Conceptualizing university–industry linkages in resource-constrained environments

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Abstract

This article problematizes the conventional models of U–I linkages by pointing to the fact that they assume a resource-abundant context in which research funding is not a constraint. While such an assumption generally holds true in developed countries it is unlikely to be the case in the context of developing nations. Paucity of research funding leads to a situation where universities possess few formal intellectual properties such as patents and copyrights. The conventional U–I linkages that are predicated on explicit knowledge are therefore generally absent in developing countries. The article argues that it is possible for universities to develop productive linkages with the industry even in resource-constrained environments (RCE) by leveraging their human capital and knowledge assimilation and dissemination capabilities. The article presents several case illustrations drawn from the higher education sector in India. The Indian case suggests that while conventional university–industry (U–I) linkages are not prevalent in the country, there are other forms of university and industry collaborations that have been largely ignored in the extant literature.

Keywords

university–industry linkages

resource constrained environments

innovation

National Innovation System

developing nations

India

Introduction

In developed countries, universities, increasingly, have come to play an important role in producing original knowledge that often has commercial applications. Universities have been recognized as one of the main actors who directly or indirectly help make a nation more innovative. Undertaking research is now considered one of the natural and desirable functions of the universities in developed countries along with teaching. In addition to this dual role, in recent years, a third function has often been assigned to universities: that of 'Mode 2' knowledge production (Gibbons et al. 1994) including commercialization of research. While 'Mode 1' knowledge production is motivated by scientific curiosity alone, Gibbons et al. (1994) argued that 'Mode 2' knowledge is context-driven research to provide solutions for real problems in the society.

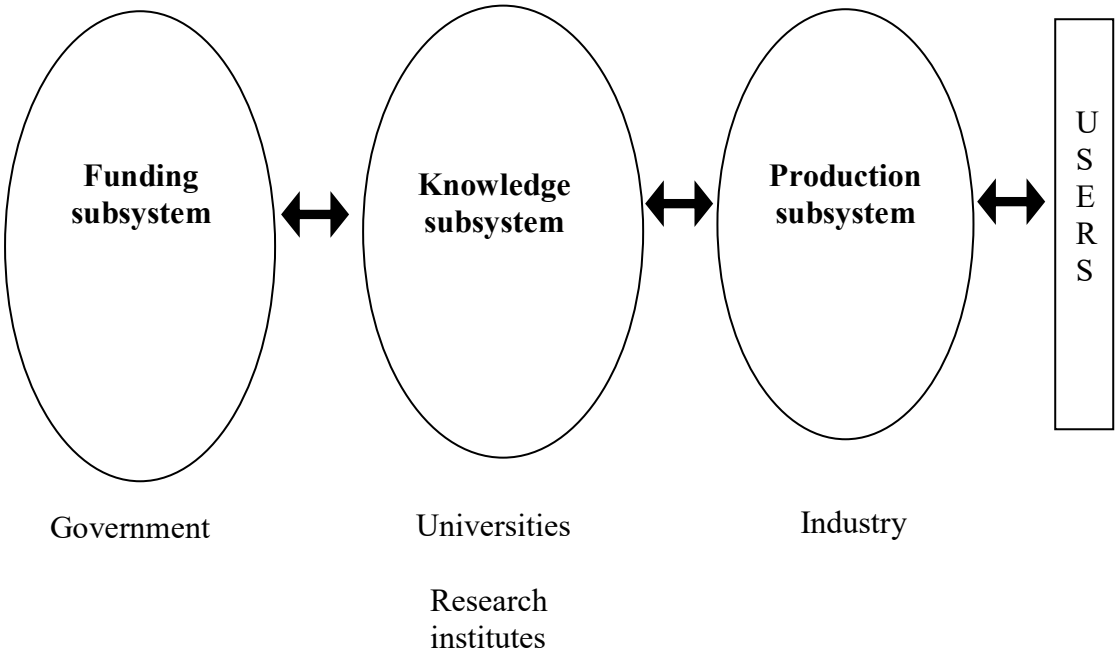
While it has become quite commonplace for universities in developed countries to conduct original research and occasionally undertake its commercialization (Shane 2004), this trend is not well pronounced in most developing nations. Policy-makers, economists and other scholars often consider this condition as a problem that needs to be redressed and exhort universities in developing countries to pursue the triple role (teaching, research and commercialization) model (Eun et al. 2006; Hershberg et al. 2007).

