in the US[1]. Hundreds of other technologies that were developed in universities around the world have been successfully commercialized and are currently being used as products and services in everyday life. One important link in translating the work done in the labs to the market is an efficient technology transfer process. Dedicated technology transfer offices (TTO) have been set up by universities and research institutes world-over and these have efficiently transferred and commercialized technologies developed in the labs. In India, there is a need for improving/strengthening systems and models to commercialize technology developed in research institutes and universities. This need is particularly relevant in the case of academic institutions compared to industrial organizations. In industry, the research efforts are mostly driven by market needs and the commercial arms that could take the technology to the market are co-located or work closely with the R&D units. In the industrial sector, there are built-in mechanisms to achieve this goal.

A quick look at the current R&D expenditure patterns in India will make it clear that most of the R&D spending happens outside the industry. The data published by DST show that in 2005–06, in India, the industrial sector (which includes both public and private sector organizations) contributed about 30% of the total R&D expenditure[2]. The government, through various ministries, agencies and research institutions accounted for the rest of the expenditure. In this scenario, where 70% of India's R&D budget is deployed through research institutions and universities, it becomes imperative that systems are put in place that will efficiently translate the technologies developed in these labs/universities to the market.

Commercialization of technologies developed in research institutes is not new to India. Organizations like CSIR, IITs, IISc, etc. have been supporting the industry by providing the technology, people and research support for decades and have been extremely successful in many cases[3]. Also, a great deal of knowledge transfer from the academia to the industry in India has happened via scientists who undertake industrial-sponsored and consulting projects. Most of the traditional commercialization efforts have been licensing deals done with commercialization partners for a fee or royalty (or a combination of upfront fee and royalty). Not all technologies being developed in these labs are suited for this model of commercialization. Some technologies need a certain level of 'de-risking' to be done, proof-of-concept demonstrated, prototype built and tested before an existing company will show interest. This 'de-risking' of the technology might take 2–3 years or more and will involve serious financial commitments. Not many companies will patiently invest in such efforts and wait for results. Many will want a shorter timeline for commercialization. In such cases, there is a need for alternate models that provide the flexibility to de-risk the technology and take it to the market. There have been recent efforts across research institutions in India to implement such alternate models of commercialization[4].

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The US universities have been particularly successful at commercializing technology created in their labs. Most of these universities and research organizations have dedicated TTOs that work towards commercializing technology. How these TTOs came into existence and started functioning is discussed in the next section. This article looks at some of the strategies these TTOs in the US universities adopt, and how we, in India, can borrow some of the strategies to commercialize technologies from Indian research organizations. Other studies have given a bird's-eye view of how technology transfer should be structured, executed, etc.[5]. This article draws insights from the data from the US universities, combines them with the experience drawn from day-to-day technology commercialization efforts and gives a practitioner's point of view and suggestions for the Indian context.

The Bayh Dole Act and technology transfer at the university

Prior to the Bayh Dole Act (which was passed in the US Congress in December 1980), the ownership of the intellectual property (IP) resulting from the research funded by the US federal government, rested with the federal government. Since, as in most countries, majority of the research funding for the US universities came from the federal government (which remains the case even today), ownership of all the resulting IP rested with the US government. At some point, it was realized that this was not the most effective way of creating value out of the technology developed in academic labs. The federal government did not give exclusive licenses to any IP – hence private investors and companies were wary of licensing and commercializing the technology as their competitors could also access the same technology if desired[6]. Also, there were issues with this centrally managed system where the policies were neither clear nor uniform[6]. By passing the Bayh Dole Act in 1980, the universities and NGOs, which received federal funding for research, were allowed to retain the ownership of the IP resulting out of these projects. Thus, the onus of exploiting this IP and the technologies was transferred to the universities and research organizations. The universities, having been given this new responsibility, started creating new divisions with teams of people who had a background in science and technology as well as experience in law, business, industry, finance, etc. These teams were chartered with the responsibility to manage the IP/technology output of universities, file for patents, maintain them, issue licenses, work with industry partners, and create the systems and best practices for commercialization. This gave birth to the relatively new profession (about 30 years old) of university technology transfer[7]. Nelson[8], and Loise and Stevens[9] capture the basis of the Bayh Dole Act and its impact on technology transfer in universities in their excellent articles.

The TTOs in the US universities have deployed various strategies for technology commercialization. They, along with other partners (from within and outside the university) put in place several flexible systems that could be used in taking technologies developed to the market. The following sections discuss some of the outcomes of such efforts and point to some of the strategies that can be adapted.