This article challenges this conventional wisdom and suggests that any generic model that attempts to describe and explain the role of universities within the national ecosystem in developing countries needs to take into account their particularities. This article holds the view that the key difference between the university system of a developed nation and that of a developing one is the level of resources available to the sector. Universities in developed nations typically operate in a 'resource-abundant' environment while those in developing nations negotiate a 'resource-constrained' one. The context fundamentally determines the nature of the university and consequently affects its collaborations with the industry.

The article is structured in the following way. First, a theoretical discussion is carried out to explicate university–industry (U–I) linkages as conceptualized under conventional models. Second, the distinction between 'resource-abundant' and 'resource-constrained' environments and its impact on U–I linkages are elucidated. A conceptual framework is put forward in this section that illustrates how U–I linkages can be fostered in resource-constrained environments (RCE). In the third section, three illustrations are presented from the Indian higher education sector. The main purpose of the case examples is to illustrate how universities in developing countries have forged effective linkages with the industry, overcoming the challenges that arise out operating in RCE. In the final section, some critical reflections are made on the explanatory power of the conceptual framework in the context of the U–I linkages that are discussed in the previous section.

Conceptualizing U–I linkages under conventional models

Innovation theories, particularly those that adopt a system perspective, acknowledge the important role that universities play in the production and commercialization of knowledge (Lundvall 1992; Freeman 1995; Etzkowitz and Leydesdorff 2000). It is worth noting that these theories have been shaped through the historical experiences in developed nations. The specificities of developing nations are largely ignored in these theoretical constructs. The resource-abundant environment under which universities operate in developed nations is assumed as the 'normal' condition. This is a huge assumption to make. The resource endowment of universities in developed nations, particularly those in the United States and Western Europe, has been shaped not only by the general prosperity of these countries but also through shared political history such as the two World Wars and the Cold War, which resulted in the generous allocation of research funding to universities to produce knowledge that could be put into military use (Geiger 1993; Nelsen 1998; Pavitt 2001). Thus, the system theories of innovation such as the National System of Innovation and the Triple Helix thesis are of relatively limited use for the purpose of this research. The resource abundant environment has engendered certain dominant forms of U–I linkages that are captured within these theoretical frameworks. But one of the main weaknesses of these theories is that they fail to recognize other forms of U–I linkages, particularly those that may arise out of a context that is resource constrained. In the following section the three popular models of innovation – the Linear Model, the National System of Innovation and the Triple Helix Thesis – are discussed and the U–I linkages as conceptualized within them are explicated.



Type 1: U–I linkages under the linear model.

Insert Figure 1 here

Figure 1 illustrates Type 1 U–I linkages. Here the state is the main provider of research funding to universities, who in turn produce intellectual properties that may include research papers (copyrights), patents and industrial design rights and utility models. These intellectual properties can either be sold outright to the industry or be licensed to them, who in turn undertake the commercialization process of converting these ideas into real products and services that are sold to consumers. This process is

characterized as the ‘Linear Model’ in the innovation literature (Freeman 1995; Godin 2009). The Linear Model arguably found its full expression in Vannevar Bush’s *Science-The Endless Frontier* (Bush 1945). The basic premise of the Linear Model is that innovation stems from basic research, normally carried out by universities and research institutes, brought about by generous state funding. Some of the knowledge that is produced through basic research has potential for practical application; the process of converting this potentiality into real products and services is led by the industry, which includes applied R&D, production and diffusion (Godin 2009). The Linear Model has been critiqued widely, particularly by historians of technology and innovation (see e.g. Rosenberg 1994: 139) but the very fact that the model continues to be cited frequently in the innovation literature, albeit often in a less than complementary sense, points to its durability. Advocates who argue for the funding of basic research in the present time often extend the same argument that Bush articulated in his 1945 treatise. Critiques who complain about the utilitarian approach of Government funding towards research (where researchers are required to demonstrate the ‘usefulness’ of their research to the wider society) perhaps do not realize to what extent their viewpoints are similar to those expressed by Bush in the mid-twentieth century.

Type 2: U–I linkages under NIS/Triple Helix Model.

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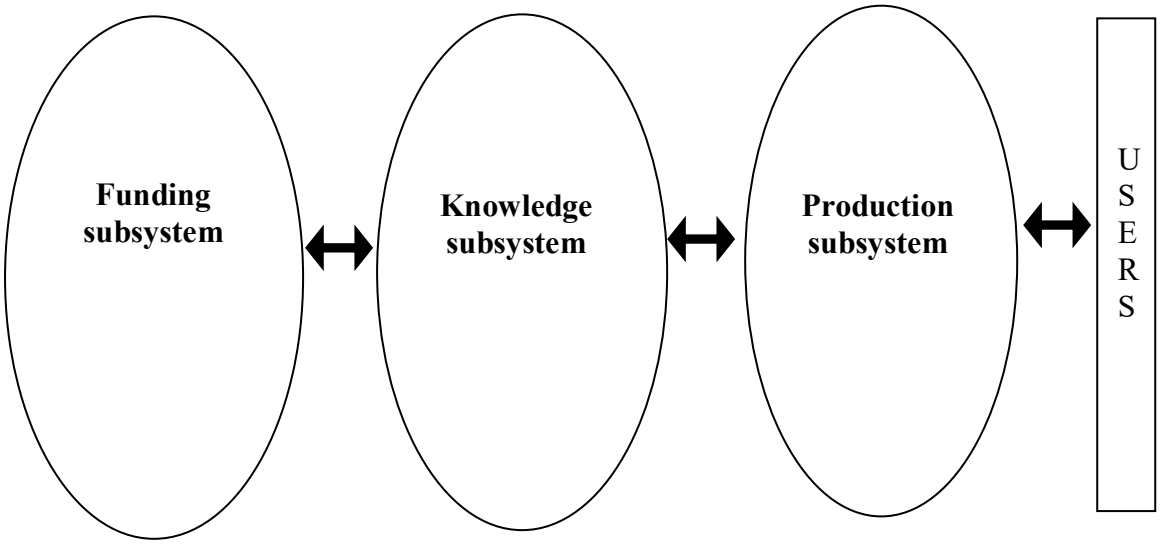


Government

Industry

Universities

Industry R&D

Research institutes

Industry

University spin outs

Insert Figure 2 here

As alluded to earlier, the Linear Model has been critiqued by many innovation scholars, and with good reason. Creativity and innovation rarely occur in a linear

fashion. Advocates of a system approach to innovation highlight the cross-connections between the different sub-systems that exist at a national or a regional level. The idea of subsystems as highlighted in Figures 1 and 2 comes out of the literature on the National Innovation System (NIS) (Lundvall 2016). Under NIS, the role of university is not fully sketched out although its importance is acknowledged. As Lundvall writes:

> Missing among these elements is the national education and training system. For different reasons, this extremely important element of the national system of innovation has not been given its proper treatment […]. There are big differences between countries in their formal and informal education and training systems, which affect their innovative capabilities […] An important task for future research is to integrate both education and training systems with innovation systems in one single analytical framework. (Lundvall 2016: 99–100)

The same issue is also discerned in Chris Freeman's work on NIS, where he focused on R&D efforts of the industry but largely ignored the role of the universities within the system (Freeman 1995)

The university is, however, not ignored in the Triple Helix Model (THM); it is in fact the model's primary concern. The THM analyses the interrelationships between three main actors in the NIS, the state, the university system and the industry, and postulates an ideal scenario where there is an interchangeability of roles amongst these actors. Universities become more entrepreneurial by undertaking

commercialization activities, and industry becomes involved in provisioning of higher education (Etzkowitz and Leydesdroff 2000)

Figure 2 illustrates Type 2 U–I linkages that are conceptualized under NIS and THM. The network/ system perspective of NIS and the idea interchangeability of roles as explicated in THM are both discernible in Figure 2. What is left unarticulated in these frameworks is the nature of the knowledge that is being generated and exploited in the knowledge and production subsystems. Knowledge, as we know from Nonaka's important work on the topic, can be Explicit or Tacit (1994). Both NIS and THM assume[1] that the linkages between the different subsystems (NIS) or actors (THM) are predicated on explicit knowledge such as patents and copyrights.