Research expenditure, technology output, licensing – current trends in the US universities

Table 1 gives the data collected from the US universities and research institutes between 2000 and 2009 by Association of University Technology Managers (AUTM). Each year, between 170 and 190 US universities/research institutions report data to the AUTM and the aggregated data for each year are presented in Table 1. As can be seen, the aggregate research expenditure has steadily increased over the years from US$ 27.7 billion in 2000 to US$ 53.6 billion in 2009. (The research expenditure data include federal, state government funding and industry funding[10].)

If we just consider the year 2009 for this discussion, the total research expenditure of US$ 53.6 billion resulted in 20,184 invention disclosures and close to 12,000 new patent applications filed. Invention disclosures are done when the scientists report their new invention to the TTO – at which stage the TTO staff discuss the invention with the scientist team and do a preliminary assessment on the patentability of the invention (novelty, non-obviousness, utility), and a quick analysis of the commercial potential of the invention. If the TTO is convinced that the invention scores on both patentability and commercial aspects, it may go ahead with filing a provisional or a full patent application. Inventions, which are weak on either or both aspects, get dropped and are not patented. Roughly 50–60% of invention disclosures are converted to patents[11].

If we consider invention disclosures as a proxy for new technology ideas resulting from the research dollars spent – it takes about US$ 2.7 million in research funding to yield one invention disclosure. Obviously, not all research spending was directed towards solving market issues and developing new technologies. A part of it was directed to fund blue-sky research projects where generation of IP was not a target or a priority. One needs to factor in such issues when interpreting the data. There are data to show that the event of Bayh Dole Act and commercialization efforts by TTOs have not affected the level of basic/blue-sky research that is conducted at universities[12] – which indicates that the ratio of the basic research to technology-focused work has remained stable.

Table 1. US universities and research institutions: aggregate data on annual research expenditure, intellectual property output, licensing deals, income earned and startups created

Year	Research expenditure (US$, million)	Invention disclosures	Patent applications– newly filed	Licenses issued*	Options issued#	Start-ups initiated	License income (US $, millions)	Research expenditure for each invention disclosure (US$, million)	License income as a percentage of research expenditure	Research expenditure for creating a startup (US$, million)
2009	53,560	20,184	11,961	4,347	951	593	2,313	2.7	4.3	90
2008	51,205	20,020	12,153	4,125	986	595	3,437	2.6	6.7	86
2007	48,603	19,740	11,749	4,323	751	551	2,703	2.5	5.6	88
2006	45,062	18,792	11,583	4,176	748	551	2,163	2.4	4.8	82
2005	42,052	17,315	10,236	4,140	749	450	2,128	2.4	5.1	93
2004	40,983	16,817	10,486			458	1,472	2.4	3.6	89
2003	38,381	15,463	7,899			373	1,418	2.5	3.7	103
2002	34,859	14,358	7,316			401	1,304	2.4	3.7	87
2001	29,838	12,612	6,367			426	1,112	2.4	3.7	70
2000	27,750	11,933	6,049			386	1,275	2.3	4.6	72

The table provides data for the 10-year period from 2000 to 2009. Each year, data from 170 to 190 universities/institutions, which chose to report data are given above.
Source: STATT database, Association of University Technology Managers (AUTM), accessed during May 2011.
*,#Licensing and options data are available in the STATT database from the year 2005 onwards.

(Another issue to be remembered while analysing these data: in reality, there is a lag of few years between when the research dollars are spent and the inventions disclosed, licenses granted for those technologies, and income generated from those licenses. The analysis presented here assumes a steady state of research spending, invention disclosures, licensing, etc. – which is quite reasonable, as is clear from the trend for the preceding years as given in Table 1.)

In 2009, 4,347 licenses and 951 options were issued and 593 startups were created to commercialize university technologies. Licenses issued earned the universities over US$ 2.3 billion – which is about 4.3% of total research expenditure for the year. It is clear that even though the technology transfer offices were creating value for the universities and scientists, the income generated through licensing can never completely fund the research activities of universities. But, this income often comes with no strings attached and hence can be used by the university for special initiatives or cutting-edge research for which funding is hard to come by[13]. TTOs have an important role to play in the university set-up – but they cannot be expected to play the role of cash cows that will fund the entire future research expenditure of any organization. The full value created by commercializing university technologies is not entirely captured in the licensing income earned by universities/TTOs. There are various other benefits to the society at large – which is presented in great detail by Heher[11] in his analysis. Typically, the royalty rates, which form a big part of the licensing revenue, are between 2% and 4% of sales. This indicates that using a technology licensed from the university, 25–50 times the value of the licensing revenue is created in the market. Another way of looking at the value created could be to see the market capitalization of the companies created around university technologies. For example, the combined market value of companies like SUN Microsystems, CISCO systems, Silicon Graphics, Genzyme, etc. would be in the tens of billions of US dollars.