Type 2 U–I linkages differ from Type 1 both in respect to the roles of the university and the industry. The industry here is much more active in providing research funding while the university plays a proactive role in the commercialization process of its intellectual properties.

To measure and evaluate U–I linkages, researchers have typically considered both the input (funding) and the output (intellectual properties such as copyrights and patents) indictors (Etzkowitz 1998, Greenhalgh and Rogers 2010). The absence of these indicators also suggests to the researchers an absence of U–I linkages (Brimble and Doner 2007). This raises the question of whether research funding and intellectual properties are necessary prerequisites of developing U–I linkages. This question assumes particular significance when one is investigating U–I linkages in a developing country. Informed by the conventional system theories of innovation, the

researcher searches for Type 1 and 2 U–I linkages and either fail to identify any such relationships or find only weak evidence of them (D'Costa 2006, Intarakumnerd et al. 2002). However, if research funding and intellectual properties are not prerequisites of U–I linkages, then these findings may not capture the full reality of such relationships in developing countries.

Conceptualizing U–I interactions in a 'resource-constrained' environment

To develop an understanding of how university and industry may interact with each other productively in a RCE, one needs to move away from traditional views that often carry with them the assumption that resources are plentiful. The funding subsystem of the NIS is usually in an impoverished state in developing countries; hence resources that are made available to produced codified or explicit knowledge in developed countries may not be readily forthcoming in these nation states. But if explicit knowledge is exploitable, so should be the case with tacit knowledge. Universities do routinely exploit tacit knowledge to develop collaborations with the industry. Coaching and mentoring and consultancy services are some of the prominent examples of U–I linkages that are based mainly on tacit knowledge.

The model of U–I linkages developed in a resource-abundant environment is based on formal intellectual properties. It is predicated on patents and copyrights (research papers). It is focused on original codified knowledge that can be protected through intellectual property rights. Forms of conventional U–I linkages such as licensing and spinouts are based primarily on such formal intellectual properties. We have already discussed how these types of intellectual properties (patents and copyrights) are

dependent on research funding, which are in turn dependent on public funding to kick start the virtuous cycle of research funding (refer to Figures 1 and 2).

The dynamics of U–I linkages in RCE are significantly different from those in resource-abundant ones. One main difference is the nature of knowledge that is transferred and synthesized through these linkages. U–I collaborations in developing countries are more likely to be dependent on tacit knowledge and human capital. The key resources that universities bring to the table are as follows:

- their ability to assimilate and disseminate knowledge
- the human capital embodied in their staff
- their reputation and trustworthiness
- their students

Universities, no matter where they are located, essentially deal in knowledge. In developing countries, universities are constrained in the production of original explicit knowledge owing to the lack of research funding. This, however, does not preclude them from assimilating and disseminating existing stock of knowledge; universities do this routinely as part of their teaching function. These capabilities can be leveraged to develop strong U–I linkages. This is not a particularly new insight. When universities do consultancy work or deliver executive education programmes or engage in coaching and mentoring, they are, in the main, exploiting the tacit knowledge of their faculty and their knowledge assimilation and dissemination capabilities. But it is worth noting that these dynamics are not captured in conventional frameworks that are pre-occupied with explicit codified knowledge. The

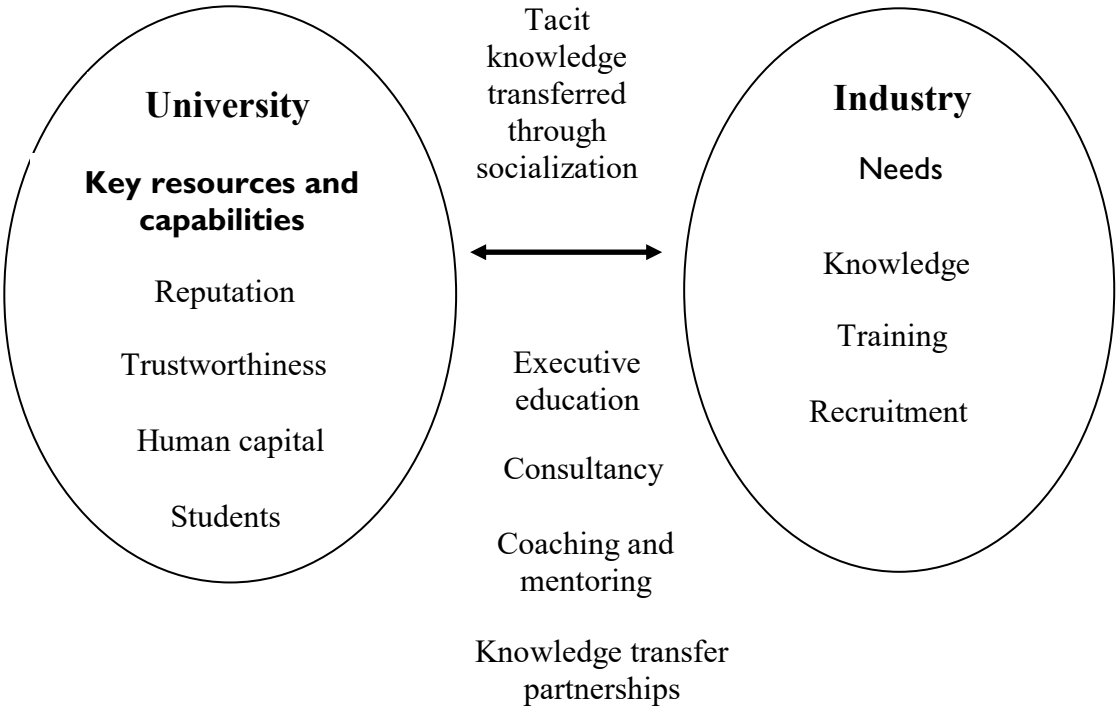
other important point to note is that a vigorous funding subsystem is not a precondition for these U–I linkages to materialize.

Reputation and trustworthiness of universities and academic staff are key resources in the context of U–I linkages. Many surveys have shown that academics and scientists are groups that are most trusted in societies.[2] Industries and policy-makers often rely on universities to produce impact assessments of planned policies as they are considered to be impartial and relatively free of vested interests.

The other key asset that universities have access to is their pool of students. Industry is in constant need of skilled labour and it has been the traditional role of the universities to provide it. But students are important to U–I linkages in more direct ways. Many students, particularly from the postgraduate cohorts, have a rich industry experience that they bring with them when they come to universities for their studies. Some of them collaborate effectively with the academic staff in their research projects. Academics also gain access to valuable industry networks through their students. In some developing countries such as India, campus recruitment by industry takes place on a very large scale and the high starting salaries of new graduates are often national news.

It is thus evident that universities possess key resources and capabilities even when the funding subsystem of their respective NIS is relatively weak.

Type 3: U–I Linkages under Resource-Constrained Environments.



Insert Figure 3 here

Figure 3 encapsulates the U–I linkages under RCE. There are specific industry needs that can be met through key resources and capabilities of the universities. A high level of research funding is not a necessary condition for the development of these

university assets, although the provision of former undoubtedly helps the latter. The primary mode of knowledge transfer in such exchanges is tacit to tacit, facilitated through 'socialization' (Nonaka and Toyoma 2003) .

In the following sections several illustrations are presented from the higher education sector in India. The information presented in the two illustrations has been collated from secondary data sources including previous research of the authors.

The case of India

Over the years, a consensus has emerged in the academic literature about the lack of effective collaboration between university and industry in India (D'Costa 2006; Joseph and Abraham 2009). But the focus of the research has been firmly on the Type 1 and 2 U–I linkages discussed in the previous sections. It is undoubtedly the case that in India, U–I linkages that are predicated on explicit knowledge, or in other words, formal intellectual properties such as patents and copyrights, are not numerous. Some select higher education institutions do engage in Type 1 and 2 collaborations but even here the intensity of these exchanges is not particularly high. The general verdict that is produced, based on such observations, is that India's NIS, and the role of the university in it, are both weak. This article does not go into the relative merits and drawbacks of this proposition. It merely points out that existing studies have generally ignored Type 3 U–I linkages- collaborations between university and industry that are based on tacit instead of explicit knowledge. Undertaking an extensive survey on

Type 3 U–I linkages in India is beyond the scope of this article, which is, in the main, conceptual in nature. Such a project may be part of future research of the authors following from this article. For the present task, select illustrations of Type 3 U–I linkages are presented; the extent of their prevalence remains to be evaluated through future research.