If we look at the startups created, it is shown that the order of US$ 53 billion in research spending was required to seed 593 startups in 2009 (or about US$ 90 million research expenditure for every startup created) – which goes to demonstrate the difficulty of commercializing research by creating a startup. One can either interpret this as the level of research intensity required to create a platform technology that could form the basis of a startup, or one can draw the lesson that the creation of startups to commercialize technology is per se a difficult task. Even with a system as entrenched as in the US, with an ecosystem supporting startup formation, only 593 startups were created with over US$ 53 billion in research funding (not counting the other funding sources like personal funds, family, friends, private investors put in these startups). Both these interpretations are true. Creating platform technologies that can justify a dedicated startup venture is expensive. Also, even with a very supportive eco-system, it is difficult to create a technology-based startup due to the various constraints of identifying a clear market opportunity, finding the right people to drive it, finding the investors to fund it, etc.

Top license earners: how they skew the picture

So far, we have looked at the aggregate picture for all universities. Table 2 presents a break-up of how the top performing/licensing universities and the others stack up.

Table 2. Comparison of the top 6% license earning universities and the rest of the universities

	Research expenditure (US$, million)	Invention disclosures	Startups initiated	License income (US$, millions)	Research expenditure for each disclosure (US$, million)	License income as a percentage of research expenditure	Research expenditure for creating a startup (US$, million)
Average per year of the top 6% license earning universities (averaged over 10 years between 2000 and 2009)	7,054 (17%)	3,023 (18%)	81 (17%)	1,164 (60%)	2.3	16.5	87
Average per year of the bottom 94% license earning universities (averaged over 10 years between 2000 and 2009)	34,175 (83%)	13,700 (82%)	397 (83%)	769 (40%)	2.5	2.2	86
Average per year of all universities (averaged over 10 years between 2000 and 2009)	41,229 (100%)	16,723 (100%)	478 (100%)	1,933 (100%)	2.5	4.7	86

Source: STATT database, AUTM, accessed during May 2011.

Data for the top 6% and bottom 94% license earning universities are presented in Table 2. For this analysis, the top 6% (i.e. top 10 universities; total sample size each year varied between 170 and 190) license income earning universities each year were selected. The average per year for a 10-year period 2000–2009 was calculated and has been presented.

Table 2 clearly shows that the top license earning universities contribute a lion's share of the overall licensing income generated by universities. In a given year, the top 6% license earners spent about 17% of the total research expenditure, generated about 18% of the invention disclosures and created 18% of the university-linked startups. But the narrative gets more dramatic when one looks at their share of the licensing income – the top 6% universities generated about 60% of the total reported licensing income in a given year. This shows how skewed the licensing landscape in the US is. Note that there is no significant difference between the research dollars spent per invention disclosure (US$ 2.3 million per disclosure for the top 6%; US$ 2.5 million for the bottom 94%) – which means that the invention disclosures and the technologies resulting from the top 6% licensing universities are of high quality and have a very high impact. This, combined with the fact that these universities have excellent TTOs to facilitate the commercialization process, enable their performance level. The top performers have a number of licenses that earn them millions of dollars in royalties and fees, which also add to their licensing success. Even for the top earners, the licensing incomes they generate make up only 16.5% of their total research expenditure – which means that even the top earners cannot afford to completely fund their research from the income generated by commercializing their technology. The picture is even starker for the rest of the universities – as can been seen from Table 2, the licensing income that the bottom 94% earn is only 2.2.% of the total research expenditure of these universities. This clearly shows that academic research, world over, will largely remain dependent on government funding. Income from licenses can provide a buffer against fluctuations in research funding and provide additional funding for specific activities, but it can never fully fund academic research to the extent that it is currently done.

Use of technology options by TTOs

Before the research done at university labs can reach the market, there is considerable de-risking to be done: demonstrating proof-of-concept for the technology idea, prototyping, appropriate testing and trials, etc. This will involve committing resources and time to test this idea. It will probably take a couple of years before the feasibility of taking this idea into the market becomes apparent – it is at this stage, when the technology idea has been tested and de-risked to some extent, that the commercial partner will be interested in licensing the technology. But, many university technologies are pre-mature for licensing. It has been reported that only 12% of the university technologies are 'ready for practical use'[14]. So, most university technologies need significant de-risking before commercialization – it would be difficult for a commercial partner to license out a premature technology and make a serious financial commitment at that stage. In such cases, where premature technology is involved, it would be beneficial if there is a tool available for the commercial partner to defer the licensing decision, but still work with the university in de-risking the technology.