Executive education at Indian Institutes of Management (IIM) Calcutta

IIMs are a group of autonomous institutes in India that specialize in management education and research. IIM-Calcutta is the oldest in the group, having been established in 1961. IIMs were set up outside of the mainstream university system as an 'autonomous institute'. This genre of higher education institutions in India enjoys a higher level of autonomy than mainstream universities (Datta 2017). Each IIM has their separate and distinct governance structures, and some are more entrepreneurial than others. IIM-Calcutta encourages its staff to develop Executive Education programmes in collaboration with industry partners. The spectrum of Executive Education programmes offered by the Institute is as follows[3]:

Management Development Programmes (MDPs): comprehensively structured classroom sessions that typically span from three days to three weeks, and are designed to address specific corporate training objectives.

Open MDPs – a calendarized set of MDPs, spreading across the functional areas in the Business Management domain.

Customized Training Programmes – also called In-Company programmes, these are tailor-made modules, created around specific mandates from corporate clients.

Long Duration Programmes (LDPs): programmes that are conducted on the distance learning format and are disseminated through satellite-based learning platforms, interspersed with brief in-campus sessions.

Executive Education Programmes of IIM-Calcutta have been proven to be very popular. The success is partly based on the reputation of the Institute, which attracts industry partners. Also critical to its success is the financial incentive to the academic staff who are successful in enroling private firms into the programmes. Academics who secure the contracts and then deliver the programmes are remunerated handsomely by the institution (Datta and Saad 2011).

Campus placements at IITs

Indian Institutes of Technology (IITs) are a group of autonomous institutes specializing in engineering studies. Much like the IIMs, IITs also enjoy a higher level of autonomy compared to mainstream universities and reside outside of the university system. The earliest IIT was established in 1951, shortly after India's independence from colonial rule in 1947. The IITs were declared as institutes of 'national importance' in the IIT Act of 1961. The designation reflected the key role that these institutions were expected to play in the planning era that was dawning on the country (Datta 2017). Between 1950 and 1990, India tried to develop its economy through a centralized planning approach that was inspired by the Soviet model. IITs were set up primarily to provide engineers in large numbers. This was an integral part of the industrial strategy of the Planning Commission of India, which was entrusted with the task of producing Five Year Plans for the country (Datta 2017).

However, after the liberalization of the economy, which started in 1991, private enterprises have flourished and IIT graduates now command high starting salaries from these companies, who recruit them often through placement weeks organized by the Institute on a periodic basis. In a newspaper article, Professor Padhy, who oversees training and placement in IIT-Roorkee, points out that 'IITs are the hub for tech talent for global companies' (Verma and Basu 2017). The same article reports that in IIT Madras as many as nineteen companies are hiring graduates for international placements (Verma and Basu 2017). Most of the major multinational companies, including firms such as Uber and Microsoft are reported to be hiring IIT graduates in these campus recruitment weeks (Verma and Basu 2017).

The attraction of IITs to the corporate recruiter is based both on the reputation of the Institutes and the quality of their student cohorts. The technical knowledge that the students acquired during their programme is paradoxically not that important in terms of securing an attractive employment offer. The vast majority of the engineers are recruited for jobs that will not require the application of their technical skills. The main asset of the student is the fact that he/she is an IIT graduate. Students have to sit an entrance examination to gain admission to the IITs. The entrance examination is widely considered to be one of the toughest in the world. In 2012, only 5% of the applicants were offered a place.[4] In comparison, top engineering schools in the United States such as MIT and Stanford had acceptance rates between 7% and 9%. Such a rigorous selection process automatically ensures that the human capital of successful candidates is high. In a sense, the IIT student entrance examination functions as an extended HR arm of private firms.

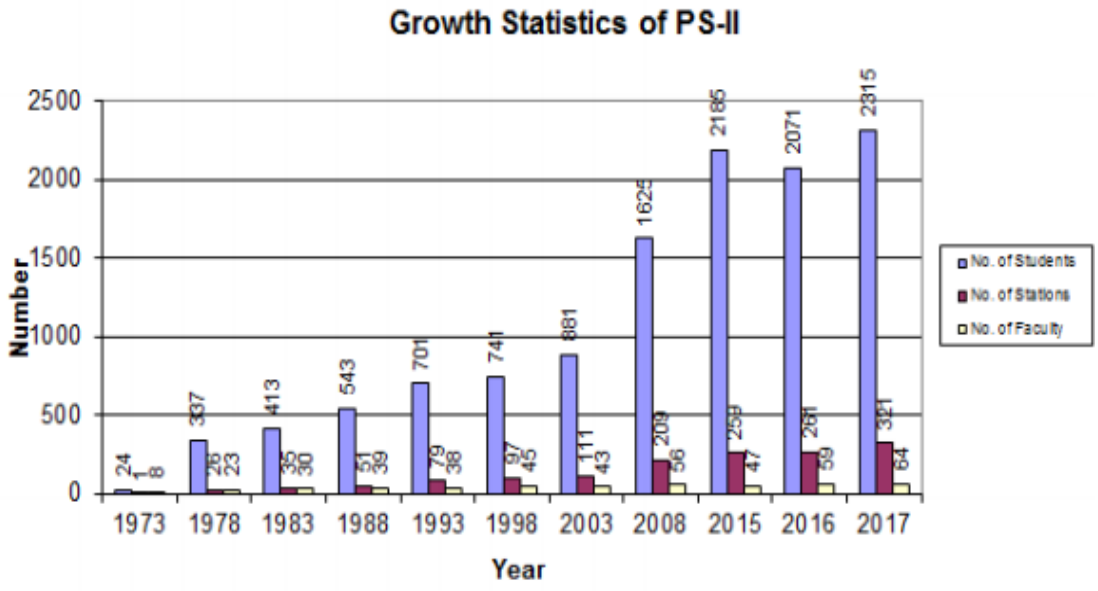
Practice schools at Birla Institute of Technology & Science, Pilani (BITS Pilani)

The BITS Pilani is an Indian institute of higher education and a deemed university. It is one of the earliest private initiatives in higher education in the post-independence period (established in 1956), and has the distinction of pioneering a particular form of U–I linkages in the school through its 'Practice School' programme. Launched in 1973, with Hindalco as its industry partner, the Practice School allows students to work in the industry and gain valuable work experience during their study programme. In its four-year undergraduate programme, students have the opportunity to take Practice School 1 (PS1), which is conducted during the summer following the second year and then again in the final year, the students spend one semester doing elective courses and the other doing Practice School II (PS II).

The duration of PS I is eight weeks. It is designed to provide the students their first comprehensive exposure to professional workplace. Orientation (up to four weeks) comprises of plant visits and interaction with company executives to facilitate the process of learning by observation and discussion. The process is aided by a Checklist (an exhaustive list of queries about different aspects of an organization). Projects (often study type, involving collecting data, organizing, analysing and presenting data/information) are assigned to promote learning by doing. Components of evaluation include Diary, Quiz, Group Discussion and Presentation to develop regularity, group learning and communication skills.

Much more intensive is PS II, which is of five and a half months' duration, carrying twenty units credit and is operated round the year, from July to December and January to June. PS-II provides an opportunity to students to experience the world of work, by