Table 3. Use of technology options by technology transfer offices (TTOs): comparison between TTOs that use options and those that do not

	Research expenditure (US$, million)	Number of options issued in a year	Licensing income (US$, millions)	Licensing income as a percentage of expenditure
Average per year per TTO for technology option users (TTOs that used one or more options in a year) (averaged over 5 years between 2005 and 2009)	343	7	17.5	5.1
Average per year per TTO for TTOs that used zero options in a year (averaged over 5 years between 2005 and 2009)	91	0	2.4	2.7

Source: STATT database, AUTM; accessed during May 2011.

Technology options provide this tool and help the commercial partner defer the decision before entering into a full-fledged licensing agreement with the university. Typically, by entering into a technology option agreement (for a small or nominal fee), the commercial partner buys a specified time period to do preliminary testing of the technology idea, during which period, the university will abstain from discussing/licensing that particular technology with a third party. At the end of the option period, the commercial partner would be given a right to license the technology from the university with the usual licensing terms. In this way, the decision point to engage is postponed to a later date for a small fee.

In the high-risk sphere of technology commercialization, technology options provide an effective tool to manage the risk involved. TTOs that use this tool aptly benefit from this strategy. Table 3 presents data for TTOs that used technology options (by issuing one or more options in a given year) and TTOs that did not use options in a given year. The data are averaged over 5 years (2005–09) and present the numbers per TTO per year. As can be seen in Table 3, the TTOs that used options earn on an average US$ 17.5 million in licensing income and attract over US$ 340 million in research funding per year. In comparison, TTOs which do not use options, earn US$ 2.4 million in licensing income and attract around US$ 90 million in research funding per year. Also, it could be the case that larger universities, which are able to attract larger research funding, are able to better manage the technology transfer process by providing a larger menu of engagement options to the commercial partners, thereby increasing the chances of commercialization. Also, note that the licensing income generated by technology option users is about 5% of their research expenditure, whereas the TTOs that do not use options generate about 2.7% of their research expenditure. Roughly 70% of the TTOs issue at least one option a year; 30% of the TTOs do not issue options.

The role of startups in technology commercialization

Each university technology is unique and might require a specific approach to commercialize. Universities cannot rely on just one model to commercialize all of their technologies. TTOs should be able to create and leverage alternative models like creating a startup around a platform technology or entering into a partnership with a commercial partner, etc. Such models would also help bring in people from outside the research labs (entrepreneurs, market experts, technologists) and bring in private funding (either by the commercialization partner or the venture capitalists, angel investors, NGOs, etc.) to de-risk the technology. TTOs in the US engage widely with all kinds of partners to commercialize their technology. Nearly 17% of all licenses granted by US universities in 2010 were to startups, 47% to small companies (with fewer than 500 employees) and 35% to large companies[15].

Table 4 presents data on research expenditure and licensing income for universities that have used the startup route (which have engaged with at least one startup a year) to commercialize their technology and universities that do not engage with startups. The table also presents average numbers per university per year (averaged over 5 years, 2005–2009). The data show that, typically, universities that attract larger research funding engage with startups to commercialize and earn on an average US$ 17.7 million per year in licensing income (about 5.3% of their annual research expenditure). However, universities that did not engage with startups earned about US$ 2.9 million in licensing revenue a year – close to 3% of their research expenditure. It could be the case that only universities that have the scale and can attract large research funding that have the technology depth are more likely to create a technology-based startup. Around 70% of the TTOs reported engage with startups to commercialize. That said, a word of caution is in order. Since there are significant systemic differences particularly in the technology startup ecosystem between the US and India (like availability of or lack thereof of risk funding, experienced entrepreneurs, service providers, etc.), how the startups in India would be able to leverage and use technologies developed in research labs is yet to be seen.

One example of successful commercialization via a startup in the US is MIT's licensing technology to Momenta Pharmaceuticals. Momenta was founded in 2001, based on the research done in the labs of Robert Langer and Ram Sasisekhara, and is involved in making

Table 4. Engaging with startups to commercialize technology: comparison between TTOs that engage with startups and TTOs that do not

	Research expenditure (US$, million)	No. of startups created per year	Licensing income earned (US$, millions)	Licensing income as a percentage of research expenditure
Average per year per TTO which engage with startups (TTOs that engage with at least one startup a year to commercialize; averaged over 5 years between 2005 and 2009)	336	4	17.7	5.3
Average per year per TTO which do not engage with startups (averaged over 5 years between 2005 and 2009)	99	0	2.9	2.9

Source: STATT database, AUTM; accessed during May 2011.

alternate versions of existing drugs using sequencing and engineering of complex sugars[16]. MIT licensed over 10 US and foreign patents to Momenta – in return for which, MIT received licensing fees, stock in the newly formed company, and royalties on products resulting from these patents. MIT was issued over 290,000 equity shares of Momenta as part of the licensing deal[17] – the value of these shares alone[18], depending upon when MIT chose to sell them, varied between US$ 1.5 and 8.5 million – this is on top of all the other licensing fees and royalties. Momenta's market capitalization in 2012 was over US$ 700 million[18].

One recent development in India, in the last decade or so, is the establishment of technology business incubators in research institutes and universities[19]. These incubators have leveraged various government funding sources and other resources, and have strengthened the ecosystem around these institutions to create technology-based startups. They provide the necessary support for faculty and students who are looking to create technology startups. They also attract entrepreneurs from various fields – who can be tapped to create and lead startups based on the university's technology. Access to and availability of motivated entrepreneurs who are willing to take technology risk is a crucial missing piece, in commercializing university technologies through startups. Universities should leverage the incubators and the entrepreneurs and other service providers that the incubators attract to create technology-based startups.

Leveraging students for technology assessment/commercialization

TTOs in the US use the services of graduate students in their campuses to perform technology/commercialization assessments and for doing market research and supporting the TTO staff in various aspects[15]. This, apart from helping keep the costs low, also serves as a training ground for students who wish to enter into industry. There are even postdocs and senior Ph D students who work for the TTOs on a temporary basis to perform these tasks. Many Indian universities like the IITs and IISc which have a large student population on campus and have excellent management schools attached to them can engage graduate students on campus for these tasks.

Leveraging external funding and people

TTOs that wish to take technology to the market should offer a slew of options and different models of engagement with commercial partners. Creating various tools for technology de-risking and bringing in external funding[20] and people[21] will help accelerate commercialization of university technologies.

Take-aways for Indian TTOs

Any comparison of technology commercialization efforts in the US and India has to be done with a light touch. First, the US universities, with the Bayh Dole Act passed in 1980, have been doing this for over 30 years. In India, only recently has there been a push to commercialize via alternate routes. Research institutions have been allowed to hold equity in startups in lieu of technology only recently as well[22]. TTOs in the US have access to a trained workforce to manage their offices and have evolved and sharpened their approaches over the years to yield optimum results. Also, the US universities operate at a very different scale in terms of total research expenditure – with over US$ 53 billion a year (that is roughly 265,000 crore rupees) – which enables the system and researchers to work on ambitious and expensive technology goals and achieve them. All said, there are definite trends and pointers that TTOs in India can pick up from their US counterparts and adapt to the Indian context.

Object of setting up TTOs

As is clear, the goal of setting up a TTO should be to create value from research and to commercialize technologies that could lead to new products and services and to achieve social and strategic targets. Academic administrators, when setting up TTOs, should avoid the temptation to see them as possible cash cows or profit centres that could significantly contribute to the research budget of the research organization. Even in the best-case scenario of the top 6% of the license-earning universities in the US, the licensing income can match only around 16–17% of a year's research expenditure.

Flexibility in engaging with partners

TTOs should create multiple models and systems to engage with various commercialization partners. Over 70% of the TTOs in the US engage with or create startups themselves to commercialize some of their technology. It is not easy to go down this route – as is demonstrated in Table 1, that close to US$ 90 million in research spending is done for each technology-based startup created in the universities.

Use of technology options

Issuing a technology option provides the commercial partner with the breathing space and time to evaluate the technology for commercial potential before engaging on a full-fledged basis with the university. Over 70% of the US TTOs issue at least one option and have demonstrated that it is a useful tool in retaining the interest of the commercial partner and taking the technology to the next step. Indian TTOs should increasingly look at issuing focused and well-drafted technology options to commercial partners.

Also, various other factors like transparency in the university's technology transfer policy should be addressed so that all stakeholders (like scientists, potential commercial partners, startups, etc.) know what to expect when they enter this exercise. This policy should also lay out how the inventors will be compensated when the university receives licensing income. TTOs should help build the ecosystem around the universities that will bring in external funding and people to take technology forward. By structuring their policies, leveraging students, and understanding and addressing the risky nature of technology development and deployment, TTOs can strengthen the commercialization efforts of universities and research organizations.

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