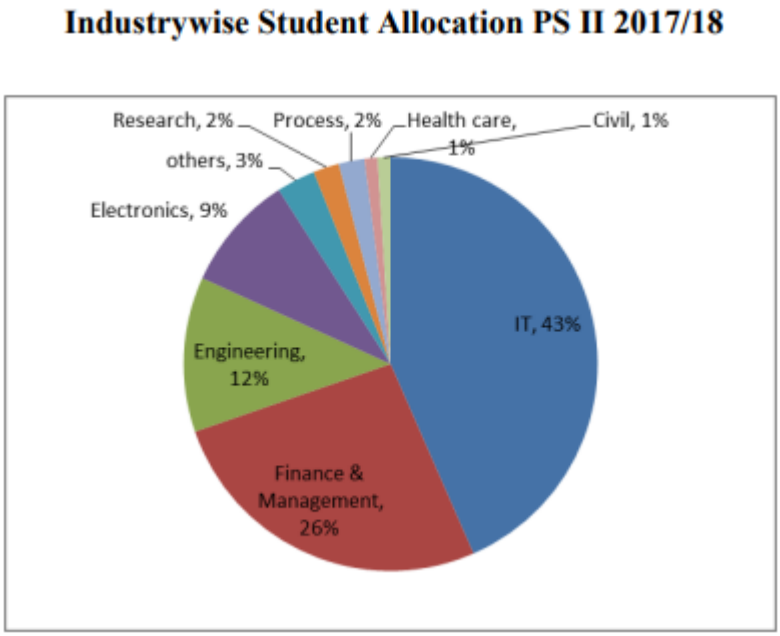
participating in live projects in industry, even before they graduate. After a brief orientation, the students are involved directly in addressing the predefined problems (generally of multidisciplinary nature) of the host organization. The students are encouraged to work independently, under the technical guidance of a professional expert and the general guidance of the faculty. They are periodically required to defend the technical aspects of their work through written and oral presentations.



Source: BITS Pilani, 2017.

Insert Figure 4 here

The PS II has witnessed strong growth over the years as can been observed from the graph in Figure 4. The programme started with one industry partner in 1973 (classified as 'stations' in Figure 4) and its growing popularity can be gauged from the fact that in 2017 there are 321 companies collaborating with BITS Pilani on this programme.



Insert Figure 5 here

A high percentage (43%) of the firms associated with PS II belongs to the IT sector as can be seen in Figure 5. Next to that is Finance and Management, with 26%, and somewhat surprisingly, considering that BITS Pilani is primarily an engineering institute, only 12% of the firms belong to the engineering sector. The students who are placed into the companies as part of PS II often end up being recruited by them after they finish their study programme. The low percentage of engineering firms (and the high percentage of IT and Finance and Management firms) suggests, as is the case with the IITs, that these companies are primarily interested in the human capital embodied in the students and less concerned with their technical capabilities.

Concluding remarks on the conceptual framework

Having presented the above illustrations of U–I linkages from India, it is pertinent to ask the following question. Does the conceptual framework (Figure 3) help us to understand these specific forms of U–I linkages? The first thing to point out is that these U–I linkages are not usually captured in academic studies that are informed by NIS or THM. But this observation does not diminish the importance of these U–I linkages. It suggests that the picture of U–I collaborations is more diverse than what is suggested through a survey of the extant literature. The focus on the generation and exploitation of explicit knowledge has diverted attention from those collaborations that facilitate tacit-to-tacit knowledge transfer.

The fact that in India, some higher education institutions recruit students through meritocratic entrance examinations would be considered quite irrelevant in the context of U–I linkages if one relies on the conventional wisdom. Yet, we have seen through one of the illustrations presented above that such a policy can add to the reputation of the institute, which can then be leveraged to foster industry collaborations. The examples show that effective U–I linkages can be forged based on tacit knowledge of the partners in such exchanges. The framework does not explain, however, why some universities and institutes are more adept in leveraging their tacit knowledge and intangibles than others. One suspects that there must be something distinctive in the organization structures and decision-making processes of these institutions, but this is something that remains to be established through future research in the area.

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Notes

[1] NIS and THM do not distinguish between tacit and explicit knowledge but a reading of them makes it abundantly clear that what is being referred to in the literature is explicit knowledge such as patents and copyrights.

[2] For example, in an IPSOS Mori survey conducted in Britain, teachers and scientists were shown to be amongst the top five professions that are most trusted. The survey can be found at this link https://www.ipsos.com/sites/default/files/migrations/en-uk/files/Assets/Docs/Polls/ipsos-mori-veracity-index-2015-topline.pdf.

[3] Information collated from the following webpage of the Institute https://www.iimcal.ac.in/programs/executive-education.

[4] Analysis of the Entrance Examination results is available at this link https://www.iitk.ac.in/new/data/jee-report/JEE-2012%20Report.pdf.